CHAPTER 24 AGRICULTURE

24.1 CROPPING PATTERN IN INDIA

Cropping systems: It is defined as the order in which the crops are grown or cultivated on a piece of land over fixed period.

Cropping Pattern: The yearly sequence and spatial arrangement of crops on a same piece of land over a same period of time

Classification/Types of cropping systems:

1) Monoculture
2) Multiple cropping (Intensive Cropping systems)
   - ✓ Parallel Multiple cropping
     a. Mixed cropping
     b. Intercropping
     c. Relay cropping
     d. Alley cropping
     e. Multistroyed cropping
   - ✓ Sequential Multiple cropping
     a. Sequential cropping
        i. Double cropping
        ii. Triple cropping
        iii. Quadruple cropping
     b. Ratoon cropping/Ratooing
3) Following or Fallow in rotation

Monoculture/Monocropping:

1) The cropping system in which only one major crop is grown on the same land year after year.
2) Repetitive growing of only one crop on same piece of land year after year.
3) It may be due to climatological and socioeconomic conditions or due to specialization of a farmer in growing a particular crop
4) Example: under rain-fed conditions, groundnut or cotton or sorghum are grown year after year due to limitation of rainfall.
5) Example: In canal irrigated areas, under waterlogged condition, rice crop is grown as it is not possible to grow any other

Season 1 Season 2 Season 3

Fig: Multiple Cropping

Advantages of monoculture/mono-cropping:

1) Convenience in sowing with the help of machinery under mechanized farming
2) It is convenient for harvesting with the help of machinery

Disadvantages:-

1) Sometimes fertility and productivity of the soil are lowered if suitable soil management practices are not followed.
2) Soil structure may be deteriorated.
3) Increase infestation of pests, diseases and weeds

Multiple Cropping (Intensive Cropping System)

1) Growing two or more crops on the same piece of land in one calendar year is known as multiple-cropping.
2) It is intensification of cropping in time and space dimensions, i.e., more number of crops within a year and more number of crops on the same piece of land at any given period.
3) It includes intercropping, mixed-cropping and sequence cropping.

Mixed-cropping:

1) Mixed-cropping is growing of two or more crops simultaneously intermingled without any row pattern.
2) It is a common practice in most of dryland tracts of India.
3) Seeds of different crops are mixed in certain proportion and are sown.
4) The objective is to meet the family requirement of cereals, pulses and vegetables
5) Examples:
    a. Maize + Green gram + Pigeon pea
    b. Sorghum + Groundnut + Pigeon pea
6) Mixed cropping is common practice in rainfed or dry farming areas.
7) Usually, cereals are grown as main crop and pulses or oilseeds as minor or mixed crop

Advantages of mixed cropping:

1) Risk of failure of crop is less
2) Fulfils the daily requirements of food grains, oilseeds, pulses etc.
3) Improve fertility of the soil if legumes are taken as minor crop
4) Better distribution of labour throughout the crop period
5) Increase gross monetary returns
6) Well balanced cattle feed is obtained
7) Safeguards against pests and diseases
8) Full utilization of space and available plant nutrients

Disadvantages:-

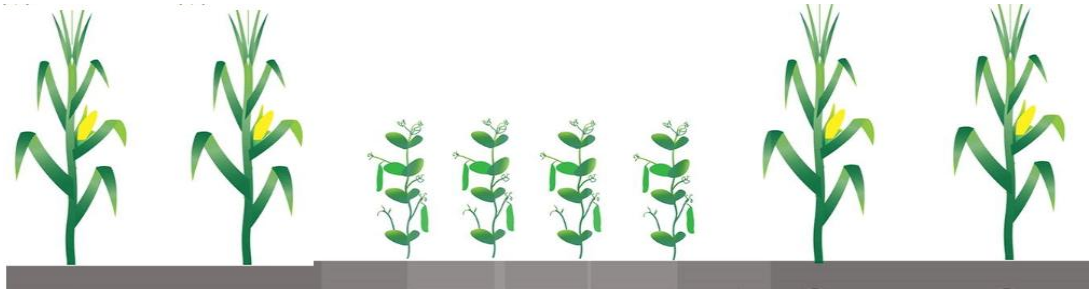
1) Sometimes control of pests, diseases and weeds become difficult
2) Sometimes affects the yield of main crop
3) Harvesting with the help of machinery is not possible

Inter-cropping:

1) Inter-cropping is growing of two or more crops simultaneously on the same piece of land with a definite row pattern.
2) For example, growing setaria and redgram in 5:1 ratio.
3) Thus, cropping intensity in space dimension is achieved.
4) Inter-cropping was originally practiced as an insurance against crop failure under rainfed conditions.
5) At present, the main objective of inter-cropping is higher productivity per unit area in addition to stability in production.
6) Intercropping system utilizes resources efficiently and their productivity is increased

For successful inter-cropping, there are certain important requirements:

1) The time of peak nutrient demands of component crops should not overlap.
2) Competition for light should be minimum among the component crops.
3) Complementarity should exist between the component crops.
4) The differences in maturity of component crops should be at least 30 days



Advantages of intercropping system:

1) It should help to Improves the soil fertility and soil productivity.
2) Maintaining the higher crop yield.
3) Better utilization of available resources.
4) It should resist the soil erosion.
5) Reduces the incidence of insect pest, disease and weeds.
6) Improves the soil structure and water holding capacity of soil.

Disadvantages:

1) Harvesting with the help of machinery is difficult.
2) Intercultural operations are not possible.
3) Competition among the resources is more.
4) Harvesting makes a time consuming/difficult.
5) Weed control is not possible.
6) Water requirement is more

Types of Inter-cropping:-

a) Parallel Cropping: Cultivation of such crops which have different natural habit and zero competition is called as parallel cropping. e.g. black gram/green gram + Maize.
b) Companion cropping: System in which production of both intercrops is equal to that of its solid planting is called as companion cropping. e.g. Mustard/Potato/Onion + Sugarcane.
c) Mixed Intercropping: Growing of two or more crops with no distinct row arrangement is called as mixed intercropping.

Difference between Intercrops and Mixed crops:

Intercropping	Mixed cropping
1. The main object is to utilize the space left between two rows of main crop especially during early growth period of main crop. 2. More emphasis is given to the main crop and the subsidiary crops are not grown at the cost of the main crop. Thus there is no competition between main and subsidiary crops. 3. Subsidiary crops are of short duration and they are harvested much earlier than the main crop. 4. Both the crops are sown in rows. The sowing time may be the same or the main crop is sown earlier than the subsidiary crops.	1. The main object is to get at least one crop under any climatic hazard e.g. flood, drought or frost conditions. 2. Here all crops are given equal and there is no main or subsidiary crop. Almost all the crops compete with one another. 3. The crops are almost of the same duration. 4. The crops may be broadcasted or sown in rows but the sowing time for all the crops is the same.

Relay cropping:

1) It is the cropping system in which succeeding crop (next crop) is or sown or planted when the first crop (preceding crop) has reached its physiological maturity stage or before it is ready to harvest is called as relay cropping.
2) Example Rice/Linseed/lentil/black gram/chickpea.

Advantages of relay cropping:

a) Better utilization of residual moisture and fertilizers.
b) Reduces the cost of cultivation practices.
c) Also reduces the cost of fertilizers and irrigation.
d) Labour requirement is less.
e) Incidence of pest, diseases and weeds is less due to early sowing operation.

Disadvantages:-

a) Risk of crop failure is more.
b) Harvesting by means machinery is difficult.
c) Lack of availability of skilled labour.
d) Greater incidence of pest, disease and weeds.

Alley cropping:

a) The system of growing jowar, maize, bajra or any other arable crop in the alleys (passage between two rows) of leguminous shrubs like subabul (Leucaena leucacephala) is called as alley cropping.
b) Growing of maize, jowar, cowpea in between rows of subabul planted at 5-10 m spacing, this system is useful for conservation of moisture and maintaining fertility of soil in dry farming areas.
c) The loppings of the subabul are used as green fodder for animals or spread in between the crop rows as mulch for conservation of soil moisture and after delaying it adds organic matter to the soil.

Advantages of alley cropping:

a) Better utilization of natural resources.
b) Reduces the cost of cultivation.
c) Improves the soil fertility and productivity.
d) Provides fodder for animals and food for human.

Disadvantages:

a) Competition among the natural resources i.e moisture, nutrients, light and space.
b) Incidence of pest, diseases and weeds is more.
c) Chances of crop failure is more.
d) Less yield is obtained.

Multistoreyed cropping:

a) In this system the crops of different height and vertical layers of leaf canopies, sunlight requirements and root system are grown together on the same field is called as multistoreyed cropping.
b) Generally, the shorter crops favouring shade and humidity are grown in passage between the rows of taller crops, which are tolerant to strong sunlight.
c) Example Growing of pineapple, sweet potato, black pepper, tapioca, turmeric, ginger etc. in coconut or arecanut.

Advantages of Multistoreyed cropping:

a) Better utilization of moisture and nutrients in different soil layers.
b) Better utilization of sunlight and space.
c) Provides a balanced food for humans.
d) Enrichment of organic matter or plant residues in soil.
e) Improve the water holding capacity of soil

Disadvantages:

a) Competition among the natural resources.
b) More area is required.
c) Lack of labour availability
d) Incidence of pest, disease and weeds is more.

Sequential multiple cropping:- It is the multiple cropping system in which two or more crops are grown in sequence on the same piece of land in a year or over a fixed period.

Sequence cropping:- In this cropping system two or more crops are grown in sequence one after another on the same piece of land in a year.

Double cropping:- It is multiple cropping system in which two crops are grown in sequence on the same piece of land in a year. e.g. Black gram-Jowar, Black gram - Wheat, Rice-Gram, Groundnut-Wheat etc.

Triple cropping:- It is the multiple cropping system in which three crops are grown in sequence on a same land in a year. It is possible when irrigation facilities are available throughout the year. e.g. G.nut-Wheat-Okra, Rice-Wheat-G.nut, Jowar-Potato-Green gram, SoybeanWheat-G.nut etc.

Quadruple cropping:- It is the multiple cropping system in which four crops are grown in a sequence on the same land in a year. It is possible under irrigated conditions throughout the year. e.g. G.nut-CorianderWheat-Green gram, Soybean-Methi-Wheat-Green gram etc.

Ratoon cropping or Ratooning:

a) The cultivation of crop regrowth after harvest is known as rotoon cropping.
b) Ratooning is one of the important systems of intensive cropping, which implies more than one harvest from one sowing/planting because of regrowth from the basal buds on the stem after harvest of first crop.
c) Thus ratooning consists of allowing the stubbles of the original crop to strike again or to produce the tillers after harvesting and to raise another crop.
d) Example: Ratooning of Sugarcane, Hybrid Jowar, Hybrid Bajra, and Redgram etc.

Advantages of multiple cropping:-

1. It increases the total production and gross monetary returns from the unit area in a year.
2. Fullfills various needs of food grains, pulses, oilseeds, vegetables, fodder etc.
3. Facilitates even distribution of labour throughout the year.
4. Better utilization of land, labour, power and other resources on the farm.

Disadvantages of multiple cropping:-

1. Fertility and productivity of the soil is lowered or exhausted if proper soil management practices are allowed.
2. Sometimes if affects the structure of the soil due to continuous cropping and irrigation.
3. Sometimes control of pests, diseases and weeds becomes difficult

INTEGRATED FARMING SYSTEM:

Integrated farming system is a holistic method of combining several enterprises like cropping system, diarying, piggery, poultry, fishery, bee-keeping, etc. in a harmonious way so as to complement each other. The objective is efficient resource utilisation and maximization of profit in such a way so as to cause least damage to soil and environment

Why the cropping pattern changes?

Both climatic factors and resources of the farmers determine the cropping pattern on a farm. Though climate plays most vital part in crop selection, the area under crop is also influenced by economic considerations of the farmer, namely irrigation water, cost of inputs and prices of the products. In any locality, the prevalent cropping system is the cumulative results of past and present decisions by individuals, communities Irrigation in India or government or their agencies. A basic requisite for higher cropping intensity is the availability of water either through precipitation or through irrigation. It is being increasingly realized that the land and water resources are not unlimited and the wise use of the same is

imperative. This is especially so for the countries like India where the population pressure is continuously increasing

The cropping pattern is influenced by:

1. Traditional social practices and dietary habits
2. The crops with practicable pest and disease control method and suitability with ecological environment.
3. The crops which are most profitable (or are high-yielding)
4. The combination of crops that result in profit maximization and cost minimization

Cropping pattern in India:

Three important features mark the cropping pattern of India:

1. Predominance of food grains crops,
2. Slight shift towards commercial crops, and
3. Noticeable increase in some individual crops.

The major pattern follows two distinct groups:

1. Kharif (monsoon crops) and
2. Rabi (post-monsoon crops).

The kharif crop includes rice, sorghum, bajra, maize, ragi, groundnut, cotton, etc. The crop occupying the highest percentage of the sown area of the region is taken as the base crop. All other possible alternative crops which are sown in the region either as substitute for the base crop in the same season or as the crops which fit in with the rotation in the subsequent season, are considered as the pattern

The Kharif Season Cropping Patterns

Rice-based cropping pattern

1. Rice is the best crop in this category and 9% of the area in India comes under rice-based cropping pattern.
2. Nearly 45% of the total rice area in India receives 30 cm per month of rainfall during at least two months (July-August) of the south western monsoon and much less during other months.
3. In contrast to these parts, the eastern and southern regions, comprising Assam, West Bengal, Coastal Orissa, Coastal Andhra Pradesh, Karnataka, Tamil Nadu and Kerala which receive 10-20 cm per month, also come under this cropping pattern.
4. On the all India basis, about 30 rice-based cropping pattern have been identified in different states.

Kharif cereals other than the rice-based cropping pattern

i) Maize, jowar, bajra form the main kharif cereals, Ragi and small millets come next, these are grown in limited area.

ii) Maize is grown in high rainfall areas, jowar in medium rainfall areas and Bajra in low rainfall areas.

iii) Ragi is a kharif cereal (2.4mha) and is mainly concentrated in Karnataka, Tamil Nadu and Andha Pradesh. These states account for more than 60% of the total area under this crop.

Kharif jowar-based cropping pattern

1. The area under the kharif jowar in India is highest in Maharashtra (2.5 mha), closely followed by Madhya Pradesh (2.3 mha).
2. In each of the states of Rajasthan, Andhra Pradesh, Karnataka and Gujarat, the area under this crop is between 1 and 1.4 mha.
3. Jowar is mainly grown in areas having rainfall range from 10 to 20 cm per month, least for 3 to 4 months of the southeastern monsoon.
4. On the all India basis, 17 major cropping patterns have been identified under this category.

Bajra-based cropping pattern: The area under bajra crop is about 12.4 mha.

1. Rajasthan has about two-third of the total area. Maharashtra, Gujarat and Uttar Pradesh together have over 4.6 mha, constituting the remaining one-third area under the bajra crop.
2. On all India basis 20 major cropping patterns have been identified with bajra as base crop.

Groundnut-based cropping pattern:

1. Groundnut is sown over an area of about 7.2 mha , mostly in five major groundnut producing states : Gujarat (24.4%) area, Andhra Pradesh, (20.2%), Tamil Nadu (35.5%), Maharashtra (12.2%) and Karnataka (12%)

Cotton-based cropping pattern:

2. Cotton is grown over 7.6 mha in India. Maharashtra shares 36%(2.8mha), followed by Gujarat with 21% (1.6 mha), Karnataka with 13% (1mha) and Madhya Pradesh with 9%(.6mha) of the area.
3. Together these four states account for about 80% of area under cotton

Rabi-season Cropping Patterns

The major cropping patterns prevalent in India during the rabi season are:

i) wheat and gram based cropping pattern, and
ii) jowar-based cropping pattern.

a) Wheat and gram based cropping patterns

These two crops are grown under identical climate and can often be substituted for each other. On the all-India level, about 19 cropping patterns have been identified with wheat and 7 cropping patterns with gram. The core of the wheat region responsible for 70 per cent of the area and 76 per cent of production comprises Punjab, Haryana, Uttar Pradesh, Madhya Pradesh flanked by Rajasthan and Gujarat in the Western region and Bihar and West Bengal in the Eastern region.

b) Rabi-Jowar based cropping patterns

On the all-India level, about 13 cropping patterns have been identified with the rabi jowar. Maharashtra has the largest number of these cropping patterns, wherein starting with the exclusive rabi jowar, bajra, pulses, oilseeds and tobacco are grown as alternative crops.

Factors Affecting Cropping Pattern

The cropping pattern is highly influenced by personal, social, cultural and economic factors of the farmers. Apart from that, it is also affected by the climatic factors of a region.

The major factors are:

i) Size of the Land Holding: In India, marginal and small farmers represent the majority of farming community. So the mono crop paddy has become predominate as it fulfils the household needs and perpetuates the subsistence agriculture with little scope for commercial crop husbandry.
ii) Literacy: Majority of the farmers are ignorant of the scientific methods involved in mixed cropping, mono cropping and other technological knowhow for practicing better cropping pattern.
iii) Disease and Pest: The cropping pattern also depends on the possibility of disease and pest infection
iv) Ecological Suitability: The cropping pattern of a particular region is highly dependent on the ecological condition (temperature, rainfall, humidity, etc.).
v) Moisture Availability: The source of irrigation greatly determines the type of the cropping pattern to be practiced. For example, in low rainfall area, dry land farming is the best possible way to profit maximization.

vi) Financial Stability: The economic condition of the farmers also affects the cropping pattern. As the cash crops (for example, cotton) involve high capital investments, these are practised only in estate farming. The marginal section of the farming community adopts low cost crops.

vii) Infrastructure facilities like Irrigation, transport, storage, trade and marketing, post-harvest handling, processing etc determines the cropping pattern

viii) Other factors:
   a. Availability of Inputs
   b. Insurance against risk
   c. Food Habits
   d. Climate
   e. Soil
   f. Government Policies

Importance of Cropping Pattern

i) **Increases Soil Fertility:** Prolonged planting of the same crop type leads to the depletion of specific nutrients in the soil. Each crop type has a different nutrient interaction with the soil, and each of them releases and absorb different types of nutrients. Because of this, crop rotation increases soil fertility by controlling deficient or excess nutrients because it replenishes nutrients that are not available or absorb nutrients that are in abundance.

ii) **Increases Crop Yield:** Cropping pattern increases the harvest obtained from a single seasonal harvest. Not only does one get a variety of crops after each season because of the incorporation of different crop types, but also a general bounty harvest. Some scientific evidence proves a 10 to 25% increase in crop yield in crop rotation rather than monoculture.

iii) **Increases Soil Nutrients:** cropping pattern allows the land to regenerate and rejuvenate its self-nutrients without having to apply more nutrients through the use of fertilizers. Leaving the land bare for a season enable the land to restore the soil nutrients lost through absorption by plants harvested in the previous season.

iv) **Reduces Soil Erosion:** it helps reduce raindrop impact on the soil and general erosion by water because the roots of the plants hold the top layer soil together. Trees planted together with crops in the farms also assists in preventing soil erosion.

v) **Improves the Soil Structure:** Cropping Pattern helps prevent soil compaction, thus improving the physical condition of the soil. Crop rotation improves the soil structure as well as soil texture. This allows for good conditions for seed germination and root proliferation.

vi) **Diversification and Reduced Cost of Production**: The cultivation of certain crops requires less labor and machinery compared to others. It helps to distribute the workload and resources used throughout the year for which the cost of production of the crops decreases to a certain extent

Emerging Problems in Cropping Patterns

Over the years the emerging scenario in the cropping pattern points to the following observations.

