CHAPTER - 21

AGRICULTURE

"A man without food
For three days will quarrel,
For a week will fight and
For a month or so will die"

AGRICULTURE

- The term agriculture is derived from two Latin words ager or agri meaning soil and cultura meaning cultivation. Agriculture is a broad term encompassing all aspects of crop production, livestock farming, fisheries, forestry etc.
- Agriculture is defined as an art, science and business of producing crops and livestock for economic purposes
- The word AGRICULTURE thus may be expanded as Activities on the Ground for Raising Intended Crops for Uplifting Livelihood Through the Use Of Rechargeable Energies.
- SilviCulture is the art of cultivating forest trees.
- Sericulture is the rearing of silkworms for the production of raw silk.
- Apiculture is the maintenance of honey bee colonies, commonly in hives, by humans
- Olericulture is the science of vegetable growing, dealing with the culture of non-woody (herbaceous) plants for food.
- Viticulture is the science, production and study of grapes
- Floriculture is a discipline of horticulture concerned with the cultivation of flowering and ornamental plants for gardens
- Arboriculture is the cultivation, management, and study of individual trees, shrubs, vines, and other perennial woody plants
- Pomology is a branch of horticulture which focuses on the cultivation, production, harvest, and storage of fruit, etc.
- Aeroponics is the process of growing plants in an air or mist environment without the use of soil or an aggregate medium
- Hydroponics is a method of growing plants using mineral nutrient solutions, in water, without soil.
- Terrestrial plants may also be grown with their roots in the mineral nutrient solution only or in an inert medium, such as perlite, gravel, mineral wool, expanded clay or coconut husk.
- Geoponic in farming practice, refers to growing plants in normal soil

Scope and Importance of Agriculture

- With a 17.2 per cent contribution to the gross domestic product (GDP), agriculture provides livelihood support to about two-thirds of country's population.
- The sector provides employment to 56.7 per cent of country's work force and is the single largest private sector occupation.
- Agriculture accounts for about 14.7 per cent of the total export earnings and provides raw material to a large number of Industries (textiles, silk, sugar, rice, flour mills, milk products).
- The agriculture sector acts as a bulwark in maintaining food security and, in the process, national security as well.
- The allied sectors like horticulture, animal husbandry, dairy and fisheries, have an important role in improving the overall economic conditions and health and nutrition of the rural masses.

Problems of Indian Agriculture

- Fragmentation of land holding.
- Existence of small and marginal farmers.
- Regional variation.
- Dependence of seasonal rainfall.
- Low productivity of land.

- Increasing of disguised unemployment.
- Disorder in marketing of Agricultural products.
- Weak land reformation.

Revolutions in Agriculture

Revolution	Related with
Green	Food grain Production
Golden	Fruit Production
Grey	Fertilizer Production
Blue	Fish Production
Black	Petroleum Production
Pink	Prawn Production
Round	Potato Production
Red	Meat/Tomato Production
Silver	Egg/Poultry Production
White	Milk Production
Yellow	Oil seeds Production

Land utilization statistics

In India

1. Total geographical area : 328.848 million ha.
2. Total reporting area : 304.300 million ha.
3. Area under cultivation : 143.000 million ha.
4. Total cropped area : 179.750 million ha.
5. Area sown more than once : 36.750 million ha.
6. Area not available for cultivation : 161.300 million ha.
7. Area under forest : 66.400 million ha.

CROP AND ITS CLASSIFICATIONS

- Agronomy is a Greek word derived from agros meaning field and nomos meaning management. It is a specialized branch in agriculture dealing with crop production and soil management. Crops refer to plants that are grown on a large scale for food, clothing, and other human uses.

Classification based on climate

1. Tropical: Crops grow well in warm & hot climate. E.g. Rice, sugarcane, Jowar etc
2. Temperate: Crops grow well in cool climate. E.g. Wheat, Oats, Gram, Potato etc.

Classification Based on growing season

1. Kharif/Rainy/Monsoon crops: The crops grown in monsoon months from June to Oct-Nov, Require warm, wet weather at major period of crop growth, also required short day length for flowering. E.g. Cotton, Rice, Jowar, bajara.
2. Rabi/winter/cold seasons crops: The crops grown in winter season from Oct to March month. Crops grow well in cold and dry weather. Require longer day length for flowering. E.g. Wheat, gram, sunflower etc.
3. Summer/Zaid crops: crops grown in summer month from March to June. Require warm dry weather for major growth period and longer day length for flowering. E.g. Groundnuts, Watermelon, Pumpkins, Gourds.

Agronomic Classification of Crops

Cereals

- Cereals are cultivated grasses grown for their edible starchy grains. Larger grains used as staple food are cereals. Rice, wheat, maize, barley and oats. The important cereal of world is rice.

1. Rice - Oryza sativa
2. Wheat
   - Bread wheat - Triticum aesticum, Triticum valgare
   - Macaroni wheat - T. durum
   - Emmer wheat - T. dicoccum (Mysore & Nilgiri)
   - Dwarf wheat - T. sphaerococcum
3. Maize or corn - Zea mays
4. Barley - Hordeum vulgare
5. Rye - Secale cereale
6. Oats - Avena sativa

Millets

- They are also annual grasses of the group cereals. But they are grown in less area or less important area whose productivity and economics are also less important.
- These are staple food of poor people. In India pearl millet is a staple food in Rajasthan
- 1) Major millets and 2) Minor millets
- It is based on area production and productivity and grain size.

Major millets

1. Sorghum /Jowar/Cholam - Sorghum bicolor
2. Pearl Millet /Bajra/cumbu - Pennisetum typhoides
3. Finger millet or ragi - Eleusine coracona

Minor millets

1. Fox tail millet / Thenai - Setaria italica
2. Little millet / Samai - Panicum miliare
3. Common millet / Panivaraugu - Panicum miliaceum
4. Barnyard millet / Kudiraivali - Echinchloacolonavar frumentaceae
5. Kodomillet / Varagu - Paspalum scrobiculatum

Pulses or Grain Legumes

- Pulses are major source of protein in Indian vegetarian diet. These are main source of protein providing most of the essential amino acids to a certain degree. Economically, pulses are cheapest source of protein.
- It is cultivated to enrich the soil, to utilize the residual moisture and to give revenue in a shorter period.