1. The dominance of cereal crops in the food grains point to the poverty of the people. It meets the demand of the low-income people, in whose case a large proportion of income is spent on cereals. Even pulses which are the source of protein for this class of people is not grown on a significant scale. Most of the farmers being marginal and small are the net purchaser of food grains and hardly can afford the high input cost for raising a successful non-food cash crop.
2. The predominance of food grains group together with the fact that a significant proportion of agricultural production is concentrated in small farms, leads one to

conclude that much of the cultivation is for self-consumption.

3. The fact that large areas remains under food grains shows that land productivity has not increased at par with technological possibilities.
4. Despite significant changes in cropping pattern, the shift towards high valued commercial crops has been very small. The result is an insignificant impact on the growth of the crop output

Effects of Current Trends in Cropping Pattern

a. **Increased use of Fertilizers and Pesticides:** We are using more and more fertilizers and pesticides of the inorganic type while growing crops which has two main disadvantages: One is that our health is being affected due to the fruits and vegetables becoming so toxic that our body cannot tolerate and we fall ill very often. Secondly, the tolerance of pests to the pesticides develops, and slowly they become ineffective.

b. **Use of Hybrid and High Yielding Varieties**: We were earlier using our indigenous seeds to grow crops, and those had better nutrition value. Now the hybrid seeds are being used after the onset of the green revolution. They are not so nutritious and this awareness has lead to the growing importance of organic farming, but it is not been done on a very large scale, so it does not have a significant impact on total production. This calls for the development of a new system in which the traditional methods and the modern scientific technique is combined to reap the advantages of both and minimize the drawbacks.

c. **Increased Water Demand:** New production techniques require the usage of ore water. In fact, we are using 10% of our water in the agricultural sector, and the need would increase if intensive cropping is done. The result is that our ground water resources are used up. More and more irrigation projects have to be undertaken by the government, which have adverse effects on the environment, and also use of agricultural land, for non-agricultural purposes.

d. **Depletion of Forest Areas:** There is need for a minimum forest area to be maintained, the specification being 33%, for the ecological balance to be maintained. Increasing the cropping intensity reduces the forest cover. We have tried to maintain a reasonable forest cover by afforestation methods and maintenance of the existing reserves. In many areas this ecological balance has been disturbed because of increase in agricultural activities, which needs to be taken care of.

24.2 AGRICULTURE BIOTECHNOLOGY

Tissue Culture

Growing plant protoplasts, cells, tissues or organs away from their natural or normal environment, under artificial condition, is known as Tissue Culture. It is also known as in vitro (In vitro is a Latin word, it means that - in glass or in test-tube) growth of plant protoplasts, cells, tissues and organs. A single explant can be multiplied into several thousand plants in a short duration and space under controlled conditions

Applications of Plant Tissue Culture:

1. Often used for commercial production of plants as well as for plant research.
2. serves as an indispensable tool for regeneration of transgenic plant
3. Clonal propagation of elite varieties,
4. conservation of endangered plants,

5. production of virus-free plants,
6. germplasm preservation,
7. Industrial production of secondary metabolites.

Gottlieb Haberlandt (1902) the German Botanist proposed the concept Totipotency He is regarded as the father of tissue culture

Basic concepts of Tissue Culture:

Basic concepts of plant tissue culture are

1. totipotency,
2. differentiation,
3. dedifferentiation and
4. redifferentiation.

Totipotency: The property of live plant cells that they have the genetic potential when cultured in nutrient medium to give rise to a complete individual plant.

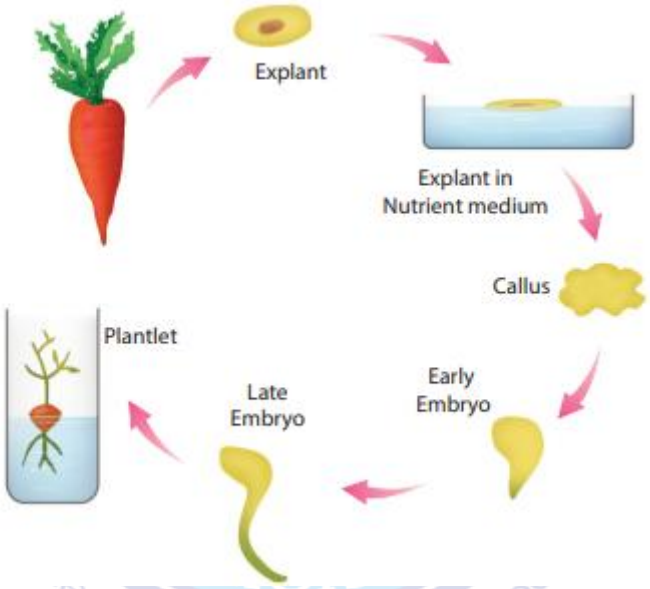


Fig: Totipotency

Differentiation: The process of biochemical and structural changes by which cells become specialized in form and function.

Redifferentiation: The further differentiation of already differentiated cell into another type of cell. For example, when the component cells of callus have the ability to form a whole plant in a nutrient medium, the phenomenon is called redifferentiation.

Dedifferentiation: The phenomenon of the reversion of mature cells to the meristematic state leading to the formation of callus is called dedifferentiation.

These two phenomena of redifferentiation and dedifferentiation are the inherent capacities of living plant cells or tissue. This is described as totipotency

Plant Tissue Culture (PTC):

Plant tissue culture is used to describe the in vitro and aseptic growth of any plant part on a tissue culture medium. This technology is based on three fundamental principles:

1. The plant part or explant must be selected and isolated from the rest of plant body.
2. The explant must be maintained in controlled physically (environmental)

and chemically defined (nutrient medium) conditions.

Explant: The tissue taken from a selected plant transferred to a culture medium often to establish a new plant

Technique Involved in PTC:

1. Sterilization

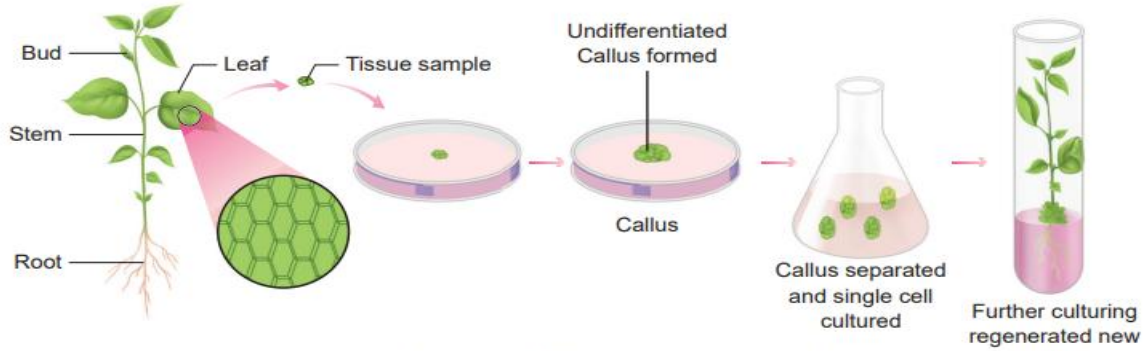
Sterilization is the technique employed to get rid of microbes such as bacteria and fungi in the culture medium, vessels and explants.

i. Maintenance of Aseptic Environment: During in vitro tissue culture maintenance of aseptic environmental condition should be followed, i.e., sterilization of glassware, forceps, scalpels, and all accessories in wet steam sterilization by autoclaving at 15 psi (121°C) for 15 to 30 minutes or dipping in 70% ethanol followed by flaming and cooling.

ii. Sterilization of culture room: Floor and walls are washed first with detergent and then with 2% sodium hypochlorite or 95% ethanol. The cabinet of laminar airflow is sterilized by clearing the work surface with 95% ethanol and then exposure of UV radiation for 15 minutes.

iii. Sterilization of Nutrient Media: Culture media are dispensed in glass containers, plugged with non-absorbent cotton or sealed with plastic closures and then sterilized using autoclave at 15 psi (121°C) for 15 to 30 minutes. The plant extracts, vitamins, amino acids and hormones are sterilized by passing through Millipore filter with 0.2 mm pore diameter and then added to sterilized culture medium inside Laminar Airflow Chamber under sterile condition.

iv. Sterilization of Explants: The plant materials to be used for tissue culture should be surface sterilized by first exposing the material in running tap water and then treating it in surface sterilization agents like 0.1% mercuric chloride, 70% ethanol under aseptic condition inside the Laminar Air Flow Chamber



Basic steps in Plant tissue culture technology

2. Media Preparation:

The success of tissue culture lies in the composition of the growth medium, plant growth regulators and culture conditions such as temperature, pH, light and humidity. No single medium is capable of maintaining optimum growth of all plant tissues. Suitable nutrient medium as per the principle of tissue culture is prepared and used. MS nutrient medium (Murashige and Skoog 1962) is commonly used. It has carbon sources, with suitable vitamins and hormones. The media formulations available for plant tissue culture other than MS are B5 medium (Gamborg.et.al 1968), White medium (white 1943), Nitsch's medium (Nitsch & Nitsch 1969). A medium may be solid or semisolid or liquid. For solidification, a gelling agent such as agar is added.

3. Culture condition

pH

The pH of medium is normally adjusted between 5.6 to 6.0 for the best result.

Temperature

The cultures should be incubated normally at constant temperature of 25°C ± 2°C for optimal growth.

Humidity and Light Intensity

The cultures require 50-60% relative humidity and 16 hours of photoperiod by the illumination of cool white fluorescent tubes of approximately 1000 lux.

Aeration

Aeration to the culture can be provided by shaking the flasks or tubes of liquid culture on automatic shaker or aeration of the medium by passing with filter-sterilized air.

4. Induction of Callus:

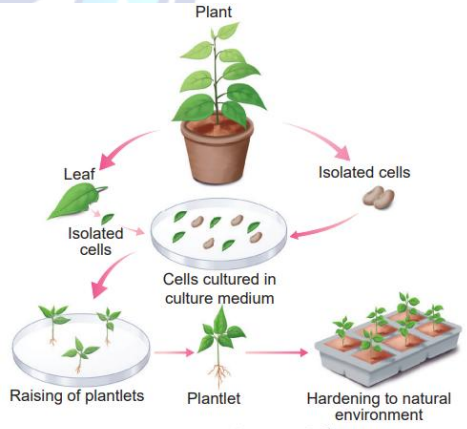
Explant of 1-2 cm sterile segment selected from leaf, stem, tuber or root is inoculated (transferring the explants to sterile glass tube containing nutrient medium) in the MS nutrient medium supplemented with auxins and incubated at 25°C ± 2°C in an alternate light and dark period of 12 hours to induce cell division and soon the upper surface of explant develops into callus. Callus is a mass of unorganized growth of plant cells or tissues in in vitro culture medium.

5. Embryogenesis

The callus cells undergoes differentiation and produces somatic embryos, known as Embryoids. The embryoids are sub-cultured to produce plantlets

6. Hardening

The plantlets developed in vitro require a hardening period and so are transferred to greenhouse or hardening chamber and then to normal environmental conditions. Hardening is the gradual exposure of in vitro developed plantlets in humid chambers in diff used light for acclimatization so as to enable them to grow under normal field conditions



Organ Culture

Types of Plant tissue cultures

Based on the type of explants other plant tissue culture types are

1) Organ culture
2) Meristem culture
3) Protoplast culture
4) Cell suspension culture.

1. **Organ culture**

The culture of embryos, anthers, ovaries, roots, shoots or other organs of plants on culture media.

2. **Meristem Culture:**

The culture of any plant meristematic tissue on culture media.

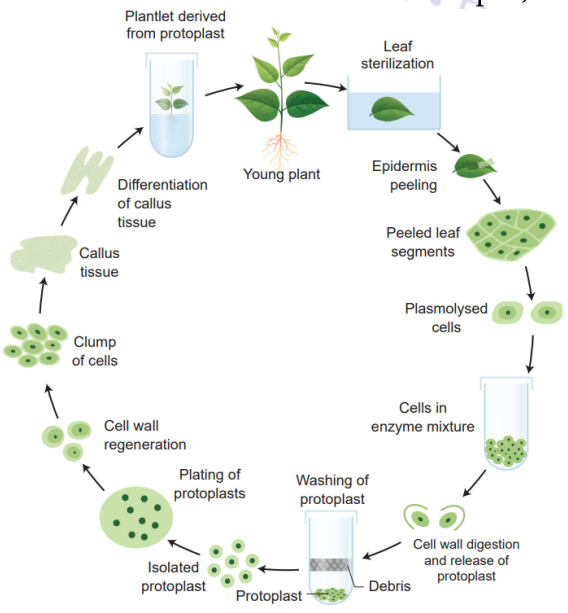
3. Protoplast Culture:

Protoplasts are cells without a cell wall, but bound by a cell membrane or plasma membrane. Using protoplasts, it is possible to regenerate whole plants from single cells and also develop somatic hybrids. The steps involved in protoplast culture

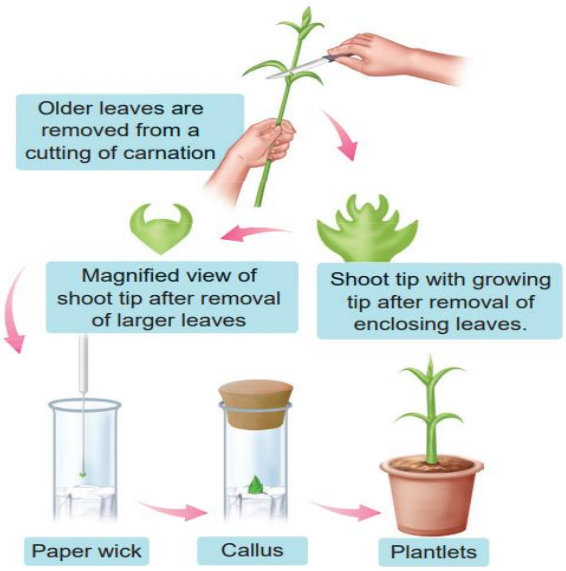
i. Isolation of protoplast: Small bits of plant tissue like leaf tissue are used for isolation of protoplast. The leaf tissue is immersed in 0.5% Macrozyme and 2% Onozuka cellulase enzymes dissolved in 13% sorbitol or mannitol at pH 5.4. It is then incubated over-night at 25°C. After a gentle teasing of cells, protoplasts are obtained, and these are then transferred to 20% sucrose solution to retain their viability. They are then centrifuged to get pure protoplasts as different from debris of cell walls.

ii. Fusion of protoplast: It is done through the use of a suitable fusogen. This is normally PEG (Polyethylene Glycol). The isolated protoplast are incubated in 25 to 30% concentration of PEG with Ca++ ions and the protoplast shows agglutination (the formation of clumps of cells) and fusion.

iii. Culture of protoplast: MS liquid medium is used with some modification in droplet, plating or micro-drop array techniques. Protoplast viability is tested with fluorescein diacetate before the culture. The cultures are incubated in continuous light 1000-2000 lux at 25°C. The cell wall formation occurs within 24-48 hours and the first division of new cells occurs between 2-7 days of culture.



Protoplast Culture



Meristem Culture

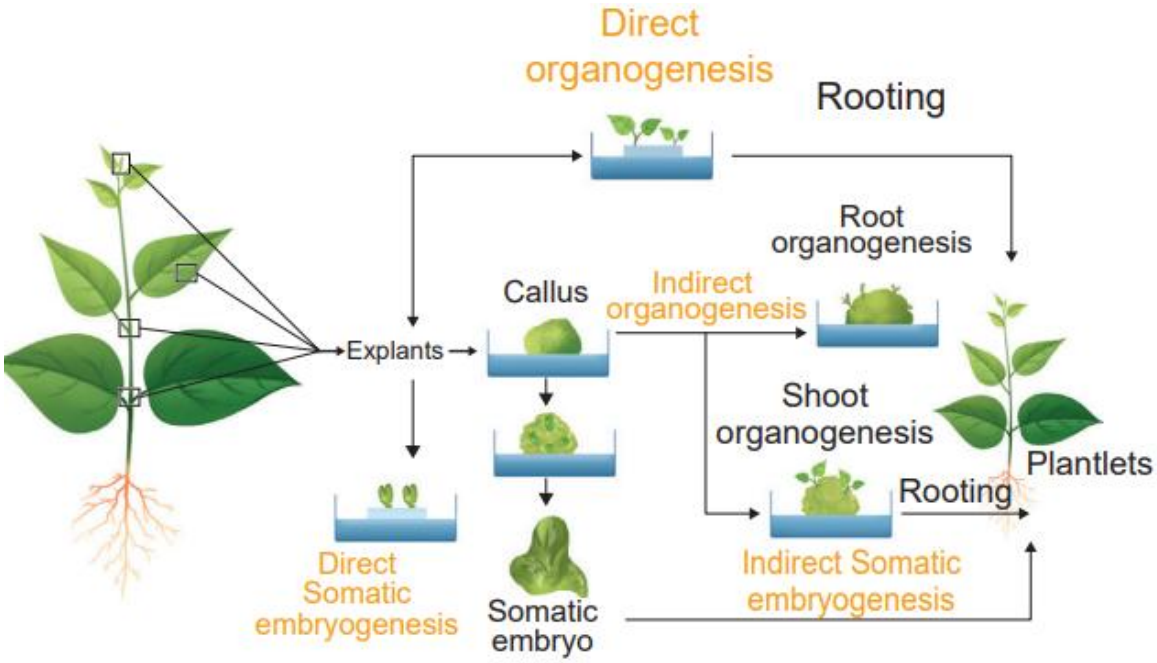
iv.Selection of somatic hybrid cells: The fusion product of protoplasts without nucleus of different cells is called a cybrid. Following this nuclear fusion take place. This process is called somatic hybridization

4. Cell Suspension Culture

The growing of cells including the culture of single cells or small aggregates of cells in vitro in liquid medium is known as cell suspension culture. The cell suspension is prepared by transferring a portion of callus to the liquid medium and agitated using rotary shaker instrument. The cells are separated from the callus tissue and used for cell suspension culture.

Plant Regeneration Pathway

From the explants, plants can be regenerated by somatic embryogenesis or organogenesis



Plant Regeneration Pathway

Somatic Embryogenesis:

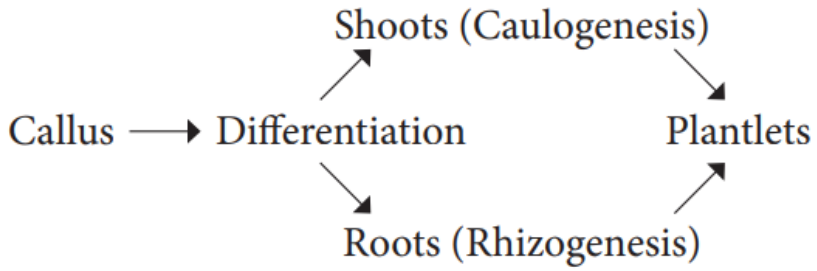
Somatic embryogenesis is the formation of embryos from the callus tissue directly and these embryos are called Embryoids or from the in vitro cells directly form pre-embryonic cells which differentiate into embryoids.

Applications

1. Somatic embryogenesis provides potential plantlets which after hardening period can establish into plants.
2. Somatic embryoids can be be used for the production of synthetic seeds.
3. Somatic embryogenesis is now reported in many plants such as Allium sativum, Hordeum vulgare, Oryza sativa, Zea mays and this possible in any plant.

Organogenesis

The morphological changes occur in the callus leading to the formation of shoot and roots is called organogenesis.



1. Organogenesis can be induced in vitro by introducing plant growth regulators in the MS medium.
2. Auxin and cytokinins induce shoot and root formation.

Applications of Plant Tissue Culture:

Plant tissue culture techniques have several applications such as:

1) Improved hybrids production through somatic hybridization.
2) Somatic embryoids can be encapsulated into synthetic seeds (synseeds). These encapsulated seeds or synthetic seeds help in conservation of plant biodiversity.
3) Production of disease resistant plants through meristem and shoot tip culture.
4) Production of stress resistant plants like herbicide tolerant, heat tolerant plants.
5) Micropropagation technique to obtain large numbers of plantlets of both crop and tree species useful in forestry within a short span of time and all through the year.
6) Production of secondary metabolites from cell culture utilized in pharmaceutical, cosmetic and food industries.

24.3 ARTIFICIAL SEED

Artificial seeds or synthetic seeds (synseeds) are produced by using embryoids (somatic embryos) obtained through in vitro culture. They may even be derived from single cells from any part of the plant that later divide to form cell mass containing dense cytoplasm, large nuclceus, starch grains, proteins, and oils etc., To prepare the artificial seeds different inert materials are used for coating the somatic embryoids like agrose and sodium alginate.

Advantages of Artificial seeds

Artificial seeds have many advantages over the true seeds

1) Millions of artificial seeds can be produced at any time at low cost.
2) They provide an easy method to produce genetically engineered plants with desirable traits.
3) It is easy to test the genotype of plants.
4) They can potentially store for long time under cryopreservation method.
5) Artificial seeds produce identical plants
6) The period of dormancy of artificial seeds is greatly reduced, hence growth is faster with a shortened life cycle.

Conservation of plant genetic resources

1) **Germplasm Conservation:** Germplasm conservation refers to the conservation of living genetic resources like pollen, seeds or tissue of plant material maintained for the purpose of selective plant breeding,

preservation in live condition and used for many research works. Germplasm conservation resources is a part of collection of seeds and pollen that are stored in seed or pollen banks, so as to maintain their viability and fertility for any later use such as hybridization and crop improvement. Germplasm conservation may also involve a gene bank, DNA bank of elite breeding lines of plant resources for the maintenance of biological diversity and also for food security

2) **Cryopreservation (–196^0 C)** Cryopreservation, also known as Cryoconservation, is a process by which protoplasts , cells, tissues, organelles, organs, extracellular matrix, enzymes or any other biological materials are subjected to preservation by cooling to very low temperature of –196°C using liquid nitrogen. At this extreme low temperature any enzymatic or chemical activity of the biological material will be totally stopped and this leads to preservation of material in dormant status. Later these materials can be activated by bringing to room temperature slowly for any experimental work

Protective agents like dimethyl sulphoxide, glycerol or sucrose are added before cryopreservation process. These protective agents are called cryoprotectants, since they protect the cells, or tissues from the stress of freezing temperature.

24.4 COMMERCIALLY AVAILABLE GENETICALLY MODIFIED CROPS

24.4.1 Genetically Modified Organisms (GMOs)

Genetic modification refers to the alteration or manipulation of genes in the organisms using rDNA techniques in order to produce the desired characteristics. The DNA fragment inserted is called transgene. Plants or animals expressing a modified endogenous gene or a foreign gene are also known as transgenic organisms.

The transgenic plants are much stable, with improved nutritional quality, resistant to diseases and tolerant to various environment conditions. Similarly transgenic animals are used to produce proteins of medicinal importance at low cost and improve livestock quality.

GM crops were first introduced in the USA in 1994 called Flavr Savr tomato, with the objective to slow its ripening process, delaying softening and rotting. Before this, genetic modification was already in use to produce insulin, vaccines, and other drugs on a large scale.

24.4.2 Objectives of the GM crops:

1) Reducing dependence on pesticides/herbicides as the toxins produced by the GM crops (such as Bt-toxins) are used to kill the pests
2) Providing resistance to certain plant viruses
3) Providing tolerance of herbicides used to control weeds
4) Reducing the need to till the soil to control weeds

Bt genes:

1) Bacillus thuringiensis (Bt) is a bacterium that produces two important proteins - cytolytic (Cyt) and crystal (Cry) toxins, which are toxic to a specific group of insects such as beetles, caterpillars, flies, mosquitoes, etc.

2) The genes expressing these toxins are engineered into plant crops so that they too have the ability to produce them. For example: Bt Cotton.

24.4.3 Methods of producing GM Crops:

To genetically modify a crop, a gene of interest (Cry or Cyt genes, or any other gene for a specific trait) is incorporated into the DNA of a plant. It involves mainly two approaches - Recombinant DNA technology using Agrobacterium tumefaciens-mediated gene transfer and the Direct approach.

Direct approach: In the direct approach the gene of interest is cloned into a plant DNA vector and then transferred into the plant using the gene gun method, electroporation method, microinjection, etc.

In the gene gun (particle bombardment) method, tiny particles of gold or tungsten are coated with the DNA (gene) solution and introduced into the plant using the gene gun or particle gun.

A.tumefaciens mediated gene transfer: A.tumefaciens is a soil bacterium and is called nature's own genetic engineer. It causes crown gall disease in many plants by transferring tumour-causing DNA into the plant's genome by using a tumour-inducing plasmid (Ti-plasmid).

This Ti plasmid can be utilised to make recombinant DNA, after removing the gene that causes gall disease.

24.4.4 Genetically Modified (GM) Plants:

GM plants are plants that have undergone intentional alteration of their genetic material through genetic engineering techniques. These modifications are carried out to introduce specific traits or characteristics that may not naturally occur within the plant's genome. For example:

1) **Bt Cotton:** Bacillus Thuringiensis (Bt) cotton is engineered to produce a protein from the bacterium Bacillus Thuringiensis that is toxic to certain insect pests. The bacteria release specialized proteins referred to as "cry proteins," which exhibit toxicity towards insects.This trait reduces the need for chemical insecticides and helps protect the cotton crop from damage.
2) **Golden Rice:** Golden rice is modified to produce higher levels of beta-carotene, a precursor of vitamin A. This modification aims to address vitamin A deficiency, a major public health concern in many developing countries.
3) **Drought-Resistant Crops**: Some plants have been engineered to tolerate drought conditions better by introducing genes that help the plant conserve water or withstand dehydration stress.
4) **Insect-Resistant Eggplant (Bt Brinjal):** Similar to Bt cotton, Bt brinjal (eggplant) produces a protein toxic to certain insect pests. This modification reduces the need for chemical insecticides, benefiting both farmers and the environment.
5) **Papaya Ringspot Virus-Resistant Papaya:** Hawaiian papaya crops were genetically modified to resist the papaya ringspot virus, which had previously devastated papaya production in Hawaii.
6) **Flavr Savr Tomato:** The Flavr Savr tomato was one of the first genetically modified foods. It was engineered to have a longer shelf life by suppressing the gene responsible for softening and decay.
7) **Resistant Cassava:** Cassava, a staple crop in many parts of the world, has been modified to resist viral diseases that can significantly reduce yields.
8) **Frost-Tolerant Strawberries**: Strawberries have been genetically modified to tolerate frost, allowing for extended growing seasons in colder climates.
9) **Non-Browning Apples**: Apples have been engineered to resist browning when sliced

or bruised, which can help reduce food waste and increase their shelf life.

24.4.5 Genetically Modified Medicines:

GM medicines, also known as biopharmaceuticals or biologic drugs, are pharmaceutical products produced using genetic engineering techniques. These drugs are derived from living organisms, such as bacteria, yeast, or mammalian cells, that have been genetically modified to produce therapeutic proteins or other bioactive molecules.

1) **Insulin:** Recombinant DNA technology has been used to produce insulin for the treatment of diabetes. Human insulin genes are inserted into bacterial or yeast cells, which then produce insulin that is identical to the naturally occurring hormone.
2) **Human Growth Hormone (HGH):** Genetically modified bacteria or mammalian cells are used to produce synthetic human growth hormone, which is used to treat growth disorders in children and hormone deficiencies in adults.
3) **Erythropoietin (EPO):** EPO, a hormone that stimulates the production of Red Blood Cells (RBC), is produced using genetically modified mammalian cells. It is used to treat anemia associated with conditions such as kidney disease and chemotherapy.
4) **Monoclonal Antibodies**: These are a class of genetically engineered proteins used to treat various diseases, including cancer, autoimmune disorders, and inflammatory conditions. Monoclonal antibodies are produced by modifying mammalian cells to produce specific antibodies that target disease-related molecules.
5) **Blood Clotting Factors:** Genetically modified cells are used to produce blood clotting factors, such as Factor VIII and Factor IX, for the treatment of hemophilia.
6) **Vaccines:** Some vaccines are produced using genetically modified organisms, such as yeast or bacteria, to express antigens that stimulate an immune response. For example, the hepatitis B vaccine is produced using genetically modified yeast cells.
7) **Enzyme Replacement Therapies**: Genetic engineering is used to produce enzymes that are deficient or absent in certain genetic disorders. For instance, enzyme replacement therapies are used to treat conditions like Gaucher's disease and Fabry disease.
8) **Cancer Therapies**: Genetically modified T cells (a type of immune cell) are being developed as a form of immunotherapy for certain types of cancer. These modified T cells are engineered to express Chimeric Antigen Receptors (CARs) that target cancer cells.
9) **Clot-Dissolving Agents**: Genetically modified bacteria or yeast can be used to produce clot-dissolving enzymes, such as tissue plasminogen activator (tPA), which is used in the treatment of certain types of strokes and heart attacks

24.4.6 Genetically Modified Animals

Genetically modified (GM) animals are those that have been deliberately modified through genetic engineering methods, aiming to incorporate particular traits or features that might not exist naturally in the animal's genetic makeup

1) GloFish: GloFish are genetically modified zebrafish that have been engineered to express fluorescent proteins from jellyfish and coral. These fish are used in scientific research and as pets to study genetic traits and environmental pollutants.
2) AquAdvantage Salmon: These salmon have been genetically modified to grow faster and reach market size more quickly. They contain genes from Chinook salmon and

ocean pout, allowing them to produce growth hormone year-round.

3) Enviropig: Enviropigs have been genetically modified to produce less phosphorus in their waste, potentially reducing the environmental impact of pig farming on water quality.
4) Knockout Mice: Mice are often genetically modified to have specific genes "knocked out" or deactivated. This allows researchers to study the effects of gene function and develop models for human diseases.
5) Transgenic Goats: Goats have been engineered to produce certain proteins in their milk that can be extracted and used for pharmaceutical purposes. For example, transgenic goats can produce antithrombin, a protein used in blood clotting disorders.
6) Genetically Modified Mosquitoes: Mosquitoes have been genetically modified to reduce their ability to transmit diseases like malaria and dengue fever. Modified mosquitoes can be engineered to carry a gene that prevents the development of the disease-causing parasite.
7) Dolly the Sheep: Dolly was the first mammal cloned from an adult somatic cell using a technique called somatic cell nuclear transfer. While not a traditional genetic modification, cloning involves altering the genetic makeup of an organism through a different process.
8) Genetically Modified Pigs for Organ Transplants: Pigs have been modified to express human genes in their organs, with the goal of making their organs suitable for transplantation into humans (xenotransplantation).
9) Featherless Chickens: Some genetically modified chickens have been bred to have fewer feathers, which could reduce the need for plucking during processing.
10) Spider Silk-Producing Goats: Certain goats have been genetically modified to produce spider silk proteins in their milk. These proteins can be used to create strong and lightweight materials.

24.4.7 Advantages of Genetically Modified Crops

GM Crops have several advantages which include:

1) **Better than conventional breeding:** Genetic Modification is one of the best methods to develop pest-resistant crops such as Bt crops.
    a. It is faster to introduce the required traits than by the conventional breeding process.
    b. It enables genetic modification in such a way that may not have been possible through conventional breeding methods, such as the introduction of a gene from different organisms.
2) **Pest resistance:** The Bt genes are toxic to many pests, thus eliminating the need for externally applied chemicals.
    a. This reduces the need for environmentally damaging pesticides.
    b. This increases yield, saves farmers' money and reduces environmental pollution.
3) **Virus resistance:** Virus-resistant traits can be introduced into vulnerable plants that lack natural resistance.
    a. This increases the productivity of crops.
4) **Drought-resistant plants:** Plants can be modified to express tolerance to drought hence, it reduces the use of groundwater.
5) **Herbicide tolerance**: GM crops are engineered to be resistant to specific herbicides that can be used to control weeds.
    a. It reduces soil erosion because the weed removal process such as ploughing and tilling is not required for these crops.

   b. This also reduces soil, water and air pollution.
6) **Sustainable agricultural practice:** Genetically modified crops enable farmers to use more sustainable agricultural practices, such as no-till farming, which keeps the carbon within the soil rather than in the atmosphere.
7) **Enhanced nutritional value:** Food crops can be modified genetically to increase their nutritional value.
   a. This can be beneficial to health, and increase food security around the world.

24.4.8 Disadvantages of Genetically Modified Crops

The unknown consequences of GM crops that can lead to the horizontal gene transfer of pesticide, herbicide, or antibiotic resistance thereby affecting the metabolism and response to the external environmental stimulus of the hosts are some of the concerns of this technology.

1) **Impact on Health:** Horizontal gene transfer of pesticide, herbicide, or antibiotic resistance to other organisms would put not only humans at risk but also cause ecological imbalances by causing the spread of disease among both plants as well as in animals.
2) **Impact of herbicide-tolerant crops:** Herbicide overuse in fields may allow weeds to develop resistance to them.
   a. For example: Glyphosate has been used as a herbicide in the United States since 1974, and its widespread usage has resulted in glyphosate-resistant weeds.
3) **Impact of pest resistance:** Pests may acquire resistance to pest-resistant traits such as Bt toxins produced by the Genetically Modified crop, which can overcome the efficacy of these crops.
4) **Impact on genetic diversity in crop varieties:** Concerns have been raised about the possibility of GM crops reducing the genetic diversity of neighbouring crops, close relatives, and weeds.
5) **Herbicide-resistant weeds:** Weeds may also cross-breed with herbicide-tolerant crops, resulting in herbicide-tolerant weeds, which is more worrisome.
6) **Effect on honeybees and other pollinators:** There is a worldwide growing concern that Genetically Modified crops may endanger the honeybee population and other pollinators.

24.4.9 Applications of GM Crops

Following are some of the applications of GM technology in plants that are being used today.

1) **Biofortification:** Biofortification is the process of enhancing micronutrient content.
   a. Genetic modification has proved to be the best method for biofortification.
   b. Example: β-carotene-enriched 'Golden Rice' was the first application of GM biofortification in 2000.
   c. It can also prevent many diseases such as cancer, diabetes and cardiovascular diseases.
2) **Edible Vaccines:** Edible vaccines can be produced from GM plants.
   a. They offer many benefits than the traditional ones due to lower manufacturing costs and much fewer side effects.
3) **Biofuels:** Fourth-generation biofuels, which is biofuel obtained from genetically modified (GM) algae and cyanobacteria, have gained considerable attention.
4) **Phytoremediation:** Genetic modification can be utilised to clean up soil and water pollutants by expressing the particular genes that express enzymes dealing with these pollutants.

24.4.10 Status of GM Crops in India/Commercial GMO crops in India

1) **Bt-Cotton:** In 2002, India commercialised Bt Cotton, which resulted in a significant improvement in cotton production, export, and the textile industry.
    a. It is the only approved GM crop for commercial cultivation in 2002.
    b. It was created to combat the widespread infestation of bollworms.
    c. Bt modification is a type of genetic modification where the Bt gene is obtained from the soil bacterium Bacillus Thuringiensis.
    d. Bt cotton is resistant to bollworm, a pest that destroys cotton plants.
    e. By 2014, around 96% of the area under cotton cultivation in India was Bt cotton.
    f. It makes India the fourth-largest cultivator of GM crops by acreage and the second largest producer of cotton.

2) **Bt-Brinjal:** The fruit and borer-resistant Bt-brinjal was approved for commercial cultivation by GEAC in 2009, but it was put on a 10-year moratorium due to public outrage and recommendations from brinjal-growing states.
    a. GEAC has approved field trials of new varieties of indigenously developed Bt-brinjal in eight states from 2020 to 2023.

3) **GM Mustard:** Commercial cultivation of high-yielding GM mustard in India has not begun yet.

✓ GEAC recently approved commercial cultivation of genetically modified mustard.

✓ Dhara Mustard Hybrid (DMH -11) was developed by a team of scientists at Delhi University.

✓ It uses a system of genes from soil bacterium that makes mustard generally a self-pollinating plant better suited to hybridisation than current methods.

✓ In September 2017, a feasibility report said that the developers of DMH-11 claimed a yield increase of 25-30% over non-hybrids, which was refuted by several NGOs.

✓ The GEAC cleared "the environmental release of mustard hybrid DMH-11 for its seed production and testing as per existing ICAR guidelines and other extant rules/regulations prior to commercial

3. Eco, Social impact of Genetically Modified Crops

Environmental Impacts:

1) "Superweeds": The use of specific herbicides with GM herbicide-tolerant crops has led to the evolution and spread of "superweeds," or weeds that can no longer be killed by those herbicides.
2) "Superpests": Some insects have developed resistance to the toxins in GM insect-resistant (Bt) crops
3) Genetic Contamination: Contamination from GM plants has serious ecological, economic and social impacts. Gene flow from GM crops poses a threat to wild and weedy crop relatives, non-GM crops and foods, and organic farming
4) Biodiversity Loss: The use of some GM crops can have negative impacts on non-target organisms and on soil and water ecosystems

Economics Impacts:

a. Increased use of chemicals
b. False promises
c. Corporate control over farming
d. Health related impacts

Regulatory Framework in India

Institutions:

1) All the activities, operations and products related to the genetically modified

organisms are regulated by the Ministry of Environment, Forest and Climate.

2) It is regulated under the Environment (Protection) Act, 1986.
3) Genetic Engineering Appraisal Committee (GEAC) under MoEFCC is authorized to review, monitor and approve all activities of GMO.
4) These activities include import, export, transport, manufacture, use or sale of GMO.
5) GM foods are also subjected to regulations of Food Safety and Standards Authority of India (FSSAI).

24.4.11 Acts and rules:

1) Environment Protection Act, 1986 (EPA)
    a. The Genetic Engineering Appraisal Committee (GEAC) serves as the principal regulatory authority for biotechnology in India. Operating as a statutory body, it operates under the purview of the Ministry of Environment, Forests and Climate Change (MoEFCC) and is established in accordance with the Environment Protection Act, 1986.
2) Biological Diversity Act, 2002
    a. Under the Act, any organization or individual seeking to access Indian biological resources, including those for GMO research or commercialization, is required to obtain prior approval and enter into benefit-sharing agreements with the National Biodiversity Authority (NBA).
    b. The Act aims to ensure that the benefits arising from the utilization of these resources are shared fairly with local communities and indigenous people.
3) Plant Quarantine Order, 2003
    a. The Plant Quarantine Order, 2003, includes provisions for regulating the import and export of GMOs, including genetically modified (GM) plants and plant materials.
4) Food Safety and Standards Act, 2006
    a. The Food Safety and Standards Act, 2006, empowers the Food Safety and Standards Authority of India (FSSAI) to establish safety standards for food products, including those derived from GMOs. It includes provisions for conducting safety assessments to determine the suitability of GMO-derived foods for human consumption.