1. Red gram - Cajanus cajan
2. Black gram - Vigna mungo
3. Green gram - V. radiata
4. Cowpea - V. unguiculata
5. Bengalgram - Cicer arietinum
6. Horsegram - Macrotyloma uniflorus
7. Dewgram - Phaseolus aconitifolius
8. Soyabean - Glycine max
9. Peas or gardenpea - Pisum sativum
10. Garden bean - Lablab purpureus

Oil Seed Crops

- These crops are cultivated for the production of oil. Either for edible on industrial or medicinal purpose. They contain more of fat.

1. Groundnut or peanut - Arachis hypogeae
2. Sesamum or gingelly - Sesamum indicum
3. Sunflower - Helianthus annuus
4. Castor - Ricinus communis
5. Linseed or flax - Linumusitatissimum
6. Niger - Guizotia abyesinia
7. Safflower - Carthamus tinctorius
8. Rapeseed & Mustard - Brassica sp.

- 45 – 50% oil content is present in these seeds.

Sugar Crops

- Juice extracted from stem used for jaggery or sugar
- Number of by products like Molasses, bagasse,pressmud
- Molasses used for alcohol and yeast formation
- Bagasse for paper making and fuel
- Pressmud used for soil amendment
- Trash (green leaf + dry foliage) – the waste is used for cattle feed
- Sugar beet – Tuber for extraction of sugar
- Tubers and tops are used as a fodder for cattle feed

1. Sugarcane - Saccharum officinarum
2. Sugar beet - Beta vulgaris var saccharata

Starch Crops or Tuber Crops

1. Potato - Solanum tuberosum
2. Tapioca or cassava - Manihot esculenta
3. Sweet potato - Ipomea batatus

Fibre Crops

- Epidermal hairs of seed coats is the economic portion
- Lint (cappas – seed) has industrial value (fibre)
- Stalk is of fuel nature, garment purpose, Seed for cattle feed,Oil is edible

Cotton

- Gassypium arboreum (Karunganni)
- G. herbaceum (uppam cotton)
- G. hirsutum (American cotton or Cambodium cotton)
- G. barbadense (Egyptian cotton or Sea island cotton)

Stem Fibres

a) Jute (channal) - Corchorus capsularis
b) Mesta (pulicha keerai) - Hibiscus cannabinus
c) Sun hemp - Crotolaria juncea
d) Sisal hemp - Agave sisalana

Narcotics

- Stimulates Nervous System

i) Tobacco - Nicotiana tabaccum
ii) Betelvine - Piper betle
iii) Arecanut - Areca catechu

Forage and Fodder Crops

Forage Crops

- The entire vegetative part is used as green fodder
- the stalks and leaves are the major economic portion for hay making
- Hay is cut into pieces and mixed with concentrated animal feed and is fed to animals

Grasses

- Napier grass - Pennisetum typhoides
- Para grass - Brachiaria mutica
- Bermuda grass (Hariyali) - Cynodon dactylon
- Guinea grass - Panicum maxium
- Rhodes grass - Chloris gayana

Legumes

1) Lucerne (Alfalfa) – Medicago sativa
2) Egyptian clover (Bersemm) - Trifolium alexandrium
3) Indian clover (Fodder senji) - Melilous parviflora
4) Sirato - Macroptilium atropurpureum
5) Stylo - Stylsanthus hamata/ scabra
6) Subabul - Leuceana leucocephala
7) Velvet bean - Mucuna cochinchinensis

Plantation Crops

- 1) Tea – leaf; 2) Coffee – seed; 3) Rubber – milk exudation; 4) Cocoa - seed

Spices and Condiments

- Products of crop plants are used to flavor taste and sometime color the fresh preserved food. E.g. ginger, garlic, chili, cumin onion, coriander, cardamom, pepper, turmeric etc.
- Medicinal & aromatic crops: Medicinal plants includes cinchona, isabgoli, opium poppy, senna, belladonna, rauwolfra, iycorice and aromatic plants such as lemon grass, citronella grass, palmorsa, Japanese mint, peppermint, rose, jasmine, henna etc.

Classification based on life of crops/duration of crops:

1. Seasonal crops: A crop completes its life cycle in one season. E.g. rice, Jowar, wheat etc.
2. Two seasonal crops: crops complete its life cycle in two seasons. E.g. Cotton, turmeric, ginger.
3. Annual crops: Crops require one full year to complete its life cycle. E.g. sugarcane.
4. Biennial crops: Crops requires two year to complete its life cycle E.g. Banana, Papaya.
5. Perennial crops: crops live for several years. E.g. Fruit crops, mango, guava etc.

Classification based on cultural method/water:

1. Rain fed: Cultivation of crop mainly based on the availability of rain water. E.g. Jowar, Bajara, Mung etc.
2. Irrigated crops: Crops cultivated with the help of irrigation water. E.g. Chili, sugarcane, Banana, papaya etc.

Classification based on root system

1. Tap root system: The main root goes deep into the soil. E.g. Tur, Grape, Cotton etc.
2. Fiber rooted: The crops whose roots are fibrous shallow & spreading into the soil. E.g. Cereal crops, wheat, rice etc.

Classification based on economic importance

1. Cash crop: Grown for earning money. E.g. Sugarcane, cotton.
2. Food crops: Grown for raising food grain for the population and & fodder for cattle. E.g. Jowar, wheat, rice etc.

Classification based on No. of cotyledons

1. Monocots or monocotyledons: Having one cotyledon in the seed. E.g. all cereals & Millets.
2. Dicots or dicotyledonous: Crops having two cotyledons in the seed. E.g. all legumes & pulses and almost all the trees.

Classification based on length of photoperiod required for floral initiation

- Most plants are influenced by relative length of the day & night, especially for floral initiation, the effect on plant is known as photoperiodism depending on the length of photoperiod required for floral ignition, plants are classified as:

1. Short-day plants: Flower initiation takes place when days are short less then ten hours. E.g. rice, Jowar, green gram, black gram etc.
2. Long day's plants: require long days are more than ten hours for floral initiation. E.g. Wheat, Barley, etc.
3. Day neutral plants: Photoperiod does not have much influence for phase change for these plants. E.g. Cotton, sunflower, etc.