24.4.12 Conventions:

1) Convention on Biological Diversity (CBD):
    a. It is a legally binding treaty to conserve biodiversity.
    Objectives:
    b. The conservation of biological diversity.
    c. The sustainable use of the components of biological diversity.
    d. The fair and equitable sharing of the benefits arising out of the utilization of genetic resources.
    e. Secretariat: Montreal, Canada.
    f. It operates under the United Nations Environment Programme.

2) The Cartagena Protocol on Biosafety:
    1. It primarily deals with the transboundary movement of living modified organisms (LMOs), it includes provisions related to the handling, transport, and use of GMOs, which can include GMOs in animals.
    2. The Cartagena Protocol on Biosafety, a supplement to the Convention on Biological Diversity.
    3. It was approved in 2000.
    4. It came into force in 2003.

3) Nagoya Protocol:

a. Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization Genetically Modified Organisms (GMO).

b. It was adopted in 2010 in Nagoya, Japan at COP10.
c. Nagoya Protocol entered into force in 2014.

24.5 INTELLECTUAL PROPERTY RIGHTS

Intellectual property (IP) refers to creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce.

24.5.1 Types | Components of intellectual property

a. Patents
b. Copyright
c. Trademarks
d. Industrial designs
e. Geographical indications
f. Trade secrets

1. **Copyright** - Copyright (or author's right) is a legal term used to describe the rights that creators have over their literary and artistic works. Works covered by copyright range from books, music, paintings, sculpture, and films, to computer programs, databases, advertisements, maps, and technical drawings.

   What can be protected using copyright?
   Exhaustive lists of works covered by copyright are usually not to be found in legislation. Nonetheless, broadly speaking, works commonly protected by copyright throughout the world include:

   a. literary works such as novels, poems, plays, reference works, newspaper articles;
   b. computer programs, databases;
   c. films, musical compositions, and choreography;
   d. artistic works such as paintings, drawings, photographs, and sculpture;
   e. architecture; and
   f. advertisements, maps, and technical drawings.

   Copyright protection extends only to expressions, and not to ideas, procedures, methods of operation or mathematical concepts as such. Copyright may or may not be available for a number of objects such as titles, slogans, or logos, depending on whether they contain sufficient authorship.

2. **Patents** - The patent rights protect an invention, new business product, or the process
   A Patent is a statutory right for an invention granted for a limited period of time to the patentee by the Government, in exchange of full disclosure of his invention for excluding others, from making, using, selling, importing the patented product or process for producing that product for those purposes without his consent

   The term of every patent granted is 20 years from the date of filing of application

   An invention relating either to a product or process that is new, involving inventive step and capable of industrial application can be patented

An invention is patentable subject matter if it meets the following **criteria** –

a) It should be novel.
b) It should have inventive step or it must be non-obvious
c) It should be capable of Industrial application.
d) It should not attract the provisions of section 3 and 4 of the Patents Act 1970.

3. **Industrial designs** - An industrial design constitutes the ornamental or aesthetic aspect of an article. A design may consist of three-dimensional features, such as the shape or surface of an article, or of two-dimensional features, such as patterns, line, or colour

   In principle, the owner of a registered industrial design or of a design patent has the right to prevent third parties from making, selling or importing articles bearing or embodying a design which is a copy, or substantially a copy, of the protected design, when such acts are undertaken for commercial purposes.

4. **Geographical indications** - Geographical indications and appellations of origin are signs used on goods that have a specific geographical origin and possess qualities, a reputation or characteristics that are essentially attributable to that place of origin. Most commonly, a geographical indication includes the name of the place of origin of the goods

   What is GI?

   a. It is an indication
   b. It originates from a definite geographical territory.
   c. It is used to identify agricultural, natural or manufactured goods
   d. The manufactured goods should be produced or processed or prepared in that territory.
   e. It should have a special quality or reputation or other characteristics

   Geographical indications are typically used for agricultural products, foodstuffs, wine and spirit drinks, handicrafts, and industrial products.

   Benefits of GI Tags

   a. It confers legal protection to Geographical Indications in India
   b. Prevents unauthorised use of a Registered Geographical Indication by others
   c. It provides legal protection to Indian Geographical Indications which in turn boost exports.
   d. It promotes economic prosperity of producers of goods produced in a geographical territory.

How a geographical indication is different from a trade mark? A trade mark is a sign which is used in the course of trade and it distinguishes goods or services of one enterprise from those of other enterprises. Whereas a geographical indication is an indication used to identify goods having special characteristics originating from a definite geographical territory.

5. **Trademarks** - A trademark protects signs, symbols, logos, words, or sounds that distinguish between the products and services from the competitors

   A trademark is a sign capable of distinguishing the goods or services of one enterprise from those of other enterprises. Trademarks are protected by intellectual property rights.

In principle, a trademark registration will confer an exclusive right to the use of the registered trademark. This implies that the trademark can be exclusively used by its owner, or licensed to another party for use in return for payment. Registration provides legal certainty and reinforces the position of the right holder, for example, in case of litigation.

The term of trademark registration can vary, but is usually ten years. It can be renewed indefinitely on payment of additional fees. Trademark rights are private rights and protection is enforced through court orders.

Types of Trade Marks/What can be registered as Trademarks?

A word or a combination of words, letters, and numerals can perfectly constitute a trademark. But trademarks may also consist of drawings, symbols, three-dimensional features such as the shape and packaging of goods, non-visible signs such as sounds or fragrances, or color shades used as distinguishing features – the possibilities are almost limitless.

Benefits of Trade Marks:

i. Distinguish your products and prevent consumer confusion
ii. Allow consumers to base their purchasing decisions
iii. Build brand image and reputation of a company
iv. Provide additional revenue and guarantee
v. Help fight against counterfeiting and unfair competition

6. **Trade secrets** - A trade secret is a company's process or practice that is not public information, which provides an economic benefit or advantage to the company or holder of the trade secret. Trade secrets must be actively protected by the company and are typically the result of research and development.

Trade secrets are intellectual property (IP) rights on confidential information which may be sold or licensed.

In general, to qualify as a trade secret, the information must be:

a. commercially valuable because it is secret,
b. be known only to a limited group of persons, and
c. be subject to reasonable steps taken by the rightful holder of the information to keep it secret, including the use of confidentiality agreements for business partners and employees.

The unauthorized acquisition, use or disclosure of such secret information in a manner contrary to honest commercial practices by others is regarded as an unfair practice and a violation of the trade secret protection.

Information Protected under Trade Secrets:

In general, any confidential business information which provides an enterprise a competitive edge and is unknown to others may be protected as a trade secret.

Trade secrets encompass both technical information, such as information concerning manufacturing processes, pharmaceutical test data, designs and drawings of computer programs, and commercial information, such as distribution methods, list of suppliers and clients, and advertising strategies.

A trade secret may be also made up of a combination of elements, each of which by

itself is in the public domain, but where the combination, which is kept secret, provides a competitive advantage.

Other examples of information that may be protected by trade secrets include financial information, formulas and recipes and source codes.

24.5.2 Benefits of IPR:

Intellectual property rights not only protect the ideas or concepts of business but also protect the genuine business assets that are vital to the products and services. Several advantages to secure intellectual property rights include:

1. **Enhances market value** - Intellectual property rights can help you generate business through the licensing, sale and even commercialization of the products and services protected under IPRs. This will ultimately improve the market share and helps in raising profits. Having registered and protected intellectual property rights can also raise the business' value in case of sale, merger or acquisition.
2. **Turn ideas and thoughts into profit-making assets** - Ideas have little value on their own but registering ideas under intellectual property rights can help you turn it into commercially successful products and services. Copyrighting or licensing the patents can lead to a steady stream of royalties and additional income.
3. **Market your products and services** - Getting intellectual property rights can help your business' image. Intellectual property rights like trademark registration can help you separate your products and services from others.
4. **Access or raise Capital** - Through sale, licensing, or by using IPRs as collateral for debt financing, an individual can monetize for debt financing. Intellectual property rights can be used as an advantage while applying for government funding like grants, subsidies, and loans.
5. **Enhances export opportunities** – A business that has registered IPRs will be able to use brands and designs to market its products and services to other markets as well. A business can also tap into the franchising agreements with overseas companies or export patented products

24.6 BIO SAFETY

Biosafety and Bioethics:

Advances in biotechnology and their applications deals with genetic manipulation

Biosafety: Biosafety is the prevention of large-scale loss of biological integrity, focusing both on ecology and human health. These prevention mechanisms include conduction of regular reviews of the biosafety in laboratory settings, as well as strict guidelines to follow. Many laboratories handling biohazards employ an ongoing risk management assessment and enforcement process for biosafety. Failures to follow such protocols can lead to increased risk of exposure to biohazards or pathogens

Bioethics - Ethical, Legal and Social Implications (ELSI):

Bioethics refers to the study of ethical issues emerging from advances in biology and medicine. It is also a moral discernment as it relates to medical policy and practice. Bioethicists are concerned with the ethical questions that arise in the relationships among life sciences, biotechnology and medicine. It

includes the study of values relating to primary care and other branches of medicine.

The scope of bioethics is directly related to biotechnology, including cloning, gene therapy, life extension, human genetic engineering, astroethics life in space, and manipulation of basic biology through altered DNA, RNA and proteins. These developments in biotechnology will affect future evolution, and may require new principles, such as biotic ethics, that values life and its basic biological characters and structures. The Ethical, Legal, and Social Implications (ELSI) program was founded in 1990 as an integral part of the Human Genome Project. The mission of the ELSI program was to identify and address issues raised by genomic research that would affect individuals, families, and society. A percentage of the Human Genome Project budget at the National Institutes of Health and the U.S. Department of Energy was devoted to ELSI research

Genetic Engineering Appraisal Committee (GEAC): GEAC is an apex body under Ministry of Environment, Forests and Climate change for regulating manufacturing, use, import, export and storage of hazardous microbes or genetically modified organisms (GMOs) and cells in the country. It was established as an apex body to accord approval of activities involving large scale use of hazardous microorganisms and recombinants in research and industrial production. The GEAC is also responsible for approval of proposals relating to release of genetically engineered organisms and products into the environment including experimental field trials

24.7 AGRO-CLIMATIC ZONES OF TAMIL NADU

Tamil Nadu is the eleventh largest state in India by area. The land area has been classified into seven agro-climatic zones based on soil characteristics, rainfall distribution, irrigation pattern, cropping pattern and other ecological and social characteristics. The following are the seven agro-climatic zones of the State

1. North Eastern zone
2. North Western zone
3. Western zone
4. Cauvery delta zone
5. Southern zone
6. High rainfall zone
7. Hill and high altitude zone

Zone	Districts	Altitude (m)	Annual rainfall (mm)	Crops grown
North Eastern	Kanchipuram, Chengalpet, Tiruvallur, Cuddalore, Villupuram, Kallakuruchi, Vellore, Tirupathur, Ranipet,Tiruvannamalai	100-200	1105	Rice, Pearl Millet, Sorghum, Gingelly, Finger Millet, Groundnut, Red Gram, Sugarcane, Cashew, Mango, Guards, Green Chillies, Brinjal, Tapioca, Yam, Banana, Jack, Guava, Watermelon, Turmeric, Tube rose, Crossandra and Lemongrass.

North Western	Dharmapuri, Salem, Namakkal	200-600	875	Sorghum, Rice, Millet, Groundnut, Horse Gram,Cotton, Sugarcane, Tapioca, Cotton, Gingelly, Chillies, Mango, Banana, Tobacco, Pulses, Jack, Tomato, Radish, Brinjal, Ladies Finger, Pepper, Arecanut, Cocoa, Coconut, Palmarosa, Chrysanthemum, Jasmine, Marigold, Rose, Tuberose, Cutflowers, Turmeric and Red Chillies.
Western	Erode, Coimbatore, Karur (part), Namakkal (part), Dindigul (part), Theni (part)	200-600	715	Sorghum, Pulses, Groundnut, Rice, Millets, Cumbu, Cotton, Sugarcane, Ragi, Black Gram, Sunflower, Green Gram, Gingelly, Red Gram, Turmeric, Maize, Banana, Onion, Castor, Tobacco, Guava, Onion, Guards, Tomato, Tea, Coffee, Coconut, Gloriosa, Flowers, Tapioca, Jasmine, Rose and other Vegetables.
Cauvery Delta Zone (CDZ)	Tiruchi, Perambalur, Pudukottai (part), Thanjavur, Nagapattinam, Mayiladuthurai, Tiruvarur, Cuddalore (part)	100-200	984	Rice, Cumbu, Maize, Cholam, Ragi, Black Gram, Green Gram, Coconut, Gingelly, Castor, Groundnut, Banana, Onion, Cashew, Betel vine, Citrus, Jack and other Vegetables.
Southern	Madurai, Sivagangai, Ramanathapuram, Virudhunagar, Tirunelveli, Tenkasi, Thoothukudi	100-600	857	Rice, Maize, Cumbu, Cholam, Ragi, Black Gram, Greengram, Groundnut, Fodder Crops, Gingelly, Castor, Cotton, Chillies, Banana, Jasmine, Coriander, Onion, Lime, Cashew and Amla.
High Rainfall	Kanniyakumari	100-2,000	1,420	Rice, Banana, Jackfruit, Mango, Tapioca, Cashew nut, Coconut, Clove, Vegetables & Tamarind.
Hilly and High Altitude	Nilgiris, Kodaikanal	> 2,000	2,124	Wheat, Garlic, Lemon, Lime, Pomegranate, Pineapple, Beans, Beetroot, Cabbage, Chowchow, Cotton, Pepper, Coffee, Potato, Banana, Mandarin, Orange,

				Pear, Cardamom, Cutflowers, Strawberry, Avocado, Tea and Ginger.

Rainfall and Crops cultivated

North Eastern zone

1. The North Eastern zone is prone to frequent cyclonic damage.
2. In this zone, 352 mm rainfall normally received during Southwest monsoon season is more adequate and therefore length of growing season accounts to 200 days.
3. Hence, rainfed crops are successfully cultivated in this zone.
4. Groundnut is the most widely cultivated rainfed crop in this zone.
5. Other crops like sesame, sorghum, pearl millet and rainfed rice are also cultivated.

North Western zone

1. The North Western zone receives 400mm of rainfall through southwest monsoon.
2. Mean maximum temperature ranges from 30°C to 37°C and mean minimum temperature from 19°C to 25.5°C.
3. Length of growing season in this zone is 180 days.
4. Crops such as finger millet, sorghum, groundnut, horse gram, sugarcane, cotton, tapioca and vegetables are widely grown in this zone.
5. Groundnut, sorghum, finger millet, sesame and small millets are grown as rainfed crops.

Western zone

1. The Western zone receives a mean annual rainfall of 715 mm in 45 rainy days of which 49 percent is received during northeast monsoon season.
2. Mean maximum temperature during April month is 35°C and during January month is 30°C.
3. Mean minimum temperature ranges from 19°C to 24°C.
4. Rice, sugarcane and banana are grown under wetland condition whereas sorghum, groundnut, small millets and pulses are grown as rainfed crops in red soils and cotton, sorghum, bengal gram and sunflower are the rainfed crops in black soils.

Cauvery Delta zone

1. Annually, a mean rainfall of 984 mm is received in the Cauvery delta zone of which more than 50 per cent is received through Northeast monsoon rains.
2. The predominant crop of this zone is rice. Other crops such as sugarcane and banana are also successfully cultivated in this zone.
3. Sorghum and groundnut are raised as rainfed crops in uplands.

Southern zone

1. The Southern zone receives a mean annual rainfall of 857 mm in 43 rainy days, of which 400 mm is received through Northeast monsoon rains.
2. The monthly mean maximum temperature ranges from 28°C to 38.5°C and monthly mean minimum temperature ranges from 21°C to 27.5°C.
3. Important crops of this zone are rice, cotton, millets, sugarcane, sunflower, coriander and bengal gram.
4. Sorghum, cotton and sunflower are cultivated as rainfed crops during Northeast monsoon season.

High rainfall zone

1. The High rainfall zone receives a mean annual rainfall of 1420mm in 64 rainy days. On an average 533, 527, 312 and 47 mm

rainfall is received during southwest monsoon, northeast monsoon, summer and winter seasons, respectively,
2. Monthly mean maximum temperature ranges from 28°C to 33°C and monthly mean minimum temperature from 22°C to 26.5°C.
3. Rice is the predominantly grown crop in this zone.
4. Widely cultivated rainfed crop is tapioca.
5. Plantation crops like coconut, rubber, pepper, and cardamom are widely cultivated in this zone.
6. Coconut- arecanut-tapioca is the predominant multi-storeyed cropping system in this zone.

Hill and high altitude zone

1. This zone covers the Nilgiris, Kodaikanal, Shevroy, Elagir Javadhi, Kollimalai, Pachamalai, Yercaud, Anamalais, Palani and Podhigaimalai.
2. This zone covers an area of 2,549 sq.kms.
3. The area under cultivation is 73,689 hectares which is only 28.9 per cent of the total geographical, area of the zone.
4. Furthermore, only 0.84 per cent of the total cultivated area is the irrigated area i.e., 621 hectares.
5. The annual normal rainfall is 2124 mm.
6. There are no dams for irrigation in this zone since there are no major rivers.
7. Paddy and groundnut are cultivated relatively in less extent.
8. The major crops are tea, coffee and vegetables.
9. Forest area is 1,50,139 hectares which is 58.9 per cent of the total geographical area of the zone.

24.8 GENETIC ENGINEERING & ITS IMPORTANCE IN AGRICULTURE

Benefits of Genetic Engineering in Agriculture:

a. **Human health and nutrition:**
   a. Genetically engineered crops are being developed to alleviate food allergies. For example, research is creating genetically engineered wheat with greatly reduced gluten content. If successful, genetically engineered wheat may allow those suffering celiac disease to enjoy foods normally made with wheat flour.
   b. Some genetically engineered crops under development are designed to alleviate serious nutrient deficiencies in humans, especially in the developing world. There are several genetically engineered crops designed to alleviate deficiencies of Vitamin A, folate, Vitamin C, iron, and other micronutrients and minerals.
   c. Toxic substances occur naturally in our foods, whether conventional or organic. Many of these substances are produced naturally by plants as they grow. Others are formed during food preparation. Certain genetically engineered crops can have considerably lower concentrations of naturally occurring toxins, such as mycotoxins, which can have serious health impacts.
   d. Genetically engineered crops can be developed to have high amounts of healthy oils. For example, a variety of soybean has been engineered to produce high amounts of a healthy oil called oleic acid.

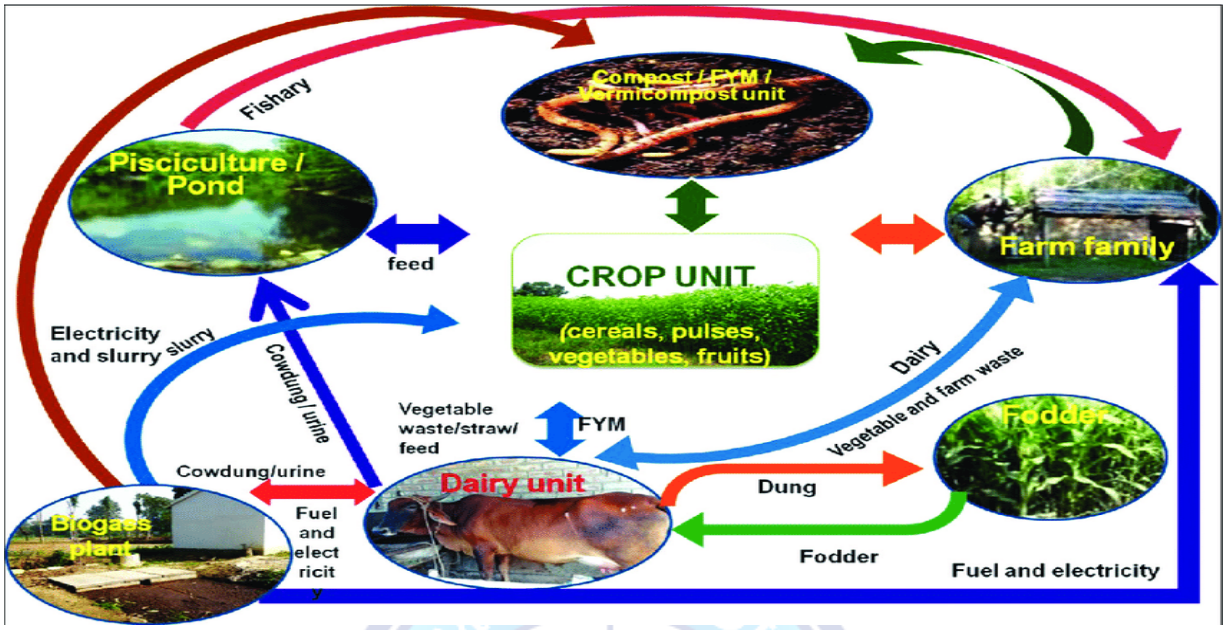
b. **Less pesticide:** Studies have shown reductions in pesticide use through the use of certain genetically engineered crops, such as those engineered to produce Bt protein. This has important benefits to consumers (less pesticide residues on foods) and the environment (less contamination of ecosystems). Significant benefits for farmers and farm workers include less exposure to pesticides and fewer pesticide poisonings.
c. **Environmentally friendly pest control:** Certain genetically engineered crops are designed to be resistant to damaging insects and diseases This can help increase yield as well as reduce pesticide use. Some genetically engineered crops, which require few insecticides, promote the buildup of natural enemies of destructive insect pests.
d. **Lower environmental footprint**: Most scientists believe that present and future genetically engineered crops can help reduce the environmental footprint of our food system. Genetically engineered crops currently under development are expected to use fertilizer and irrigation more efficiently, reducing the impact of farming on water quality and water supplies. Others are expected to reduce emissions of greenhouse gases. Still others are expected to reduce food waste, which will have important environmental benefits.
e. **Soil conservation:** Use of certain genetically engineered varieties can facilitate the expansion of no-tillage agriculture in some crops. This protects the land from erosion and helps promote healthy soils. No-tillage farming may also increase natural carbon storage in soils, which helps to mitigate climate change. Finally, notill farming helps protect rivers, lakes, and streams, by reducing runoff of nutrients and soil that pollute surface waters.
f. **Increased yield**: Numerous studies have found yield increases associated with the use of genetically engineered crops due to improved insect and weed control. Conventional breeding also produces yield increases, so crop improvement benefits from both conventional techniques and from genetic engineering.
g. **Reduced labor costs**: Genetically engineered crops that allow for pesticide reductions often mean that labor costs are reduced. It is important to note that reduced labor needs may affect local employment, which can be a negative consequence of improved farming efficiency.
h. **Higher profits**: Many times, farmers' profits are higher with genetically engineered crops. In developed countries, this helps support farmers, while in developing countries, higher profits mean greater food security and a better quality of life for farm families.
i. **Stress-tolerant crops:** Farmers must produce crops under the environmental stresses of a changing climate. Genetically engineered traits are being developed to protect against those stresses, including crop tolerance to flooding, drought, and temperature extremes

24.9 INTEGRATED FARMING SYSTEM (IFS)

Integrated farming system is a sustainable agricultural system that integrates livestock, crop production, fish, poultry, tree crops, plantation crops and other systems that benefit each other.

It is based on the concept that 'there is no waste' and 'waste is only a misplaced resource' which means waste from one component becomes an input for another part of the system.

IFS approach is considered to be the most powerful tool for enhancing profitability of farming systems especially for small and marginal farmers to make them bountiful



Goals/Objectives of Integrated Farming System:

a. Enhancing productivity per unit area
b. Proper waste management
c. Generation of continuous income round the year
d. Reducing use of chemicals
e. Maximization of yield of all component enterprises
f. Soil health management
g. Diversification of income
h. Biodiversity conservation
i. Food security
j. Empowerment of small-scale farmers
k. Reduces suicides
l. Reduces the impacts of climate change and natural calamities like drought
m. Energy security
n. Carbon sequestration through agro forestry
o. Increase the employment

Characteristics of Integrated Farming System:

An integrated farming system (IFS) is a sustainable agricultural production system that involves the integration of different agricultural and non-agricultural components. The characteristics of an IFS are as follows:

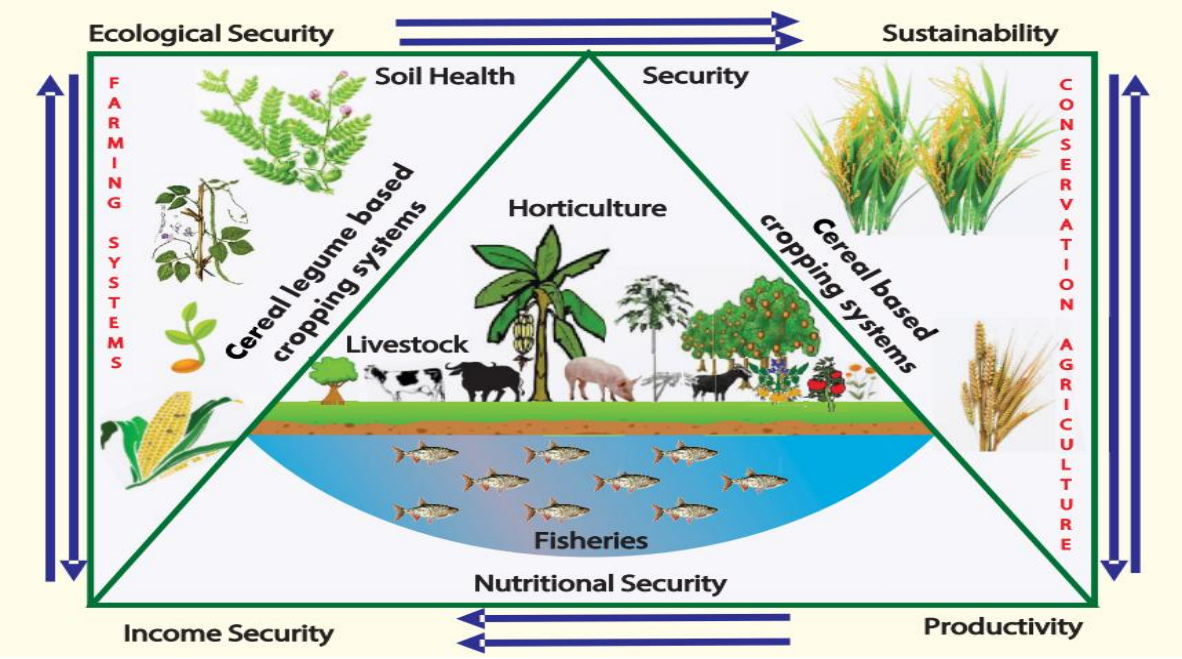
1. **Integration:** IFS emphasizes the integration of different farming components, such as crops, livestock, and trees, into a single system to optimize the use of resources and reduce waste.
2. **Diversification:** IFS seeks to promote diversity by growing a variety of crops, raising different types of livestock, and incorporating other components such as fish ponds and beekeeping into the farming system.
3. **Resource conservation:** IFS promotes the conservation of natural resources, such as soil, water, and biodiversity, through practices such as crop rotations, intercropping, agroforestry, and the use of organic and natural fertilizers.
4. **Efficiency:** IFS seeks to optimize resource use and minimize waste by using integrated

pest management (IPM), efficient water management, and other sustainable practices.

5. **Livelihood improvement:** IFS aims to improve the livelihoods of farmers by increasing productivity, diversifying income streams, and improving food security and nutrition.
6. **Sustainability:** IFS seeks to create a more sustainable farming system that can adapt to changing environmental and economic conditions, while also contributing to climate change mitigation and biodiversity conservation
7. **Farm management:** IFS requires proper farm management practices such as proper planning, monitoring and evaluation, record keeping and decision-making for effective utilization of resources.
8. **Social benefits:** IFS can help to improve the livelihoods of rural communities by providing them with sustainable farming practices that improve their productivity, income, and overall well-being.
9. **Adaptability:** IFS can be adapted to different agro-climatic zones, production systems, and cultural practices. It can be customized according to the specific needs and conditions of farmers.

Components of IFS:

1. Piggery
2. Poultry
3. Duckery
4. Fishery
5. Plantation crops
6. Apiary
7. Mushroom Cultivation
8. Vermicomposting
9. Fruit cultivation



Factors affecting farming type:

1. Physical factor (climate, soil, topography)
2. Economic factor Marketing cost Labor availability Capital land value Prevalent pests and diseases,
3. Social factor (community type, ease of transportation, marketing facilities, and cooperative spirit) (income, production, minimising cost etc.),
4. Availability of resources and components.

Factors to be considered:__The following factors have to be considered while selecting IFS in rainfed areas.

Soil types, rainfall and its distribution and length of growing season are the major factors that decide the selection of suitable annual crops, trees and livestock components. The needs and resource base of the farmers also decides the selection of IFS components in any farm.

Suitable grain crops: According to soil type we can select suitable crops.

Black soil:

Cereals: Maize
Millets: Sorghum, bajra
Pulses: Greengram, blackgram, redgram, chickpea, soybean, horse gram
Oilseeds: Sunflower, safflower
FIbre: Cotton
Other crops: Coriander, chillies,

Red soil

Millets: Sorghum
Minor Millets: ragi, tenai, samai, pani varagu, varagu
Pulses: Lab- lab, greengram, red gram, soybean, horse gram, cowpea
Oilseeds: Groundnut, castor, sesame

2. Suitable forage crops

Black soils

Fodder sorghum, fodder bajra, fodder cowpea, desmanthus, Rhodes grass, Mayil kondai pul, Elusine sp., Thomson grass

Red soils

Fodder cholam, fodder bajra, Neelakolukattai (Blue Buffel Grass), fodder ragi, Sanku pushpam (Conch flower creeper), fodder cowpea, Muyal Masal (Stylo), siratro, marvel grasses, spear grass, vettiver

3. Suitable tree species

Tamarind, Vagai (Ladies tongue), Arappu, Kodai vel, Neem, Hardwickia binata, Ber, Indian Gooseberry, Casuarina, Silk cotton etc, are suitable for red gravelly/sandy red loam soils.

Karu vel, A.tortilis, A.albida, Neem, Vagai, Holoptelia integrifolia, Manja neythi, Hibiscus tilifolia, Gmelina arborea, Casuarina, Subabuland Adina cordifolia are suitable for black soils.

4. Suitable livestock and birds

Goat, sheep, white cattle, black cattle, pigeon, rabbit, quail and poultry

Example:

1. Agriculture + Horticulture + Poultry + Fishery + Azolla + Mushroom
    a. Mushroom cultivation : Straw residues for manuring, composting, mushrooms
    b. Poultry : Egg/ meat, Manure, feeds for pig, income
    c. Azolla : Bio-fertilzer, balanced feed for all cattles, natural fertilizer for rice
2. Agriculture + Horticulture + Poultry + Fishery
3. Horticulture + Duckery + Fishery + Plantation crops + Vermicomposting + Apiary
4. Horticulture + Piggery + Fisheries + Plantation Crops
    a. Pig dung acts as excellent pond fertilizer and some fishes feeds directly on the pig excreta
    b. Pond water is used for cleaning pigsties and bathing the pigs
    c. Plantation trees as shade for the fishery pond or planted as fodder production between orchard trees to prevent soil erosion

Integrated farming systems models for India's agro-ecological zones

High altitude cold desert: Pastures with forestry, sheep, goats, rabbits, and yak and limited crops like millets, wheat, barley, vegetables, and fodders.

Arid and desert regions: Animal husbandry with camels, sheep, and goats with moderate crop components involving pearl millet, wheat, pulses, oilseeds, and fodders.

Western and Central Himalayas: Emphasis on horticultural crops with crops like maize, wheat, rice, pulses, and fodders on terraces, pastures with forestry, poultry, sheep, goats, rabbits, and yak.

Eastern Himalayas: Horticultural crops with crops like maize, wheat, rice, pulses, and pasture on terraces, pastures with forestry, sheep, goats, rabbits, yak, and cold-water fisheries at altitudes of more than 2,000 meters above mean sea level (MAMSL). Maize, rice, french bean, rice bean, pigs, poultry, fishery, and cole crops like cabbage at more than 1,000 mamsl. Rice, pulses, dairy, fish culture, and vegetables in zones lower than 1,000 m amsl.

Indo-Gangetic Plains: Intensive crop husbandry involving rice, maize, wheat, mustard, pulses, and dairy.

Central and southern highlands: Crops such as millets, pulses, and cotton along with dairy cattle, sheep, goat, and poultry.

Central and southern highlands: Crops such as millets, pulses, and cotton along with dairy cattle, sheep, goat, and poultry.

Western Ghats: Plantation crops, rice and pulses, and livestock components including cattle, sheep, and goats.

Delta and coastal plains: Rice and pulse crops along with fish and poultry.

Advantages of Integrated Farming System

1. Higher food production to equate the demand of the exploding population of our nation
2. Increased farm income through proper residue recycling and allied components
3. Sustainable soil fertility and productivity through organic waste recycling
4. Integration of allied activities will result in the availability of nutritious food enriched with protein, carbohydrate, fat, minerals and vitamins
5. Integrated farming will help in environmental protection through effective recycling of waste from animal activities like piggery, poultry and pigeon rearing
6. Reduced production cost of components through input recycling from the byproducts of allied enterprises
7. Regular stable income through the products like egg, milk, mushroom, vegetables, honey and silkworm cocoons from the linked activities in integrated farming
8. Inclusion of biogas & agro forestry in integrated farming system will solve the prognosticated energy crisis
9. Cultivation of fodder crops as intercropping and as border cropping will result in the availability of adequate nutritious fodder for animal components like milch cow, goat / sheep, pig and rabbit
10. Firewood and construction wood requirements could be met from the agroforestry system without affecting the natural forest
11. Avoidance of soil loss through erosion by agro-forestry and proper cultivation of each part of land by integrated farming
12. Generation of regular employment for the farm family members of small and marginal farmers.

Challenges/Limitations of IFS:

1. Lack of knowledge about sustainable farming systems
2. Unavailability of various farming system models
3. Lack of credit facilities with low interest rates
4. Lack of banking acumen and habit to fully utilise loan facilities
5. Lack of marketing information among farmers
6. Lack of deep freezing and storage facilities
7. Dedicated/committed extension services
8. Lack of timely availability of inputs
9. Lack of knowledge/education within agricultural population, particularly among rural youth

Issues to be considered

1. The need for adaptive research to develop an efficient IFS model
2. The provision of training to technicians, extension workers, and farm engineers to support and sustain farming systems
3. The availability of adequate banking facilities and loans, with a priority for small and marginal farmers
4. The provision of assured marketing facilities, particularly for perishable commodities

Integrated Farming System is a promising approach for increasing productivity and profitability through recycling the farm by-products and efficient utilization of available resources. Further it generates employment opportunities to the farming communities round the year and provide a better economic and nutritional security

It also maintains environmental quality and ecological stability

24.10 COMPOSTING

Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions. Raw organic materials such as crop residues, animal wastes, food garbage, some municipal wastes and suitable industrial wastes, enhance their suitability for application to the soil as a fertilizing resource, after having undergone composting.

A mass of rotted organic matter made from waste is called compost.

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

Why composting is necessary?

1. The rejected biological materials contain complex chemical compounds such as lignin, cellulose, hemicellulose, polysaccharides, proteins, lipids etc.
2. These complex materials cannot be used as such as resource materials.
3. The complex materials should be converted into simple inorganic element as available nutrient.
4. The material put into soil without conversion will undergo conversion inside the soil.
5. This conversion process take away all energy and available nutrients from the soil affecting the crop.
6. Hence conversion period is mandatory.

Advantages of Composting

a. Volume reduction of waste.
b. Final weight of compost is very less.
c. Composting temperature kill pathogen, weed seeds and seeds.
d. Matured compost comes into equilibrium with the soil.

e. During composting number of wastes from several sources are blended together.
f. Excellent soil conditioner
g. Saleable product
h. Improves manure handling
i. Reduces the risk of pollution
j. Pathogen reduction
k. Additional revenue.
l. Suppress plant diseases and pests.
m. Reduce or eliminate the need for chemical fertilizers.
n. Promote higher yields of agricultural crops.
o. Facilitate reforestation, wetlands restoration, and habitat revitalization efforts by amending contaminated, compacted, and marginal soils.
p. Cost-effectively remediate soils contaminated by hazardous waste.
q. Remove solids, oil, grease, and heavy metals from storm water runoff.
r. Capture and destroy 99.6 percent of industrial volatile organic chemicals (VOCs) in contaminated air.
s. Provide cost savings of at least 50 percent over conventional soil, water, and air pollution remediation technologies, where applicable.

The Benefits of Using Composts to Agriculture

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

Improves the Physical Properties of Soils

a. Reduces the soil bulk density and improves the soil structure directly by loosening heavy soils with organic matter, and indirectly by means of aggregate-stabilizing humus contained in composts. Incorporating composts into compacted soils improves root penetration and turf establishment.
b. Increases the water-holding capacity of the soil directly by binding water to organic matter, and indirectly by improving the soil structure, thus improving the absorption and movement of water into the soil. Therefore, water requirement and irrigation will be reduced.
c. Protects the surface soil from water and wind erosion by reducing the soil-dispersion action of beating raindrops, increasing infiltration, reducing water runoff, and increasing surface wetness. Preventing erosion is essential for protecting waterways and maintaining the quality and productivity of the soil.
d. Helps bind the soil particles into crumbs by the fungi or actinomycetes mycelia contained in the compost and stimulated in the soil by its application, generally increasing the stability of the soil against wind and water erosion.
e. Improves soil aeration and thus supplies enough oxygen to the roots and escapes excess carbon dioxide from the root space.
f. Increases the soil temperature directly by its dark color, which increases heat absorption by the soil, and indirectly by the improved soil structure.
g. Helps moderate soil temperature and prevents rapid fluctuations of soil temperature, hence, providing a better environment for root growth. This is especially true of compost used as a surface mulch.

Enhances the Chemical Properties of Soils

a. Enables soils to hold more plant nutrients and increases the cation exchange capacity (CEC), anion exchange capacity (AEC), and buffering capacity of soils for longer periods of time after composts are applied to soils. This is important mainly for soils containing little clay and organic matter.
b. Builds up nutrients in the soil. Composts contain the major nutrients required by all plants [N,P,K, calcium (Ca), magnesium(Mg), and S] plus essential micronutrients or trace elements, such as copper (Cu), zinc (Zn), iron (Fe), manganese (Mn), boron (B), and molybdenum (Mb).
c. The nutrients from mature composts are released to the plants slowly and steadily. The benefits will last for more than one season.
d. Stabilizes the volatile nitrogen of raw materials into large protein particles during composting, thereby reducing N losses.
e. Provides active agents, such as growth substances, which may be beneficial mainly to germinating plants.
f. Adds organic matter and humus to regenerate poor soils.
g. Buffers the soil against rapid changes due to acidity, alkalinity, salinity, pesticides, and toxic heavy metals.