TILLAGE

- Tillage is the mechanical manipulation of soil with tools and implements for obtaining conditions ideal for seed germination, seedling establishment and growth of crops.
- **Tilth:** It is the physical l condition of soil obtained out of tillage (or) it is the result of tillage. The tilth may be a coarse tilth, fine tilth or moderate tilth. Based on the requirement of crops being grown and the soil where we are cultivating.
- **Types of tillage:** Tillage operations may be grouped into

  1. On season tillage 2. Off-season tillage
- **On-season tillage:** Tillage operations that are done for raising crops in the same season or at the onset of the crop season are known as on season tillage.
- **Preparatory tillage:** This refers to tillage operations that are done to prepare the field for raising crops. It consists of deep opening and loosening of the soil to bring about a desirable tilth as well as to incorporate or uproot weeds and crop stubble when the soil is in a workable condition.

Types of preparatory tillage

1. Primary tillage
2. Secondary tillage

- **Primary tillage:** The tillage operation that is done after the harvest of crop to bring the land under cultivation is known as primary tillage. Ploughing is the opening of compact soil with the help of different ploughs. Country plough, mould board plough, bose plough, tractor and power tiller are used for primary tillage.
- **Secondary tillage:** The tillage operations that are performed on the soil after primary tillage to bring a good soil tilth are known as secondary tillage. Secondary tillage consists of lighter or finer operation which is done to clean the soil, break the clods and incorporate the manure and fertilizers. Harrowing and planking is done to serve those purposes
- **Dry tillage:** Dry tillage is practiced for crops that are sown or planted in dry land condition having sufficient moisture for germination of seeds. This is suitable for crops like broadcasted paddy, jute, wheat, oilseed crops, pulses, potato and vegetable crops.
- **Wet or puddling tillage:** The tillage operation that is done in a land with standing water is called wet or puddling tillage. Puddling operation consists of ploughing repeatedly in standing water until the soil becomes soft and muddy. Puddling creates an impervious layer below the surface to reduce deep percolation losses of water and to provide soft seed bed for planting rice.
- **Off-season tillage:** Tillage operations done for conditioning the soil suitably for the forthcoming main season crop are called off-season tillage. Off season tillage may be

  1. Post harvest tillage
  2. Summer tillage
  3. Winter tillage
  4. Fallow tillage
- **Special purpose tillage:** Tillage operations intended to serve special purposes are said to be special purpose tillage. They are, 1) sub soiling, 2) levelling, 3) clean tillage, 4) blind tillage, 5) wet tillage and 6) zero tillage.
- **Sub soiling:** To break the hard pan beneath the plough layer special tillage operations (chiselling) are performed to reduce compaction. Sub soiling is essential once in four to five years where heavy machineries are used for field operations, seeding, harvesting, transporting etc.

Advantages

- greater volume of soil may be obtained for cultivation of crops
- excess water may percolate downward to recharge the permanent water table
- reduce runoff and soil erosion
- roots of crop plants can penetrate deeper to extract moisture from the water table
- **Clean tillage:** It refers to working of the soil of the entire field in such a way no living plant is left undisturbed. It is practiced to control weeds, soil borne pathogen and pests.

- **Blind tillage:** It refers to tillage done after seeding or planting the crop (in a sterile soil) either at the pre – emergence stage of the crop plants or while they are in the early stages of growth so that crop plants (cereals, tuber crops etc.) do not get damaged, but extra plants and broad leaved weeds are uprooted.
- **Zero tillage (No tillage):** In this, new crop is planted in the residues of the previous crop without any prior soil tillage or seed bed preparation and it is possible when all the weeds are controlled by the use of herbicides.

Advantages of Zero tillage

1. Zero tilled soils are homogenous in structure with more number of earthworms
2. Organic matter content increases due to less mineralization
3. Surface runoff is reduced due to presence of mulch

Disadvantages

1. Higher amount of nitrogen has to be applied for mineralization of organic matter in zero tillage
2. Perennial weeds may be a problem
3. High number of volunteer plants and buildup of pests

CROPPING

- **Cropping intensity:** Number of crops cultivated in a piece of land per annum is cropping intensity. In Punjab and Tamil Nadu the cropping intensity is more than 100 per cent i.e. around 140-150%. In Rajasthan the cropping intensity is less.

Cropping pattern

- The yearly sequence and spatial arrangement of crops and fallow on a given area is called cropping pattern

Cropping system

- The cropping pattern used on a farm and its interactions with farm resources, other farm enterprises, and available technology which determine their makeup.
- **Multiple cropping:** Growing more than two crops in a piece of land in a year in orderly succession. It is also called as intensive cropping. It is used to intensify the production. It is possible only when assured resources are available (land, labour, capital and water)
- **Double cropping:** Growing two crops a year in sequence. Example: Rice - Pulse
- **Triple cropping:** Growing three crops a year in sequence. Example: Rice - Rice - Pulse
- **Quadruple cropping:** Growing four crops in a year in sequence
- **Monoculture:** Repetitive growing of the same sole crop in the same land.
- **Mono cropping:** Continuous production of one and the same crop year after year or season after season is called mono cropping.
- **Sole cropping:** One crop variety grown alone in a pure stand at normal density.

Sequential cropping

- Growing of two or more crops in sequence on the same field in a year. The succeeding crop is planted after the preceeding crop has been harvested
  - The crop intensification is done in time dimension
  - Ex: Rice-rice-cotton
- Relay cropping Growing the succeeding crop when previous crop attend its maturity stage-or-sowing of the next crop immediately before the harvest of the standing crops.

E.g. 1) Paddy-Lucerne.

2) Rice-Cauliflower-Onion-summer gourds.

Ratoon cropping

- Raising a crop with regrowth coming out of roots or stocks of the harvested crop
  - Ex: Sugarcane (8 ratoons in Cuba)
  - Banana – one plant crop followed by two ratoon crops normally
  - Sorghum and Lucerne fodder- many ratoons Ist cutting 70 DAS and thereafter every 35-40 days.
  - Pineapple crop is extensively ratooned.