Improves the Biological Properties of Soils

a. Supplies food and encourages the growth of beneficial microorganisms and earthworms.
b. Helps suppress certain plant diseases, soil borne diseases, and parasites.
c. Research has shown that composts can help control plant diseases (e.g. Pythium root rot, Rhizoctonia root rot, chili wilt, and parasitic nematode) and reduce crop losses. A major California fruit and vegetable grower was able to cut pesticide use by 80% after three years of compost applications as part of an organic matter management system. Research has also indicated that some composts, particularly those prepared from tree barks, release chemicals that inhibit some plant pathogens. Disease control with compost has been attributed to four possible mechanisms:
    1) successful competition for nutrients by beneficial microorganisms;
    2) antibiotic production by beneficial microorganisms;
    3) successful predation against pathogens by beneficial microorganisms;
    4) activation of disease-resistant genes in plants by composts; and
    5) high temperatures that result from composting kill pathogens.
d. Reduces and kills weed seeds by a combination of factors including the heat of the compost pile, rotting, and premature germination.

Economic and Social Benefits of Composting

The economic and social benefits of composting include the following:

a. Brings higher prices for organically grown crops.
b. Composting can offer several potential economic benefits to communities:
c. Extends current landfill longevity and delays the construction of a more expensive replacement landfill or incinerator.
d. Reduces or avoids landfill or combustor tipping fees, and reduces waste disposal fees and long-distance transportation costs.
e. Offers environmental benefits from reduced landfill and combustion use.
f. Creates new jobs for citizens.
g. Produces marketable products and a less-cost alternative to standard landfill cover, artificial soil amendments, and conventional bioremediation techniques.

h. Provides a source of plant nutrients and improves soil fertility; results in significant cost savings by reducing the need for water, pesticides, fungicides, herbicides, and nematodes.
i. Used as an alternative to natural topsoil in new construction, landscape renovations, and container gardens. Using composts in these types of applications is not only less expensive than purchasing topsoil, but it can also often produce better results when establishing a healthy vegetative cover.
j. Used as mulch for trees, orchards, landscapes, lawns, gardens, and makes an excellent potting mix. Placed over the roots of plants, compost mulch conserves water and stabilizes soil temperatures. In addition, it keeps plants healthy by controlling weeds, providing a slow release of nutrients, and preventing soil loss through erosion.

25.10.1 TYPES OF COMPOSTING TECHNIQUES

a. Coir pith composting
b. Poultry Composting
c. Crop Residue Composting
d. Safal Composting
e. Vermicomposting

Coir pith Composting:

Coir pith is a by-product generated from coir industries. It is composed of short fibres and the mesocarp pith remaining after the extraction of long fibres from the reused or fresh coconut husk. The ratio of fibre to pith in the coconut mesocarp is 30:70, weight by weight basis. In India, husks obtained from about 40-60% of the coconuts produced are used for coir fibre production.

Coir pith has high porosity and holds up to 500% moisture that makes it a unique input as soil amendment. In addition to these important physical properties, it contains high concentration of potash which makes it more useful. However, high polyphenolic content makes raw coir-pith toxic to roots of many crops. Therefore, composting is an ideal option for its beneficial utilization in agriculture as this can help in reducing the concentration of toxic phenolics and make the plant nutrients easily available.

The largest by products of coconut is coconut husk from which coir fibre is extracted. This extraction process generates a large quantity of dusty material called coir dust or coir pith. Large quantity of coir waste of about 7.5 million tonnes is available annually form coir industries in India. In Tamil Nadu state alone 5 lakh tons of coir dust is available.

Coir pith has gained importance owing to its properties for use as a growth medium in Horticulture. Because of wider carbon and nitrogen ratio and lower biodegradability due to high lignin content, coir pith is still not considered as a good carbon source for use in agriculture. Coir pith is composted to reduce the wider C:N ratio, reduce the lignin and cellulose content and also to increase the manorial value of pith. Composting of coir pith reduces its bulkiness and converts plant nutrients to the available form

Benefits:

a. The addition of composted coir dust improves soil texture, structure and tilth, sandy soil become more compact and clayey soil become more arable.
b. It improves the soil aggregation
c. It improves the water holding capacity (more than 5 times its dry weight) contributing towards increased soil moisture.
d. The bulk density of both the sub surface (15-30 cm) sioil is reduced to considerable extent with the application composted coir pith.
e. Composted coir dust contains all plant nutrient elements and it can provide a supplemental effect along with inorganic fertilizers.

f. There is improvement in cation exchange capacity of soils, where composted coir pith is applied.
g. Coir pith compost application increased the soil native microflora because of addition of humic materials.
h. Ammonification, nitrification and nitrogen fixation are increased due to improved microbiological activity.

Application of coir pith compost

a. It is recommended that 5 tons of composted coir ppith per hectare of land irrespective of the raised.
b. Is is advised that composted coir pith should be applied basally before take up the sowing.
c. For nursery development in poly bags and in mud pots, while preparing the potting mixture 20 % of composted coir pith can be mixed with the soil and sand before filing it in the poly bag or mud pot
d. For applying to the established trees like coconut, mango, banana and other fruit bearing trees, minimum 5 kg composted coir pith is required.

Limitation in using composted coir pith

a. It is not economical to buy composted coir pith and put in the farm for large areas. It is better to prepare compost in the own farm.
b. Before buying composted coir dust, it should be ensured that the material is composted completely and quality analysis certificate is available with the material.
c. If immature compost is applied to the soil, even after entering into the soil, it will undergo decomposition inside the soil, by taking nutrients from the soil. Because of this, standing crop will get affected.

Composting of Poultry Wastes

Poultry industry is one of the largest and fastest growing livestock production systems in the world. In India, there are about 3430 million populations of poultry with a waste generation of 3.30 million tonnes per year. The localized nature of poultry production also means that it can represent a large percentage of the agricultural economy in many states or regions. Although economical and successful, the poultry industry is currently facing with a number of highly complex and challenging environmental problems, many of which are related to its size and geographically concentrated nature. From an agricultural perspective, poultry wastes plays major role in the contamination of ground water through nitrate nitrogen. Also, the eutrophication of surface water due to phosphorus, pesticides, heavy metals and pathogens present in the poultry wastes applied to soils are the central environmental issues at the present time.

Among the animal manures, poultry droppings have higher nutrient contents. It has nitrogen (4.55 to 5.46 %), phosphorus (2.46 to 2.82 %), potassium (2.02 to 2.32 %), calcium (4.52 to 8.15 %), magnesium (0.52 to 0.73 %) and appreciable quantities of micronutrients like Cu, Zn, Fe, Mn etc. In addition to this cellulose (2.26 to 3.62%), hermicellulose (1.89 to 2.77 %) and lignin (1.07 to 2.16 %) are also present in poultry waste. These components upon microbial action can be converted to value added compost with high nutrient status. In poultry droppings, nearly 60%of nitrogen which is present as uric acid and urea is lost through ammonia volatilization by hydrolysis. This loss of nitrogen reduces the agronomic value of the product, besides causing atmospheric pollution. Composting with amendment seems promising in conservation of nitrogen in poultry droppings. Nitrogen in poultry waste can be effectively conserved by composting with suitable organic amendment. The technologies developed will be highly useful to the poultry farmers.

Benefits:

Poultry wastes contain higher concentrations of nitrogen, calcium and phosphorus than

wastes of other animal species and the presence of nutrients provides more incentive for the utilization of this resource. The loss of nitrogen from poultry droppings can be effectively conserved by composting with coir pith and serves as a good source of organic nutrients to agricultural fields. To make the organic nutrients present in poultry waste available to plants, the waste has to be composted suitably to minimize the volatilization of ammonia.

Crop Residue Composting

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

Benefits:

a. Quality and enriched manure from the crop and animal residues available in the farm. The manure contains both nutrients and beneficial microorganisms.
b. There is improvement in the physical, chemical and biological properties of the soil due to regular addition of biocompost.
c. Quality products will be obtained from the crop due to improvement in the soil fertility status.
d. Soil organic matter content increased and soil biodiversity also improved due to enhanced soil organic matter content.

Safal Composting (Fortified Composting)

India has enough potential for providing the nutrients through animal dung base organic manures. Animal dung is plenty available with the Indian farmers, but hardly few farmers utilized it as processed and mature manure or in form of compost. Rest of farmers just apply it in the field without taken care as immature and un-decomposed material, which is high in temperature resulting in non-nutritive residues leading to release of harmful pathogenic microbes, besides that such immature material application (due its wide C: N ratio) its negatively affect on productivity due to created shortage of nitrogen in soil.This type of compost heaps is available in every village throughout the country that's poorly performed for crop productivity and promotes the infestation of disease and insects. Its proper decomposition is the major and important issue for the country farmers particularly in Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Maharashtra and Gujarat where buffalo's population is high.

Organic manures maintain and restore the active soil life and health. These manures are important sources of plant nutrients, soil carbon conversation and beneficial microbial buildup in soil. But the available rural animal dung manure is made of poor quality due its un-decomposed process being very hot even after ten years lying in the heap. One dialog that is true with manure: compost should not be hot. If hot it is not consider as compost.

Organic carbon is the "Life-Glucose for dying-Soil" and mature compost is the master key for revival of soil health". Organic manures maintain and restore soil life and sustainable crop productivity and is the important sources of plant nutrients that help in soil life and sustainable crop productivity and is the important sources of plant nutrients that help in soil carbon conservation and maintains soil health buildup through beneficial micro-organisms. Mature compost should be cool, soft texture, fair smell, dark brown color, non

pathogenic, crop buster, capable to good water holding, carbon recharging, full with enzymatic activity, hormones, and antibiotics for better plant growth promoting properties.

Composting is an attractive proposition for turning on-farm organic waste materials into a good farm resource.[composting is an exothermic aerobic biological process that stabilizes biodegradable organic matter (BOM). Decomposition rates are affected by all factors that commonly affect microbial growth, i.e. carbon nitrogen ratio, oxygen supply, moisture, pH, temperature, and nutrient levels]. A measure of compost that is conducive for crop growth refers to maturity representing relationship between compost quality and crop growth. On the other hand stability refers to the aerobic biological activity, representing relationship between compost quality and biological activity within the compost.

To avoiding the boring and laborious process of composting methodology, a simple, cost effective, lest laborious, short time maturity, good quality, quick field response base technology may be the substitute of urea, interesting, easy to operate and easy adoptive to farmers. Time saving composting methodology, which readily releases the nutrients, suitable production technology to Indian farmers, is the hour.

Safal mean successful/ value added or fortified composting technology which has been introduced after reviewing the existing ten compost production methodologies working in India. It is based on most simple concept that, works on the base of natural aeration, to reduce the heap temperature to normal and incubation by adding inoculums for accelerate the decomposition process and value addition through natural minerals for nutrient enrichment by natural mean on natural dung heap.

Benefits of safal compost production Technologies

1) No need of regular turning of dung heap material
2) No extra cost on structure construction
3) Least laborious (only three-hour labour) work for complete composting
4) No market-oriented input required
5) This method would fasten the mineralization process and hence make the nutrients readily and easily available to the crops.
6) Quality performance is better than other composting methods due to high biological activity with decomposition process at normal temperature with added natural minerals in compost.
7) 45 Days safal compost is comparable with FCO suggested standards for compost

Beneficial effects of organic Manures

1) Provides micro and macronutrients
2) Foods for microorganisms and stimulate their activity
3) Increase the humus content and promote fertility
4) Improves soil properties
5) Increase WHC in sandy soils and drainage in clayey soils
6) Increase CEC and buffer action
7) Check the soil erosion
8) Provide vitamins, hormones, and antibiotics for better plant growth promoting substances
9) Increase the availability of nutrients and its cycles.

24.11 VERMICULTURE

Vermiculture means artificial rearing or cultivation of worms (Earthworms) and the technology is the scientific process of using them for the betterment of human beings.

Vermicompost is the excreta of earthworm, which is rich in humus. Earthworms eat cow dung or farm yard manure along with other

farm wastes and pass it through their body and in the process convert it into vermicompost.

Vermicomposting is the process of turning organic debris into worm castings. The worm castings are very important to the fertility of the soil. The castings contain high amounts of nitrogen, potassium, phosphorus, calcium, and magnesium. Castings contain: 5 times the available nitrogen, 7 times the available potash, and 1 ½ times more calcium than found in good topsoil.

Several researchers have demonstrated that earthworm castings have excellent aeration, porosity, structure, drainage, and moisture-holding capacity. The content of the earthworm castings, along with the natural tillage by the worms burrowing action, enhances the permeability of water in the soil. Worm castings can hold close to nine times their weight in water. "Vermiconversion," or using earthworms to convert waste into soil additives, has been done on a relatively small scale for some time. A recommended rate of vermicompost application is 15-20 percent.

Materials used in vermi-compost: Materials for preparation of Vermicompost are

a. Any types of biodegradable wastes-
b. Crop residues
c. Weed biomass
d. Vegetable waste
e. Leaf litter
f. Hotel refuse
g. Waste from agro-industries
h. Biodegradable portion of urban and rural wastes

The municipal wastes; non-toxic solid and liquid waste of the industries and household garbage's can also be converted into vermicompost in the same manner. Earthworms not only convert garbage into valuable manure but keep the environment healthy. Conversion of garbage by earthworms into compost and the multiplication of earthworms are simple process and can be easily handled by the farmers.

Advantages of Vermi-compost:

a. Vermicompost is rich in all essential plant nutrients.
b. Provides excellent effect on overall plant growth, encourages the growth of new shoots / leaves and improves the quality and shelf life of the produce.
c. Vermicompost is free flowing, easy to apply, handle and store and does not have bad odour.
d. It improves soil structure, texture, aeration, and waterholding capacity and prevents soil erosion.
e. Vermicompost is rich in beneficial micro flora such as a fixers, P- solubilizers, cellulose decomposing micro-flora etc in addition to improve soil environment.
f. Vermicompost contains earthworm cocoons and increases the population and activity of earthworm in the soil.
g. It neutralizes the soil protection.
h. It prevents nutrient losses and increases the use efficiency of chemical fertilizers.
i. Vermicompost is free from pathogens, toxic elements, weed seeds etc.
j. Vermicompost minimizes the incidence of pest and diseases.
k. It enhances the decomposition of organic matter in soil.
l. It contains valuable vitamins, enzymes and hormones like auxins, gibberellins etc.

Compost worms are not subject to diseases caused by micro-organisms, but they are subject to predation by certain animals and insects (red mites are the worst) and to a disease known as "sour crop" caused by environmental conditions.

24.12 BIO-FERTILIZER

Biofertilizers are ready to use live formulates of such beneficial microorganisms which on application to seed, root or soil mobilize the availability of nutrients by their biological activity in particular, and help build up the micro-flora and in turn the soil health in general.

Biofertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. Biofertilizers could be also called as microbial cultures, bioinoculants, bacterial inoculants or bacterial fertilizers.

1. They are efficient in fixing nitrogen, solubilising phosphate and decomposing cellulose.
2. They are designed to improve the soil fertility, plant growth, and also the number and biological activity of beneficial microorganisms in the soil.
3. They are eco-friendly organic agro inputs and are more efficient and cost effective than chemical fertilizers

What are the benefits from using biofertilizers?

1. Increase crop yield by 20-30%.
2. Replace chemical nitrogen and phosphorus by 25%.
3. Stimulate plant growth.
4. Activate the soil biologically.
5. Restore natural soil fertility.
6. Provide protection against drought and some soil borne diseases.

What are the advantages of bio-fertilizers?

1. Cost effective.
2. Suppliment to fertilizers.
3. Eco-friendly (Friendly with nature).
4. Reduces the costs towards fertilizers use, especially regarding nitrogen and phosphorus.

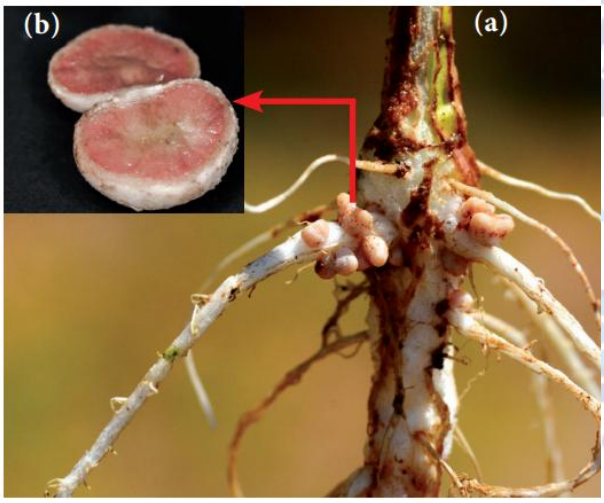
Classification of Biofertilizers:

SI. No.	Groups	Examples
N2 fixing Biofertilizers		
1.	Free-living	*Azotobacter, Beijerinkia, Clostridium, Klebsiella, Anabaena, Nostoc,*
2.	Symbiotic	*Rhizobium, Frankia, Anabaena azollae*
3.	Associative Symbiotic	*Azospirillum*
P Solubilizing Biofertilizers		
1.	Bacteria	*Bacillus megaterium* var. *phosphaticum, Bacillus subtilis Bacillus circulans, Pseudomonas striata*
2.	Fungi	*Penicillium sp, Aspergillus awamori*
P Mobilizing Biofertilizers		
1.	Arbuscular mycorrhiza	*Glomus sp.,Gigaspora sp.,Acaulospora sp., Scutellospora sp.* & *Sclerocystis sp.*
2.	Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*
3.	Ericoid mycorrhizae	*Pezizella ericae*
4.	Orchid mycorrhiza	*Rhizoctonia solani*
Biofertilizers for Micro nutrients		
1.	Silicate and Zinc solubilizers	*Bacillus* sp.

Plant Growth Promoting Rhizobacteria		
1.	Pseudomonas	*Pseudomonas fluorescens*

Rhizobium:

1. Bio-fertilisers containing rhizobium bacteria are called rhizobium bio-fertilizer culture.
2. Symbiotic bacteria that reside inside the root nodules convert the atmospheric nitrogen into a bio available form to the plants.
3. This nitrogen fixing bacterium when applied to the soil undergoes multiplication and fixes the atmospheric nitrogen in the soil.
4. Rhizobium is best suited for the paddy fields which increase the yield by 15 – 40%.

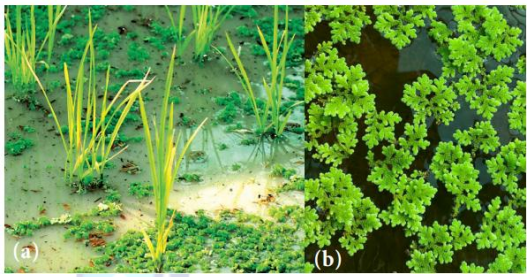


Azotobacter

1. Of the several species of Azotobacter, A. chroococcum happens to be the dominant inhabitant in arable soils capable of fixing N2 (2-15 mg N2 fixed /g of carbon source) in culture media.
2. The bacterium produces abundant slime which helps in soil aggregation.
3. The numbers of A. chroococcum in Indian soils rarely exceeds 105/g soil due to lack of organic matter and the presence of antagonistic microorganisms in soil.

Azolla

1. Azolla is a free-floating water fern that fixes the atmospheric nitrogen in association with nitrogen fixing blue green alga Anabaena azolla.
2. It is used as a bio-fertilizer for wetland rice cultivation and is known to contribute 40 – 60 kg/ha/crop.
3. The agronomic potential of Azolla is quite significant particularly for increasing the yield of rice crop, as it quickly decompose in soil.