Intercropping

- Growing two or more crops simultaneously with distinct row arrangement on the same field at the same time.
  - **Base crop:** primary crop which is planted/ sown at its optimum sole crop population in an intercropping situation.
  - **Intercrop :** This is a second crop planted in between rows of base crop with a view to obtain extra yields with intercrop without compromise in the main crop yields

Advantages of Intercropping

- Better use of growth resources including light, nutrients and water
- Suppression of weeds
- Yield & stability - even if one crop fails due to unforeseen situations, another crop will yield and provides some secured income
- Successful intercropping gives higher equivalent yields (yield of base crop + yield of intercrop), higher cropping intensity
- Reduced pest and disease incidences
- Improvement of soil health and agro-eco system

Examples of Inter cropping

- Ex: Maize + Cowpea 1:1
- Sorghum + Redgram 2:2
- Groundnut + Redgram 6:1
- Potato + Mustard 3:1
- Wheat + Mustard 8:1

Types of intercropping

- Strip intercropping
- Parellel cropping
- Synergistic cropping
  - Additive Series (Paired row intercropping)
  - Replacement Series
- Multi storey cropping
- Relay intercropping
- Alley cropping

Strip intercropping

- Growing of two or more crops simultaneously in strips wide enough to permit independent cultivation but narrow enough for the crops to interact each other.
- Ex:6 rows of groundnut and 4 rows of redgram in strips

Parellel cropping

- Growing of two crops simultaneously which have different growth habits and no competion among themselves
- Ex: Blackgram with maize
- Soybean with cotton

Synergestic Cropping

- Yields of both crops are higher than of their pure crops on unit area basis
- Ex: Sugarcane + Potato

Multi storey cropping

- Cultivation of more than two crops of different heights simultaneously on a piece of land in any certain period
  - Ex: Coconut + Pepper + cocoa + pineapple

Relay intercropping

- In a long duration base crop, growing two sets of intercrops one after another is called relay intercropping
  - Ex; Redgram – base crop 180 days
  - Groundnut/onion/coriander-I set of intercrops
  - Samai/ thenai/panivaragu- 2nd set of intercrops

Alley cropping

- Alley cropping is a system in which food crops are grown in alleys formed by hedge rows of trees or shrubs. The essential feature of the system is that hedge rows are cut back at planting and kept pruned during cropping to prevent shading and to reduce competition with food crops.
  - Ex: Subabul raised at 6 m row spacing
  - The space between two rows called alleys
  - The intercrops are raised in the alley space
  - E.g. cotton, sorghum, blackgram

Mixed cropping

- Growing of two or more crops simultaneously intermingled without row arrangement is known as mixed cropping
- It is a common practice in most of dryland tracts in India
- Seeds of different crops are mixed in certain proportion and are sown
- The objective is to meet the family requirement of cereals, pulses and vegetables, it is a subsistence farming
- Ex: Sorghum, Bajra and cowpea are mixed and broadcasted in rainfed conditions (with low rainfall situations) to avoid complete crop failures and with ascertaining the minimum yields

Difference between inter cropping and mixed cropping

Inter cropping	Mixed cropping
The main objective of inter cropping is to utilise the space between rows of main crop and to produce more grain per unit area	The main objective of mixed cropping is insurance against crop failure.
There is no competition between main and inter crop (subsidiary crop)	There is competition between component crops. Here all crops are given equal importance and care. Hence, there is no difference between component crops
In inter cropping, the main crop may be a long duration one and the inter crop may be a short duration/early maturing one	Crops may or may not be of same duration
Main and inter crops are sown in definite row arrangement	There is no specific row arrangement. Generally crop seeds are mixed and broadcasted
The sowing time of both the crops may or may not be the same. Sometimes the main crops is sown earlier than the inter crop	The sowing time of component crops is same.

FARMING SYSTEMS

Definitions

- Farm – is a piece of land with specific boundaries, where crop and livestock enterprises are taken up under common management
- Farming – is the process of harnessing solar energy in the form of economic plant and animal products
- System – a set of components which are interdependent and interacting

Wetland farming

- Wet land – soils flooded or irrigated through lake, pond or canal and land is always in submerged condition
- Wetland farming: is the practice of growing crops in soils flooded through natural flow of water for most part of the year

Garden land/ irrigated Dry land farming

- Garden land – soils irrigated with ground water sources
- Garden land farming: Growing crops with supplemental irrigation by lifting water from underground sources.

Dry land farming

- Dry land – soils purely depends rainfall for moisture
- Dryland farming: is the practice of crop production entirely depending upon rainfall and the moisture conserved in the soil
- This is practiced in areas where annual rainfall is less than 750mm.The crops may face moisture stress frequently due to erratic distribution or failure of monsoon

Rain fed farming

- Crop production in areas where rainfall is more than 750mm (i.e assured rainfall areas). Here moisture stress will be minimum. Soil conservation is given more importance

Mixed Farming

- Mixed farming is defined as a system of farming on a particular farm which includes crop production, raising live stock, poultry, fisheries, bee keeping etc. to sustain and satisfy as many needs of the farmer as possible. Subsistence is important objective of mixed farming. While higher profitability without altering ecological balance is important in farming system.

Advantages:

1. It offers highest return on farm business, as the byproducts of farm are properly utilized.
2. It provides work throughout year.
3. Efficient utilization of land, labour, equipment and other resources.
4. The crop by-products such as straw, fodder etc. is used for feeding of livestock and in return they provide milk.
5. Manures available from livestock to maintain soil fertility.
6. It helps in supplying all the food needs of the family members.

Specialized Farming

- The farm in which 50% or more income of total crop production is derived from a single crop is called specialized farming

Diversified Farming

- A diversified farming has several production enterprises or sources of income but no source of income equal as much as 50% of the total income. It is also called as general farming.

CROP ROTATION

- Growing of different crops on a piece of land is a preplanned succession. The principle of crop rotation is to utilise the available resources to the fullest extent in order to harvest the maximum in a unit land without affecting the soil health.
- Ex- Rice-Red Gram -Banana

Principles of crop rotation

- Leguminous crops should be grown before non-leguminous crops because legumes fix atmospheric N into the soil and add organic matter to the soil.
- Crops with tap roots (deep rooted like cotton) should be followed by those which have fibrous (shallow rooted crops like sorghum or maize) root system. This facilitates proper and uniform use of nutrients from the soil.
- More exhaustive crops should be followed by less exhaustive crops because crops like potato, sugarcane, maize etc. need more inputs such as better tillage, more fertilizers, greater number of irrigation etc.
- Selection of crop should be based on need or demand
- Crops of same family should not be grown in succession because they act as alternate hosts for insect pests and diseases
- The selection of crops should suit farmers financial conditions
- The crop selected should also suit to the soil and climatic condition

SUSTAINABLE AGRICULTURE

- It is a form of agriculture aimed at meeting the needs of the present generation without endangering the resource base of the future generations. It is considered as a system of cultivation with the use of manure, crop rotation and minimal tillage and with minimum dependence on synthetic fertilizers, pesticides and antibiotics. It is a balanced management system of renewable resources including soil, wildlife, forests, crops, fish, livestock, plant genetic resources and ecosystems without degradation and to provide food, livelihood for current and future generations maintaining or improving productivity and ecosystem services of these resources.
- Sustainable agriculture has to prevent land degradation and soil erosion. It has to replenish nutrients and control weeds, pests and diseases through biological and cultural methods.
- Degradation of natural resources is the main issue threatening sustainable development of agriculture.