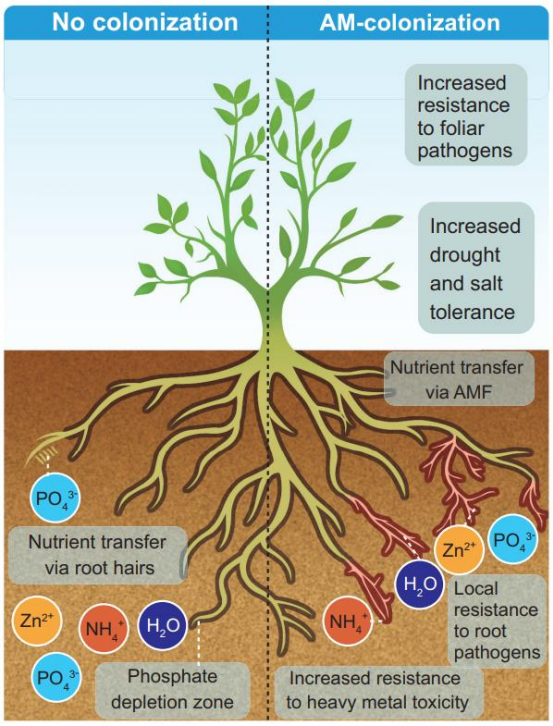
Cyanobacteria

1. Both free-living as well as symbiotic cyanobacteria (blue green algae) have been harnessed in rice cultivation in India.
2. A composite culture of BGA having heterocystous Nostoc, Anabaena, Aulosira etc. is given as primary inoculum in trays, polythene lined pots and later mass multiplied in the field for application as soil based flakes to the rice growing field at the rate of 10 kg/ha.
3. The final product is not free from extraneous contaminants and not very often monitored for checking the presence of desiredalgal flora.
4. Once so much publicized as a biofertilizer for the rice crop, it has not presently attracted the attention of rice growers all over India except pockets in the Southern States, notably Tamil Nadu.

5. The benefits due to algalization could be to the extent of 20-30 kg N/ha under ideal conditions but the labour oriented methodology for the preparation of BGA biofertilizer is in itself a limitation.
6. Quality control measures are not usually followed except perhaps for random checking for the presence of desired species qualitatively.

Arbuscular mycorrhizae

1. Arbuscular mycorrhizae (AM) is formed by the symbiotic association between certain phycomycetous fungi and angiosperm roots.
2. They have the ability to dissolve the phosphates found in abundance in the soil.
3. Apart from increasing the availability of phosphorus, AM provides necessary strength to resist disease, germs and unfavourable weather conditions.
4. It also assures water availability



Benefits of AM colonisation

Liquid Biofertilizers:

Biofertilizers are such as Rhizobium, Azospirillum and Phosphobacteria provide nitrogen and phosphorous nutrients to crop plants through nitrogen fixation and phosphorous solubilization processes. These Biofertilizers could be effectively utilized for rice, pulses, millets, cotton, sugarcane, vegetable and other horticulture crops. Biofertilizers is one of the prime input in organic farming not only enhances the crop growth and yield but also improves the soil health and sustain soil fertility. At present, Biofertilizers are supplied to the farmers as carrier based inoculants. As an alternative, liquid formulation technology has been developed which has more advantages than the carrier inoculants

Benefits

The advantages of Liquid Bio-fertilizer over conventional carrier based Bio-fertilizers are listed below:

1. Longer shelf life -12-24 months.
2. No contamination.
3. No loss of properties due to storage upto 45° c.
4. Greater potentials to fight with native population.
5. High populations can be maintained more than 109 cells/ml upto 12 months to 24 months.
6. Easy identification by typical fermented smell.
7. Cost saving on carrier material, pulverization, neutralization, sterilization, packing and transport.
8. Quality control protocols are easy and quick.
9. Better survival on seeds and soil.
10. No need of running Bio-fertilizer production units through out the year.
11. Very much easy to use by the farmer.

12. Dosages is 10 time less than carrier based powder Bio-fertilizers.
13. High commercial revenues.
14. High export potential.
15. Very high enzymatic activity since contamination is nil.

Seaweed Liquid Fertilizer:

1. Seaweed liquid fertilizer (SLF) contains cytokinin, gibberellins and auxin apart from macro and micro nutrients.
2. Most seaweed based fertilizers are made from kelp(brown algae) which grows to length of 150 metres.
3. seaweed Liquid fertilizer is not only organic but also eco-friendly.
4. The alginates in the seaweed that react with metals in the soil and form long, cross-linked polymers in the soil.
5. These polymers improve the crumbing in the soil, swell up when they get wet and retain moisture for a long time.
6. They are especially useful in organic gardening which provides carbohydrates for plants. Seaweed has more than 70 minerals, vitamins and enzymes.
7. It promotes vigorous growth. Improves resistance of plants to frost and disease.
8. Seeds soaked in seaweed extract germinate much rapidly and develop a better root system

Constraints in Biofertilizer Technology:

Though the biofertilizer technology is a low cost, ecofriendly technology, several constraints limit the application or implementation of the technology the constraints may be environmental, technological, infrastructural, financial, human resources, unawareness, quality, marketing, etc. The different constraints in one way or other affecting the technique at production, or marketing or usage.

Technological constraints

1. Use of improper, less efficient strains for production.
2. Lack of qualified technical personnel in production units.
3. Unavailability of good quality carrier material or use of different carrier materials by different producers without knowing the quality of the materials.
4. Production of poor quality inoculants without understanding the basic microbiological techniques
5. Short shelf life of inoculants.

Infrastructural constraints

1. Non-availability of suitable facilities for production
2. Lack of essential equipments, power supply, etc.
3. Space availability for laboratory, production, storage, etc.
4. Lack of facility for cold storage of inoculant packets

Financial constraints

1. Non-availability of sufficient funds and problems in getting bank loans
2. Less return by sale of products in smaller production units.

Environmental constraints

1. Seasonal demand for biofertilizers
2. Simultaneous cropping operations and short span of sowing/planting in a particular locality
3. Soil characteristics like salinity, acidity, drought, water logging, etc.

Human resources and quality constraints

1. Lack of technically qualified staff in the production units.
2. Lack of suitable training on the production techniques.
3. Ignorance on the quality of the product by the manufacturer
4. Non-availability of quality specifications and quick quality control methods

5. No regulation or act on the quality of the products

Awareness on the technology

1. Unawareness on the benefits of the technology
2. Problem in the adoption of the technology by the farmers due to different methods of inoculation.
3. No visual difference in the crop growth immediately as that of inorganic fertilizers.
4. Awareness on the technology

Unawareness on the benefits of the technology.

1. Problem in the adoption of the technology by the farmers due to different methods of inoculation.
2. No visual difference in the crop growth immediately as that of inorganic fertilizers.
3. Unawareness on the damages caused on the ecosystem by continuous application of inorganic fertilizer.

Marketing constraints

1. Non availability of right inoculant at the right place in right time.
2. Lack of retain outlets or the market network for the producers.

Bio-Pesticides:

1. Bio-pesticides are biological agents used for the control of plant pests.
2. They are in high use due to their non-toxic, cheaper and eco-friendly characteristics as compared to chemical or synthetic pesticides.
3. Bio-pesticides have become an integral component of pest management in terms of the environmental and health issues attributed to the use of chemicals in agriculture.

Trichoderma:

1. Trichoderma species are free-living fungi that are common in soil and root ecosystem.
2. They have been recognized as bio-control agent for
    a. the control of plant disease
    b. ability to enhance root growth development
    c. crop productivity
    d. resistance to abiotic stress and
    e. uptake and use of nutrients.

Beauveria

1. Beauveria species is an entomo-pathogenic fungus that grows naturally in soils throughout the world.
2. It acts as a parasite on various arthropod species causing white muscardine disease without affecting the plant health and growth.
3. It also controls damping off of tomato caused by Rhizoctonia solani.

24.13 MANURES

Manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition. The art of collecting and using wastes from animal, human and vegetable sources for improving crop productivity is as old as agriculture. Manures are the organic materials derived from animal, human and plant residues which contain plant nutrients in complex organic forms. Naturally occurring or synthetic chemicals containing plant nutrients are called fertilizers. Manures with low nutrient, content per unit quantity have longer residual effect besides improving soil physical properties compared to fertilizer with high nutrient content. Major sources of manures are:

1. Cattle shed wastes-dung, urine and slurry from biogas plants

2. Human habitation wastes-night soil, human urine, town refuse, sewage, sludge and sullage
3. Poultry litter, droppings of sheep and goat
4. Slaughterhouse wastes-bone meal, meat meal, blood meal, horn and hoof meal, Fish wastes
5. Byproducts of agro industries-oil cakes, bagasse and press mud, fruit and vegetable processing wastes etc
6. Crop wastes-sugarcane trash, stubbles and other related material
7. Water hyacinth, weeds and tank silt, and
8. Green manure crops and green leaf manuring material

Classification of Manures:

Manures can also be grouped, into

1. Bulky organic manures and
2. concentrated organic manures based on concentration of the nutrients.

Bulky organic manures

Bulky organic manures contain small percentage of nutrients and they are applied in large quantities. The most important and widely used bulky organic manures are:

(1) Farmyard manure (FYM),
(2) compost and
(3) green-manure

Use of bulky organic manures has **several advantages:**

(1) They supply plant nutrients including micronutrients
(2) They improve soil physical properties like structure, water holding capacity etc.,
(3) They increase the availability of nutrients
(4) Carbon dioxide released during decomposition acts as a CO2 fertilizer and
(5) Plant parasitic nematodes and fungi are controlled to some extent by altering the balance of microorganisms in the soil.

Concentrated organic manures

Concentrated organic manures have higher nutrient content than bulky organic manure. The important concentrated organic manures are

(1) oilcakes,
(2) blood meal,
(3) fish manure etc.

These are also known as organic nitrogen fertilizer. Before their organic nitrogen is used by the crops, it is converted through bacterial action into readily usable ammoniacal nitrogen and nitrate nitrogen. These organic fertilizers are, therefore, relatively slow acting, but they supply available nitrogen for a longer period.

Oil cakes: After oil is extracted from oilseeds, the remaining solid portion is dried as cake which can, be used as manure. The oil cakes are of two types:

- ✓ Edible oil cakes which can be safely fed to livestock; e.g.: Groundnut cake, Coconut cake etc., and
- ✓ Non edible oil cakes which are not fit for feeding livestock; e.g.: Castor cake, Neem cake, Mahua cake etc.,

Both edible and non-edible oil cakes can be used as manures. However, edible oil cakes are fed to cattle and non-edible oil cakes are used as manures especially for horticultural crops. Nutrients present in oil cakes, after mineralization, are made available to crops 7 to 10 days after application. Oilcakes need to be well powdered before application for even distribution and quicker decomposition.

Green Manure

Green manuring is the practice of growing a short duration, succulent and leafy legume crop and ploughing the plants in the same field before they form seeds.

Green undecomposed material used as manure is called green manure. It is obtained in two ways: by growing green manure crops or by

collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest. Green manuring is growing in the field plants usually belonging to leguminous family and incorporating into the soil after sufficient growth. The plants that are grown for green manure known as green manure crops.

The most important green manure crops are

1. sunnhemp,
2. dhaincha,
3. pillipesara,
4. clusterbeans and
5. Sesbania rostrata.

manure. Plants growing in wastelands, field bunds etc., are another source of green leaf manure.

The **important plant species** useful for green leaf manure are

1. neem,
2. mahua,
3. wild indigo,
4. Glyricidia,
5. Karanji (Pongamia glabra)
6. calotropis,
7. avise(Sesbania grandiflora),
8. subabul and other shrubs.

Advantages

1. Improves soil structure
2. Increases water holding capacity and
3. Decreases soil loss by erosion

GREEN LEAF MANURE

Green leaf manuring refers to adding the loppings from legume plants or trees to a field and then incorporating them into the soil by ploughing.

Application of green leaves and twigs of trees, shrubs and herbs collected from elsewhere is known as green leaf manuring. Forest tree leaves are the main sources for green leaf

Advantages

1. Green manuring improves soil structure, increases water holding capacity and decreases soil loss by erosion.
2. Growing of green manure crops in the off season reduces weed proliferation and weed growth.
3. Green manuring helps in reclamation of alkaline soils. Root knot nematodes can be controlled by green manuring

Neem Use and Potential in Organic Agriculture

Neem in Pest Management

Unlike chemical insecticides, neem compounds work on the insect's hormonal system, not on the digestive or nervous system and therefore does not lead to development of resistance in future generations. These compounds belong to a general class of natural products called liminoids'. The liminoids present in neem make it a harmless and effective insecticides, pesticide, nematicide, fungicide etc. The most significant liminoids found in neem with proven ability to block insect growth are: azadirachtin, salanin, meliantriol and nimbin. Azadirachtin is currently considered as neem's main agent for controlling insects. 'It appears to cause 90% of the effect on most pests. It does not kill insects - at least not immediately - instead it both repels and disrupts their growth and reproduction. Research over the past years has shown that it is the most potent growth regulator and feeding deterrent ever assayed. It will repel or reduce the feeding of many species of pest insects as well as some nematodes. In fact, it is so potent that a mere trace of its presence prevents some insects from even touching the plants.'

Neem extracts are known to act on various insects by:

1. Disrupting or inhibiting the development of eggs, larvae or pupae.
2. Blocking the moulting of larvae or nymphs
3. Disrupting mating and sexual communication
4. Repelling larvae and adults
5. Deterring females from laying eggs
6. Sterilizing adults
7. Poisoning larvae and adults
8. Deterring feeding
9. Blocking the ability to "swallow" (that is, reducing the motility of the gut)
10. Sending metamorphosis awry at various stages
11. Inhibiting the formation of chitin.

Uses of Neem Extracts:

1. Neem Leaf Extract - The extract is beneficial against leaf eating caterpillars, grubs, locusts and grasshoppers. To the extract, emulsifier is added as mentioned in kernel extract.
2. **Neem Against Non-Insect Pests**
3. **For protecting Stored Grains**
4. **Neem for Soil Fertility and Fertilizer Management**

Panchagavya

Panchagavya, an organic product has the potential to play the role of promoting growth and providing immunity in plant system. Panchagavya consists of nine products viz. cow dung, cow urine, milk, curd, jaggery, ghee, banana, Tender coconut and water. When suitably mixed and used, these have miraculous effects.

Beneficial effects of Panchagavya on commercial crops:

Mango

1. Induces dense flowering with more female flowers
2. Irregular or alternate bearing habit is not experienced and continues to fruit regularly
3. Enhances keeping quality by 12 days in room temperature
4. Flavour and aroma are extraordinary

Acid lime

1. Continuous flowering is ensured round the year
2. Fruits are plumpy with strong aroma
3. Shelf life is extended by 10 days

Guava

1. Higher TSS
2. Shelf life is extended by 5 days

Banana

1. In addition to adding with irrigation water and spraying, 3% solution (100 ml) was tied up at the naval end of the bunch after the male bud is removed. The bunch size becomes uniform. One month earlier harvest was witnessed. The size of the top and bottom hands was uniformly big.

Turmeric

2. Enhances the yield by 22%
3. Extra long fingers
4. Ensure low drainage loss
5. Narrows the ratio of mother and finger rhizomes
6. Helps survival of dragon fly, spider etc which in turn reduce pest and disease load
7. Sold for premium price as mother/seed rhizome
8. Enriches the curcumin content

Jasmine

1. Exceptional aroma and fragrance
2. No incidence of bud worm
3. Continuous flowering throughout the year

Vegetables

1. Yield enhancement by 18% and in few cases like Cucumber, the yield is doubled
2. Wholesome vegetables with shiny and appealing skin
3. Extended shelf life
4. Very tasty with strong flavour

Dasagavya

Dasagavya, is an organic preparation made from ten products in the form of panchagavya and certain plant extracts. "Gavya" is th term given to cow's products comprising of cow dung, cow urine, cow's milk, curd and ghee, which have miraculous effects on plant growth when suitably mixed.

Advantages

1. Increases growth, yield and quality of the crops
2. Controls pests like aphids, thrips, mites and other sucking pests
3. Controls diseases like leaf spot, leaf blight, powdery mildew etc.

24.14 IRRIGATION MANAGEMENT

DRIP IRRIGATION:

Drip irrigation refers to application of water in small quantity to the zone of the plants through a network of plastic pipes fitted with emitters. Drip irrigation in its present form has become compatible with plastics that are durable and easily moulded into a variety and complexity of shapes required for pipe and emitters.

MERITS

1. Increased water use efficiency
2. Better crop yield
3. Uniform and better quality of the produce
4. Efficient and economic use or fertiliser through fertigation
5. Less weed growth
6. Minimum damage to the soil structure
7. Avoidance of leaf burn due to saline soil
8. Usage in undulating areas and slow permeable soil

9. Low energy requirement (i.e.) labour saving
10. High uniformity suitable for automization

DEMERITS

1. Clogging of drippers
2. Chemical precipitation
3. Salt accumulation at wetting front

FERTIGATION:

ADVANTAGES

1. Eliminates manual application
2. Quick and convenient
3. Uniformity in application
4. High efficiency and saving of fertiliser upto 30 - 40%
5. Less fel1ilizer leaching
6. Better penetration of P and K in the layers
7. Co-ordination of nutrition requirement with crop stage or development
8. Possibility of dosage control.
9. Others like herbicides, pesticides, acid, etc can also he applied

LIMITATIONS

1. Toxicity to field workers
2. Chance of backflow into water source, for that NRV and vacuum valve has to be installed
3. Insoluble fel1ilisers are not suitable (super phosphate)
4. Corrosive effect of fertiliser
5. Phosphate may get precipitated in the pipe line and dripper due to pH reaction
6. The high cost of establishing fertigation systems: Majority of farmers are poor in India.
7. Clogging of lines: It is due to precipitation of bicarbonates and insoluble di-calcium phosphate, magnesium phosphate and calcium carbonate
8. Salt injury: In arid climate, mobile nutrient anions such as nitrate and chloride together with cations Na+ and Ca2+ may accumulate around the wet zone on the soil surface due to evaporation
9. Nutrient deficiency: On heavy clay soils, water ponding may be there and at high temperature due to anaerobic conditions, nitrate N loss by denitrification may be there.
10. Oxygen deficiency: Oxygen might be excluded from the saturation zone when there is continuous supply of water at higher regime in the wet soil volume
11. Lack of awareness: Efforts are needed to create awareness among people to create demand for micro irrigation system and water soluble fertilizers

Characteristics of fertilizers for fertigation

Any fertilizer applied through drip irrigation should have following characteristics:

1. High nutrient content readily available to plants
2. Soluble at field temperature conditions
3. Fast dissolution in irrigation water
4. Should not clog filters and emitters
5. Low content of insolubles (<0.02%)
6. Minimum content of conditioning agents and compatible with other fertilizers
7. Minimal interaction with irrigation water
8. It should not result in drastic changes in water pH
9. It should be low corrosive for control head system

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. The pressure is usually obtained by pumping. With careful selection of nozzle sizes, operating pressure and sprinkler spacing the amount of irrigation water required to refill the crop root zone can be applied nearly uniform at the rate to suit the infiltration rate of soil

Advantages of sprinkler irrigation

1. Elimination of the channels for conveyance, therefore no conveyance loss
2. Suitable to all types of soil except heavy clay
3. Suitable for irrigating crops where the plant population per unit area is very high. It is most suitable for oil seeds and other cereal and vegetable crops
4. Water saving
5. Closer control of water application convenient for giving light and frequent irrigation and higher water application efficiency
6. Increase in yield
7. Mobility of system
8. May also be used for undulating area
9. Saves land as no bunds etc. are required
10. Influences greater conducive micro-climate
11. Areas located at a higher elevation than the source can be irrigated
12. Possibility of using soluble fertilizers and chemicals
13. Less problem of clogging of sprinkler nozzles due to sediment laden water

PLASTIC MULCHING FOR CROP PRODUCTION

Mulching is the process or practice of covering the soil/ground to make more favourable conditions for plant growth, development and efficient crop production. Mulch technical term means 'covering of soil'. While natural mulches such as leaf, straw, dead leaves and compost have been used for centuries, during the last 60 years the advent of synthetic materials has altered the methods and benefits of mulching. The research as well as field data available on effect of synthetic mulches make a vast volume of useful literature. When compared to other mulches plastic mulches are completely impermeable to water; it therefore prevents direct evaporation of moisture from the soil and thus limits the water losses and soil erosion over the surface. In this manner it plays a positive role in water conservation. The suppression of evaporation also has a supplementary effect; it prevents the rise of water containing salt, which is important in countries with high salt content water resources.