ORGANIC FARMING

- Organic farming is a production system where all kinds of agricultural products are produced organically, including grains, meat, dairy, eggs, fibers such as cotton, flowers, and processed food products
- Organic farming avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators and livestock feed additives.

Components of organic farming

- It largely rely upon crop rotations, crop residues, animal manure, legumes, green manure, on/off farm organic wastes, mechanical cultivation, mineral bearing rocks and aspects of biological control of pests and diseases to maintain soil productivity and tilth to supply plant nutrients.

Scope

1. A sustainable agricultural system which maintains and improves soil fertility so as to guarantee for adequate food security in the future.
2. It relies upon resources from its own area which is not depended much on imported resources.
3. It helps in maintaining the stability of natural ecosystem

Concepts

1. Building up of biological soil fertility
2. Control of pests, diseases and weeds through development of an ecological balance within the system and by use of bioagents and various cultural techniques.
3. It recycles all wastes and manure within the farm.

- Eco-farming: Farming in relation to ecosystem.
- Biological farming: Farming in relation to biological diversity.
- Biodynamic farming: Farming which is biologically organic and ecologically sound and sustainable farming.

Organic farming –Components:

- The components of organic farming are
  - i) Organic manures
  - ii) Non- chemical weed control and
  - iii) Biological pest and disease management.

Principles:

- The three interrelated principles are
  - i) Mixed farming
  - ii) Crop rotation
  - iii) Organic cycle optimization

Eco-farming:

- It is the farming mutually reinforcing ecological approaches to food production. It aims at the maintenance of soil chemically, biologically and physically the way nature would do if left alone. Soil would then take proper care of plants growing on it. Feed the soil, not the plant is the watchword and slogan of ecological farming.

PERMACULTURE

- Bill Mollison, an Australian ecologist, and one of his students, David Holmgren, coined the word "permaculture" in 1978. It is a contraction of "permanent agriculture" or "permanent culture."
- It is defined as a design system for creating sustainable human environments. It uses ecology as the basis for designing integrated systems of food production, housing, appropriate technology, and community development.
- Permaculture is built upon an ethic of caring for the earth and interacting with the environment in mutually beneficial ways.
- A central theme in Permaculture is the design of ecological landscapes that produce food. Emphasis is placed on multi-use plants, cultural practices such as sheet mulching and trellising, and the integration of animals to recycle nutrients and graze weeds.

Characteristics

- It is one of the most holistic, integrated systems analysis and design methodologies found in the world.
- It can be applied to create productive ecosystems from the human- use standpoint or to help degraded ecosystems recover health and wildness.
- It can be applied in any ecosystem, no matter how degraded.
- It values and validates traditional knowledge and experience.
- Incorporates sustainable agriculture practices and land management techniques and strategies from around the world
- It is a bridge between traditional cultures and emergent earth-tuned cultures.
- It promotes organic agriculture, which does not use pesticides.
- It aims to maximize symbiotic and synergistic relationships between site components.
- It's design is site specific, client specific, and culture specific

INTEGRATED FARMING SYSTEM

- Integration of farm enterprises such as cropping systems, animal husbandry, fisheries, forestry etc. for optimal utilisation of resources bringing prosperity to the farmer. According to the availability of land, type of land, water, capital, resources, technical skill of the farmer, market facilities etc., and the components of farming system are to be chosen and adopted for better results.

Benefits of Integrated Farming System

- Steady income other than income from regular cropping
- Risk coverage due to subsidiary allocation in the event of unexpected crop failures
- Employment opportunity
- Higher productivity
- Augmented returns and recycling of organics
- Easily adopted by marginal and submarginal farmers
- General uplift of farm activities
- Better utilisation of land, labour, time and available manures in the farm.

ELEMENTS REQUIRED IN PLANT GROWTH

1. **Macronutrients:**

➢ Based on the relative abundance in plants, viz., Nitrogen (N); Phosphorous (P), Potassium (K), Sulfur (S), Calcium (Ca) and Magnesium (Mg)

2. **Micronutrients:**

➢ Their concentration is very small. They are also referred to as minor elements.

➢ Iron (Fe); Zinc (Zn); Manganese (Mg),Copper (Cu),Boron (B), Chlorine (Cl) and Molybdenum (Mo) .In some plants, other than the above, Sodium (Na), Cobalt (Co), Vanadium (Va), Nickel (Ni) and Silicon (Si) are considered as essential micronutrients

Nitrogen (N)

a] N is an essential constituent of proteins and is present in many other compounds of great physiological importance in plant metabolism

b] N is an integral part of chlorophyll, which is primary observer of light energy needed for photosynthesis.

c] N also imparts vigorous vegetative growth and dark green colour to plants.

➢ Phosphorus (P) is an essential part of the enzymes which help the crop to fix light energy. It forms an integral part of nucleic acids, the carriers of genetic information, and is important in stimulating root growth

➢ Potassium (K) is involved in processes which ensure carbon assimilation and the transportation of photosynthates throughout the plant for growth and the storage of sugars and proteins. The potassium ion is also important for water regulation and uptake. Furthermore, the presence of potassium in sufficient amounts ensures resistance to frost, drought and certain diseases

➢ Magnesium occurs in chlorophyll and is also an activator of enzymes,

➢ Sulphur forms part of two essential amino acids which are among the many building blocks of protein. It is also found in vitamin B1 and in several important enzymes.

➢ Calcium is required for plant growth, cell division and enlargement. The growth of root and shoot tips and storage organs is also affected by calcium as it is a component of cell membranes. Calcium is also vital for pollen growth and to prevent leaf fall

MANURES

➢ Manures are plant and animal wastes that are used as source of plant nutrients They release nutrients after their decomposition .Manures can be grouped into bulky organic manures and concentrated organic manures

Fertilizers

➢ Fertilizers are industrially manufactured chemical containing plant nutrients Nutrient content is higher in fertilizers than organic manures and nutrients are released almost immediately

Role of manures

1. Organic manures bind the sandy soil and improve its water holding capacity.
2. They open the clayey soil and help in aeration better root growth.
3. They add plant nutrients in small percentage and also add micro nutrients which are essential for plant growth the microbial activity is increased which helps in releasing plant nutrients in available for e.g. bulky organic manures- FYM, compost from organic waste, night soil, sludge, sewage, sheep folding, green manures, concentrated organic manures- oilcakes (edible, non-edible), blood meal, fish meal, bone meal.
4. Organic manures should be incorporated before the sowing or planting because of slow release of nutrients

Classification of Organic manures

Farm Yard Manure

➢ This is the traditional manure and is mostly readily available to the farmers. Farm yard manure is a decomposed mixture of Cattle dung and urine with straw and litter used as bedding material and residues from the fodder fed to the cattle..

Compost Manure

➢ Compost is well rotted organic manure prepared by decomposition of organic matter. Composting is largely a biological process in which micro-organisms of both types, aerobic (require oxygen for deep development) and anaerobic (functions in absence of air or free oxygen), decompose the

organic matter and lower down the C:N ratio of refuse. The final product of composting is well rotted manure known as compost

Sheep and Goat droppings

- It is also valuable organic manure. It contains about 0.5 to 0.7 % N, 0.4 to 0.6% P2O5 and 0.3 –1.0% K2O. It is effective to all types of crops

Concentrated organic manures

Oil cakes

- There are many varieties of oil cakes which contains not only nitrogen but also some P and K along with large percentage of organic matter. These oil cakes are of two types.
  i. Edible oil cakes- suitable for feeding cattle.
  ii. Non-edible oil cakes-not suitable for feeding cattle.
- Oil cakes are quick acting organic manure. Though they are insoluble in water, their nitrogen became quickly available to plants in about a week or in 10 days after application.

Bone Meal

- Bones from slaughter houses, carcasses of all animals and from meat industry constitute bone meal, which is the oldest phosphatic fertilizer used. It also contains some N.

Fish meal

- Fish manure or meal is processed by drying non-edible fish, carcasses of fish and wastes from fish industry. It contains 4.0-10.0 % nitrogen, 3.0-9.0 % P and 0.3 to 1.5 % K. Fishmeal is quick acting organic manure and is suitable for application to all crops on all soils.

Green Manuring

- It is a practice of ploughing in the green plant grown in the field or adding green plants from outside and incorporating them into the soil for improving the physical structure as well as fertility of the soil. E.g.: Sannhemp, Dhaicha, Pillipesara, Shervi, Urd, Mung, Cowpea, Berseem, Senji, etc.

Green leaf Manuring

- Green leaf manuring refers to adding the green leaf and green twigs from legume plants or trees to a field and then incorporating them into the soil by ploughing. E.g.: Glyricidia, wild Dhaicha, Karanj (pongamia), leucaena.

Bio-fertilizers

- Bio-fertilizers are the preparations containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolyotic micro-organisms used for application to seed or composting areas with the objective of increasing the numbers of such micro-organisms and accelerating those microbial processes which augment the availability of nutrients that can be easily assimilated by plants. Bio-fertilizers harness atmospheric nitrogen with the help of specialized micro-organisms which may be free living in soil or symbiotic with plants.

Nitrogen fixers

1. Symbiotic: - Rhizobium, inoculants for legumes.
2. Non-symbiotic: - For cereals, millets and vegetables.

a) Bacteria:-
   i) Aerobic:-Azatobacter, Azomonas, Azospirillum.
   ii) Anaerobic:- Closteridium, chlorobium
   iii) Facultative anaerobes- Bacillus, Eisherichia

b) Blue green algae- Anabaena, Anabaenopsis, Nostoe
   A. Phosphate solubilizing micro-organisms.
   B. Cellulolytic and lignolytic micro organisms.
   C. Sulphur dissolving bacteria.
   D. Azolla.

Integrated Nutrient Management (INM)

- Judicious combination of organic, inorganic and biofertilizers which replenishes the soil nutrients which are removed by the crops is referred as Integrated Nutrient Management system
- To sustain the productivity of different crops and cropping systems, efficient nutrient management is vital. There is a need to develop more efficient, economic and integrated system of nutrient management for realizing high crop productivity without diminishing soil fertility

WEEDS

- Weeds are unwanted and undesirable plant that interfere with utilization of land and water resources and thus adversely affect crop production and human welfare
- They are gregarious in nature compared to crop plants.

Harmful effects of weeds

1. Weeds compete with main crop for space, light, moistire and soil nutrients thus causing reduction in yield.
2. Affect quality of farm produce, livestock products such as milk and skin
3. Act as alternate host for pests and pathogens
4. Cause health problems to human beings eg; Parthenium causes allergy
5. Increase cost of cultivation due to weeding problem
6. Aquatic weeds transpire large quantity of water, obstruct flow of water
7. Reduce the land value (if cynodon, parthenium are present in the land)
8. Some weeds are poisonous to livestock.

Beneficial effects of weeds

1. Weed as soil binders
2. as manure
3. as human food
4. as fodder
5. Weed as fuel
6. Weed as mats and screens
7. Weed as medicine: Many weeds have great therapeutic properties and used as medicine. Eg.

Phyllanthus niruri	– Jaundice
Eclipta alba	– Scorpion sting
Centella asiatica	– Improves memory
Cynodon dactylon	– Asthma, piles
Cyperus rotundus	– Stimulates milk secretion

8. Weed as indicators: Weeds are useful as indicators of good and bad soils. Colonum occurs in rich soils while Cymbopogon denotes poor light soil and Sedges are found in ill-drained soils

➢ Genetically modified crops (GM crops, or biotech crops) are plants, the DNA of which has been modified using genetic engineering techniques, which are then used in agriculture.

Watershed Management

➢ A watershed is an area of land and water bounded by a drainage divide within which the surface runoff collects and flows out of the watershed through a single outlet into a lager river (or) lake.

Micro Irrigation

➢ Micro irrigation is defined as the methods in which low volume of water is applied at low pressure & high frequency. The system has extensive network of pipes at operated at low pressure. At pre-determined spacing outlets are provided for emission water generally known as emitters.

Sprinkler Irrigation

➢ In the sprinkler method of irrigation, water is sprayed into the air and allowed to fall on the ground surface somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small orifices or nozzles.

Drip irrigation:

➢ Drip irrigation is also called trickle irrigation and involves dripping water onto the soil at very low rates from a system of small diameter plastic pipes fitted with outlets called emitters.

➢ Water is applied close to plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile.

Terracing:

➢ "A terrace is an embankment or ridge of earth constructed across a slope to control runoff and minimize soil erosion".

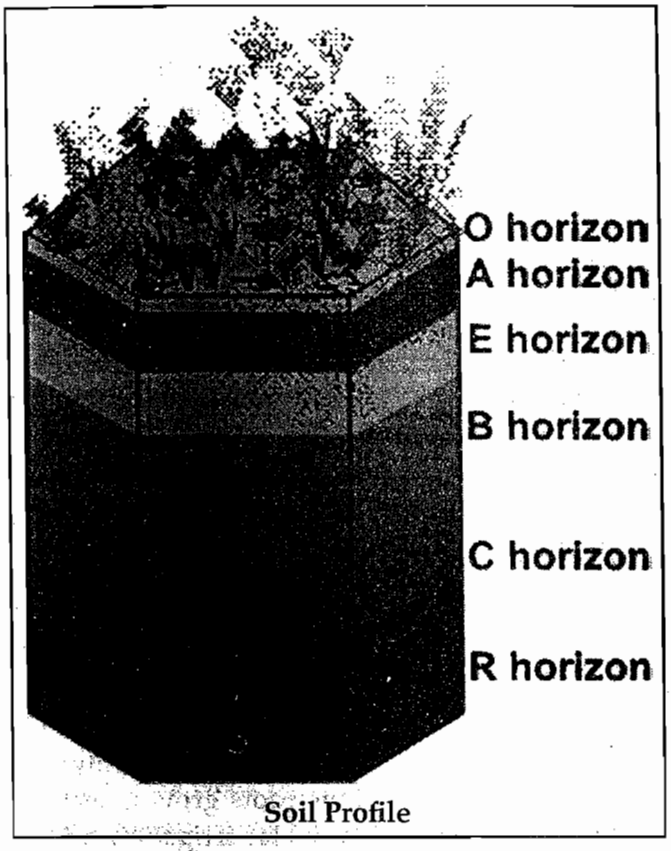
➢ It reduces the length of the hill side slope, thereby reducing sheet and rill erosion and prevents formation of gullies.

SOIL

➢ Soil is a natural body of mineral and organic constituents differentiated into horizons usually unconsolidated, of variable depth which differs among themselves as well as from the underlying parent material in morphology, physical makeup, chemical properties and composition and biological characteristics.

➢ Soil profile: The vertical section of the soil showing the various layers from the surface to the unaffected parent material is known as a soil profile. The various layers are known as horizons.

➢ There are 5 master horizons in the soil profile. Not all soil profiles contain all 5 horizons; and so, soil profiles differ from one location to another.



Soil Profile

- The 5 master horizons are represented by the letters: O, A, E, B, and C.
- **O:** The O horizon is a surface horizon that is comprised of organic material at various stages of decomposition. It is most prominent in forested areas where there is the accumulation of debris fallen from trees.
- **A:** The A horizon is a surface horizon that largely consists of minerals (sand, silt, and clay) and with appreciable amounts of organic matter. This horizon is predominantly the surface layer of many soils in grasslands and agricultural lands.
- **E:** The E horizon is a subsurface horizon that has been heavily leached. Leaching is the process in which soluble nutrients are lost from the soil due to precipitation or irrigation. The horizon is typically light in color. It is generally found beneath the O horizon.
- **B:** The B horizon is a subsurface horizon that has accumulated from the layer(s) above. It is a site of deposition of certain minerals that have leached from the layer(s) above.
- **C:** The C horizon is a subsurface horizon. It is the least weathered horizon. Also known as the saprolite, it is unconsolidated, loose parent material.
- **R:** Unweathered rock exists below the parent material.
- **Soil texture** refers to the relative proportion of particles or it is the relative percentage by weight of the three soil separates viz., sand, silt and clay or simply refers to the size of soil particles.
- **Loam :** A type of soil texture with good water holding capacity and drainage suitable for cultivation of variety of crops.
- **Soil structure:** The arrangement and organization of primary and secondary particles in a soil mass is known as soil structure.

Saline soils

- Saline soils are characterised by higher amount of water soluble salt, due to which the crop growth is affected.

Sodic soils

- Sodic soils are characterised by the predominance of sodium in the complex with the exchangeable sodium percentage exceeding 15 per cent and the pH more than 8.5.

Acid soils

- Acid soils are characteristically low in pH (<6.0). Predominance of H+ and Al3+ cause acidity resulting in deficiency of P, K, Ca, Mg, Mo and B.

Sandy soils

- Sandy soils are containing predominant amounts of sand resulting in higher percolation rates and nutrient losses.
- Alkaline soil: A soil with pH above 7, usually above 8.5 are considered alkaline. Alkaline soils often occur in arid regions that receive less than 25 inches of rain per year.
- Calcariuos soil- Soils with kankar nodules in the plough zone and subsoil.
- Alfisol: Soils with grey to brown surface horizons, medium to high supply of bases and B horizons of illuvial clay accumulation. These soils formed mostly under forest or savanna vegetation in climates with slight to pronounced seasonal moisture deficit.
- Aridisol: Minerals soils that have an aridic moisture regime. These are desert soil.

Podzolization:

- It is a process of soil formation resulting in the formation of Podzols and Podzolic soils.

- podzolization is the negative of calcification. The calcification process tends to concentrate calcium in the lower part of the B horizon, whereas podzolization leaches the entire solum of calcium carbonates.
- The other bases along with calcium are also removed and the whole soil becomes distinctly acidic. In fact, the process is essentially one of the processes of acid leaching.

Laterization:

- The term laterite is derived from the word later meaning brick or tile and was originally applied to a group of high clay Indian soils found in Malabar hills of Kerala, Tamil Nadu, Karnataka and Maharashtra.
- It refers specifically to a particular cemented horizon in certain soils which when dried, become very hard, like a brick.
- Laterization is the process that removes silica, instead of sesquioxides from the upper layers and thereby leaving sesquioxides to concentrate in the solum.

Gleization:

- It is a process of soil formation resulting in the development of a glei (or gley horizon) in the lower part of the soil profile above the parent material due to poor drainage condition (lack of oxygen) and where waterlogged conditions prevail. Such soils are called hydro orphic soils.

Salinization:

- It is the process of accumulation of salts, such as sulphates and chlorides of calcium, magnesium, sodium and potassium, in soils in the form of a salty (salic) horizon.
- It is quite common in arid and semi arid regions.
- It may also take place through capillary rise of saline ground water and by inundation with seawater in marine and coastal soils.
- Salt accumulation may also result from irrigation or seepage in areas of impeded drainage.

Desalinization:

- It is the removal of excess soluble salts by leaching from horizons or soil profile (that contained enough soluble salts to impair the plant growth) by ponding water and improving the drainage conditions by installing artificial drainage network.

Solonization or Alkalization:

- The process involves the accumulation of sodium ions on the exchange complex of the clay, resulting in the formation of sodic soils (Solonetz).
- All cations in solution are engaged in a reversible reaction with the exchange sites on the clay and organic matter particles.

Solodization or dealkalization:

- The process refers to the removal of Na^+ from the exchange sites. This process involves dispersion of clay. Dispersion occurs when Na^+ ions become hydrated.
- Much of the dispersion can be eliminated if Ca^{++} and or Mg^{++} ions are concentrated in the water, which is used to leach the soonest. These Ca and Mg ion can replace the Na on exchange complex, and the salts of sodium are leached out.

STAGES OF SOIL EROSION

Splash erosion

- Splash erosion is the first stage of the erosion process. It occurs when raindrops hit bare soil. The explosive impact breaks up soil aggregates so that individual soil particles are 'splashed' onto the soil surface.

Sheet erosion

- Sheet erosion refers to the uniform movement of a thin layer of soil across an expanse of land devoid of vegetative cover. Raindrops detach soil particles, which go into solution as runoff occurs and are transported downstream to a point of deposition.

Rill erosion

- When sheet flows begin to concentrate on the land surface, rill erosion occurs. While sheet erosion is generally invisible, rill erosion leaves visible scouring on the landscape. This type of erosion occurs when the duration or intensity of rain increases and runoff volumes accelerate.

Gully erosion

- Rill erosion evolves into gully erosion as duration or intensity of rain continues to increase and runoff volumes continue to accelerate. A gully is generally defined as a scoured out area that is not crossable with tillage or grading equipment.

- **Ammonification:** Production of ammonia as a result of the biological decomposition of organic nitrogen compounds.
- **Border cropping:** is growing of crops on the border areas of the plot or field
- Ex; Safflower as border crop in potato
- **Border strip irrigation:** It is an efficient method of irrigation close growing crops. In this method the field is divided by low flat levels into series of strips, each of which is flooded separately.
- **Allelopathy:** is defined as direct or indirect harmful effect of one plant over the other crop species through the exudation of toxic substances from the roots or the decomposition of crop residues
- **C:N ratio:** The ratio of the weight of organic C to the weight of total N in the soil.
- **Check basin:** It is a method of irrigation with beds and channel for retaining water to form a pond
- **Heaving:** Injury to plants caused by lifting upward of the plant along with soil from it's normal position in temperate regions where snowfall is common
- **Contour farming:** is the farming practice of ploughing across a slope following its elevation contour lines.
- **Cover crops:** crops which are grown to cover the soil in order to reduce the loss of the moisture from the soil due to leaching and erosion.
- **Critical stage of irrigation:** the period or the stage of development of lifecycle of the crop when it is most sensitive to moisture stress, results in yield loss
- **Hard pan :** It is a hard and impermeable layer formed in the soil profile by accumulation of materials such as salts, clay etc which impedes drainage
- **Growth regulators:** Organic substances which in minute amount may participate in the control of growth processes Ex :Auxins, Cytokinins
- **Heliophytes :** Plants of sun loving species, require intense light for normal development Ex: Rice, Wheat, Cotton, Sugarcane
- **Sciophytes :** Plants which are shade loving and require less light intensity
- **Heliotropism :** It is the movement of the plant parts towards the sun Ex: Sunflower
- **Geotropism:** A growth movement in response to gravity. Eg Groundnut peg penetration into the soil
- **Herbicide :** A chemical used for killing or inhibiting the growth of unwanted plants Ex: Atrazine
- **Insecticide :** It is the chemical used for killing the insects : Endosulfan
- **Hidden hunger :** Is the condition where plants do not exhibit visual symptoms of deficiency for the short supply of particular nutrients but will result in yield losses
- **Humus :** A brown or black organic substance consisting of partially or wholly decayed vegetable or animal matter that provides nutrients for plants and increases the ability of soil to retain water
- **Mulching :** Practice of covering the soil surface with materials like plant residues, straw, leaves or plastic film to reduce evaporation, restrict weed growth and maintain the soil temperature
- **Puddling :** It is the ploughing operation carried out in stagnated water conditions to create an impervious layer below the plough pan
- **Shifting cultivation :** It is the old practice of cutting and clearing of forest for cultivating crops for a certain period of time as long as the soils having fertility
- **Subsidiary farming :** Settled Farming in river banks and streams in addition to gathering & hunting
- **Subsistence farming :** Raising the crops only for family needs and not for commercial : "Grow it and eat it"

System of Rice Intensification (SRI)

- System of Rice Intensification (SRI) emerged in the 1980's as a synthesis of locally advantageous rice production practices encountered in Madagascar by Fr Henri de Laulanie
- SRI is a combination of several practices those include changes in nursery management, time of transplanting, water and weed management. It emphasizes altering of certain agronomic practices of the conventional way of rice cultivation. All these new practices are together known as System of Rice Intensification (SRI).
- Principle - 'More with Less'

- SRI is not a fixed package of technical specifications, but a system of production with four main components, viz., soil fertility management, planting method, weed control and water (irrigation) management. Rice yield increased with less water and with reduction in chemical inputs.

Sustainable Sugarcane Initiative (SSI)

- Sustainable Sugarcane Initiative (SSI) is an innovative set of agronomic practices that involves using less seeds, raising seeds in a nursery, and following new planting methods, with wider seed spacing, and better water and nutrient management to increase the cane yields significantly.
- SSI methods can increase sugarcane yields by at least 20% with 30% less water and a 25% reduction in chemical inputs.
- The SSI method of sugarcane cultivation was evolved from the principles of 'More with Less' followed in SRI (System of Rice Intensification) and introduced in India by the WWF-ICRISAT collaborative project in 2009.