Advantages of plastic mulching

1. It is completely impermeable to water.
2. It prevents the direct evaporation of moisture form the soil and thus limits the water losses and conserves moisture.
3. By evaporation suppression, it prevents the rise of water containing salts.
4. Mulch can facilitate fertilizer placement and reduce the loss of plant nutrient through leaching.
5. Mulches can also provide a barrier to soil pathogens
6. Opaque mulches prevent germination of annual weeds from receiving light
7. Reflective mulches will repel certain insects
8. Mulches maintain a warm temperature even during nighttime which enables seeds to germinate quickly and for young plants to rapidly establish a strong root growth system.
9. Synthetic mulches play a major role in soil solarisation process.
10. Mulches develop a microclimatic underside of the sheet, which is higher in carbondi-oxide due to the higher level of microbial activity.
11. Under mulch, the soil structure is maintained during cropping period
12. Early germination almost 2-3 days.
13. Better nodulation in crops like Groundnut.
14. Less nematodes population.
15. Water erosion is completely averted since soil is completely covered form bearing action of rain drops.
16. When compared to organic mulches, it serves for a longer period.

Moisture conservation

1. Plastic film with its moisture barrier properties does not allow the soil moisture to escape Water that evaporates from the

soil surface under mulch film, condenses on the lower surface of the film and falls back as droplets.
2. Thus moisture is preserved for several days and increases the period between two irrigations.
3. The irrigation water or rainfall either moves into the soil thru holes on the mulch around the plant area or through the un-mulched area.

Weed control

1. Black plastic film does not allow the sunlight to pass through on to the soil
2. Photosynthesis does not take place in the absence of sunlight below black film hence, it arrests weed growth

Limitations

1. They are costly to use in commercial production when compared to organic mulches.

2. Probability of 'burning' or 'scorching' of the young pants due to high temperature of black film.
3. Difficulty in application of top dressed fertilizer
4. Reptile movement and rodent activities are experienced in some places.
5. More runoff
6. Environmental pollution
7. Difficult in machinery movement
8. Can not be used for more than one season using thin mulches
9. Weed penetration with thin films
10. Toxic to livestock

Areas of application

Mulching is mainly employed for

1. Moisture conservation in rainfed areas
2. Reduction of irrigation frequency and water saving in irrigated areas
3. Soil temperature moderation in greenhouse cultivation
4. Soil solorisation for control of soil borne diseases
5. Reduce the rain impact, prevent soil erosion and maintain soil structure
6. In places where high value crops only to be cultivated

24.15 GREENHOUSE TECHNOLOGY

Growing plants is both an art and a science. About 95% of plants, either food crops or cash crops are grown in open field. Since time immemorial, man has learnt how to grow plants under natural environmental conditions. In some of the temperate regions where the climatic conditions are extremely adverse and no crops can be grown, man has developed methods of growing some high value crop continuously by providing protection from the excessive cold, which is called as Greenhouse Technology. So, Greenhouse Technology is the technique of providing favourable environment condition to the plants. It is rather used to protect the plants from the adverse climatic conditions such as wind, cold, precipitation, excessive radiation, extreme temperature, insects and diseases. It is also of vital importance to create an ideal micro climate around the plants. This is possible by erecting a greenhouse / glass house, where the environmental conditions are so modified that one can grow any plant in any place at any time by providing suitable environmental conditions with minimum labour.

Greenhouses are framed or inflated structures covered with transparent or translucent material large enough to grow crops under partial or fully controlled environmental conditions to get optimum growth and productivity

Advantages of greenhouses :

1. The yield may be 10-12 times higher than that of out door cultivation depending upon the type of greenhouse, type of crop, environmental control facilities.
2. Reliability of crop increases under greenhouse cultivation.
3. Ideally suited for vegetables and flower crops.
4. Year round production of floricultural crops.
5. Off-season production of vegetable and fruit crops.
6. Disease-free and genetically superior transplants can be produced continuously.
7. Efficient utilisation of chemicals, pesticides to control pest and diseases.
8. Water requirement of crops very limited and easy to control.
9. Maintenance of stock plants, cultivating grafted plant-lets and micro propagated plant-lets.
10. Hardening of tissue cultured plants
11. Production of quality produce free of blemishes.
12. Most useful in monitoring and controlling the instability of various ecological system.
13. Modern techniques of Hydroponic (Soil less culture), Aeroponics and Nutrient film techniques are possible only under greenhouse cultivation.

Scope for green house technology

There is a scope for using greenhouse technology for the following reasons

1) Lot of barren land is available which can be deployed for erection of green houses.
2) Low rainfall results in lack of irrigation water. Green house technology could be utilized by storing rain water and using it by drip system (Low evaporative loss of water in green houses).
3) There is a continuous demand for vegetables and flowers throughout the year.
4) There is a scope for propagation and raising nursery.
5) Government schemes are available for promoting greenhouse technology and subsidized rates for plastic and polythene.
6) Large number of unemployed youth could be diverted towards sophisticated farming in green houses.
7) There is a vast scope for export of produce.
8) There is a scope for production of exotic crops as their demand is increasing in the domestic markets.
9) Diverting educated young students towards rural area for using greenhouse technology.
10) Generating employment in erection, maintenance and marketing of greenhouse technology.
11) Ideal technology for marginal farmers

CLIMATE CONTROL IN GREEN HOUSE:

The components responsible for plant growth viz. light, temperature, CO_2 , humidity and air circulation can be controlled as under in green house

1) Ventilation: It is necessary for proper air circulation in the green houses. For natural circulation keep the sides of green house (curtains) open during day time only. Exhaust fan may also be used for dragging air out during summer
2) Temperature control: Use of fan and pad system, exhausting hot air out, use of screen and using water sprinklers / foggers temperature could be controlled. Shade net of black colour is used at the top below the cladding material to reduce light intensity whenever required.
    a. **Cooling :** Cooling of greenhouse is necessary wherever the outside temperature goes beyond 30° C

and also when cool crops are to be grown. Depending upon the cladding material and the ventilation, inside temperature remains 8 to 10° C higher than the outside temperature. In order to create better growing conditions, it will be necessary to cool the greenhouse. This can be done through evaporative cooling method, using horizontal draft fans on one side and cooling pads on the other side. The capacity of the fan and size of the pad depends on the length and width of the greenhouse and also elevation and other parameters. This system is known as fan and pad system which is very effective where the ambient humidity is low, with high temperature.

b. **Heating :** Heating is required in places where the winter temperature is very low. At higher elevations, where temperatures do not normally go above 30°C, cooling may not be necessary, only providing proper ventilation will serve the purpose. However, these places may require heating during winter. Greenhouses can be heated with the help of oil burners, hot water (or steam) or propane (or electric) heaters. Heating is a regular process in temperate countries, where temperature goes below 0^0C.

c. **CO2 control :** CO2 enrichment is done by trapping natural CO2 in the greenhouse upto 1500-2000 ppm. General level is 300 to 350 ppm whereas at 1200-1500 plant gives good response

3) Control of light intensity : Using UV stabilized sheet and shade net, light intensity is controlled up to 30000 to 60000 lux.

4) Humidity control : Relative Humidity inside the green house should be 50-80%. It is controlled by using air circulation, using sprinkles and controlling evaporation through opening and closing of side curtains

Classification of greenhouses:

Greenhouse structure of various types are used for crop production. Although there are advantages in each type for a particular application, in general there is no single type greenhouse, which can be constituted as the best. Different types of greenhouses are designed to meet the specific needs. The different types of greenhouses based on shape, utility, material and construction are briefly given below:

1. **Greenhouse type based on shape:**

For the purpose of classification, the uniqueness of cross section of the greenhouses can be considered as a factor. The commonly followed types of greenhouses based on shape are:

1) Lean to type greenhouse.
2) Even span type greenhouse.
3) Uneven span type greenhouse.
4) Ridge and furrow type.
5) Saw tooth type.
6) Quonset greenhouse.
7) Interlocking ridges and furrow type Quonset greenhouse.
8) Ground to ground greenhouse.

2. **Greenhouse type based on Utility**

Classification can be made depending on the functions or utilities. Of the different utilities, artificial cooling and heating are more expensive and elaborate. Hence based on this, they are classified in to two types.

1) Greenhouses for active heating.
2) Greenhouses for active cooling.

3. **Greenhouse type based on construction**
The type of construction predominantly is influenced by structural material, though the covering material also influence the type. Higher the span, stronger should be the material and more structural members are used to make sturdy tissues. For smaller spans, simple designs like hoops can be followed. So based on construction, greenhouses can be classified as

1) Wooden framed structure.
2) Pipe framed structure.
3) Truss framed structure.

4. Greenhouse type based on covering material

Covering materials are the important component of the greenhouse structure. They have direct influence on greenhouse effect, inside the structure and they alter the air temperature inside. The types of frames and method of fixing also varies with covering material. Hence based on the type of covering material they may be classified as

a) Glass glazing.
b) Fibre glass reinforced plastic (FRP) glazing
c) Plastic film

Integrated pest management for greenhouse crops:

Integrated Pest Management is the system that utilizes all suitable techniques in a compatible manner to reduce pest population and maintain them at levels below those causing economic and health injury.

The following steps should be considered to control pest and disease in greenhouse.

a. Use resistant varieties
b. Use pest and disease free healthy planting material.
c. Practice good sanitation techniques.
d. Monitor crop on daily basis
e. Monitor and suppress insect population.
f. Modify the environment
g. Avoid plant stress
h. Use pheromen trap, light trap, sticky cards,etc.

24.16 LIQUID NANO UREA

1. Recently, the Prime Minister inaugurated the first Liquid Nano Urea (LNU) plant at Kalol, Gujarat.
2. It is Indigenous Urea, introduced firstly by the Indian Farmers Fertiliser Cooperative Limited (IFFCO) for farmers across the world.
3. It is urea in the form of a nanoparticle. It is a nutrient (liquid) to provide nitrogen to plants as an alternative to the conventional urea.
4. Urea is a chemical nitrogen fertiliser, white in colour, which artificially provides nitrogen, a major nutrient required by plants.
5. It is developed to replace conventional urea and it can curtail the requirement of the same by at least 50%.

Objective: It is aimed at reducing the unbalanced and indiscriminate use of conventional urea, increase crop productivity, and reduce soil, water, and air pollution.

Significance:

1. Improves Plant Nutrition:
    a. It has been found effective and efficient for plant nutrition which increases production with improved nutritional quality.
    b. It will boost a balanced nutrition program by reducing the excess use of Urea application in the soil and will make the crops stronger, healthier and protect them from the lodging effect.

c. Lodging is the bending over of the stems near ground level of grain crops, which makes them very difficult to harvest, and can dramatically reduce yield.

2. Improves Environment:
   a. It will also have a huge positive impact on the quality of underground water, a very significant reduction in global warming with an impact on climate change and sustainable development.
3. Increase Farmers' Income:
   a. It is easy on the pocket of farmers and will be effective in increasing farmers' income. It will also significantly bring down the cost of logistics and warehousing.

24.17 CURRENT AFFAIRS UPDATES ON AGRICULTURE

1. **AgriSURE Fund and Krishi Nivesh Portal.**

AgriSURE Fund:

a. Stands for – Agri Fund for Startups and Rural Enterprises (AgriSURE)
b. Aim – Foster innovation and sustainability in India's agricultural sector.
c. Objective – To support approximately 85 agri startups, with investment sizes of up to Rs 25 crore each.
d. Managed by – NABVENTURES, a wholly owned subsidiary of NABARD.
e. Ministry – Ministry of Agriculture & Farmers Welfare.
f. Features –
   i. Support investments in sector-specific and debt Alternative Investment Funds (AIFs).
   ii. Direct equity support for start-ups in agriculture and allied sectors
   iii. Offers both equity and debt support.
   iv. Focuses on high-risk, high-impact activities in the agriculture value chain.

Krishi Nivesh Portal:

a. Also known as – Agriculture Investment Portal
b. A centralized, one-stop platform designed for agri-investors to access benefits from various government schemes related to agriculture and allied sectors.
c. Purpose –
d. Facilitate investment in the agriculture sector.
e. Provide a unified platform for accessing multiple government schemes.
f. Enhance transparency and efficiency in service delivery.

2. **PM-PRANAM (PM Programme for Restoration, Awareness Generation, Nourishment, and Amelioration of Mother-Earth):**
   1. Aim – To encourage the sustainable use of fertilizers, and promoting organic and natural farming.
   2. Nodal agency – Ministry of Chemicals and Fertilizers.
   3. Launched in – Union Budget 2023–24.
   4. All States/UTs are covered under the scheme.
   5. Funding – No separate budget and will be financed by the savings of existing fertilizer subsidy.
   6. Allocation –
      a. If a State/UT reduces its chemical fertilizer consumption in a financial year compared to the previous 3 years' average, 50% of the saved subsidy will be granted to that State/UT.
      b. 70% of the grant provided under the scheme can be used for asset creation related to

technological adoption of alternate fertilisers.

c. 30% grant money can be used for incentivizing farmers, panchayats, farmer producer organizations, self-help groups, etc.

3. Paramparagat Krishi Vikas Yojana (PKVY):

a. An extended component of Soil Health Management (SHM) under the National Mission on Sustainable Agriculture (NMSA).
b. Launched in – 2015
c. Type – Centrally Sponsored Scheme (CSS).
d. Aim – To promote organic farming and to enhance farmer's net income per unit of land.

4. World Soil Health Index:

✓ Objective – To standardise measure for analysing and comparing soil quality in different regions and ecosystems, and identify trends of degradation or improvement.
✓ Soil Degradation:
  - Change in soil health, resulting in diminished capacity of ecosystem to provide goods and services.
  - Status – According to World Atlas of Desertification, 75% of land is already degraded
  - Scenario in India – Around 32% of land is under degradation and 25% is undergoing desertification.
  - Causes – Unsustainable Agricultural Practices, Deforestation, Industrial Pollution etc.
✓ Impacts –
  - Reduced soil fertility leading to decline in agriculture output.
  - Releases stored carbon, contributing to greenhouse gas emissions
  - Decrease in soil organisms affecting nutrient cycling and pest control
✓ Global and National Initiatives to prevent Soil Degradation:
  - Global Land Degradation Neutrality under UNCCD.
  - Bonn Challenge to restore 350 million hectares degraded and deforested landscapes by 2030.
  - Global Soil Partnership Action Plan 2022-2030 by FAO.
  - Land Use and Land Cover Atlas of India – Released by National Remote Sensing Centre (NRSC)
  - India Soil Health Card Scheme.
  - Organic Farming Initiatives like Paramparagat Krishi Vikas Yojana

5. Purple Revolution:

✓ Purple Revolution – A scheme intended to support rapid growth of lavender cultivation in Jammu and Kashmir
✓ Under – Aroma Mission
✓ Products – Lavender oil, Lavender water (used to make incense sticks) and Hydrosol (formed after distillation from the flowers and is used to make soaps and room fresheners)
✓ Agencies – Council of Scientific and Industrial Research (CSIR) and Indian Institute of Integrative Medicine, Jammu (IIIM Jammu)
✓ Significance –
  - In sync with government policy of doubling farm incomes
  - Lavender cultivation also provided employment to women farmers thus gave impetus to inclusive growth.

6. Aroma Mission:

✓ Objective – To promote the cultivation of aromatic crops for essential oils that are in great demand by the aroma industry.
✓ Aroma Crops – Lavender, Damask rose, Mushk bala
✓ Nodal Agencies –

- Nodal laboratory – CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), Lucknow.
- Participating laboratories – CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT), Palampur; CSIR-Indian Institute of Integrative Medicine (CSIR-IIIM), Jammu etc.

✓ Coverage – Focus on areas of Vidarbha, Bundelkhand, Gujarat, Marathwada, Rajasthan, Andhra Pradesh, Odisha and other states where farmers are exposed to frequent episodes of weather extremes and account for maximum suicides.

✓ Intended Outcomes –

- Bring about 5500 ha of additional area under captive cultivation aromatic cash crops particularly targeting rain-fed and degraded land across the country.
- Provide technical and infrastructural support for distillation and values-addition to farmers all over the country.
- Enabling effective buy-back mechanisms to assure remunerative prices to the farmers
- Value-addition to essential oils and aroma ingredients for their integration in global trade and economy

7. National Livestock Mission:

✓ Ministry – Ministry of Fisheries, Animal Husbandry and Dairying

✓ Type – Both Centrally Sponsored and Central sector

✓ Key objectives –

- Entrepreneurship development in small ruminant, poultry and piggery sector & Fodder sector.
- Increase of per-animal productivity through breed improvement.
- Breed improvement of Livestock and Poultry
- Feed & Fodder
- Innovation and Extension Jurisdiction

✓ Components – 3 Sub-Mission

✓ Nano DAP Fertiliser:

✓ Nano DAP – A unique liquid fertilizer product that contains nanoparticles of Diammonium Phosphate (DAP).

✓ Features – Source of nitrogen and phosphorus (2 key primary nutrients essential for the growth of crops)

✓ Contains 8% Nitrogen and 16% Phosphorus by volume.

✓ Comes in liquid form, unlike conventional DAP which is in granular form

✓ Advantages of Nano DAP:

- Higher Crop Yield – Due to small size and more surface area to volume ratio, it enhances nutrient availability to crops
- Reduction in Chemical Fertilizer Usage – One bottle of Nano DAP can potentially replace the phosphorus requirement met by conventional DAP by 50%.
- Environment Friendly – Precision and targeted application of Nano DAP leads to agriculture sustainability and safety of the environment by reducing soil, air and water pollution.

✓ Di-Ammonium Phosphate:

- 2nd most commonly used fertilizers in India after urea.
- Feature – High in phosphorus (P) that stimulates root establishment and development

8. Urea gold:

✓ Urea gold will support the other initiative of government in the sphere of Environmentally Friendly Fertilizers (EFFs).

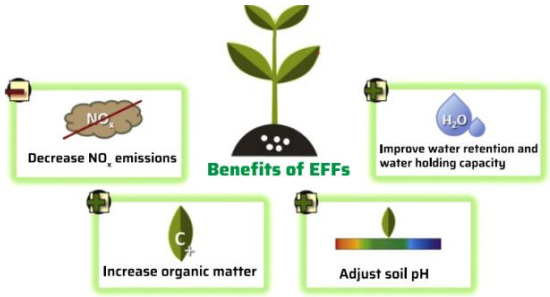
✓ A Sulphur-Coated Urea (SCU).

✓ A non-organic slow-release fertilizer

- ✓ Prepared by – Coating preheated urea granules with molten sulphur.
- ✓ Benefits of Sulphur coating –
  - Ensures a more gradual release of nitrogen.
  - Prolongs the urea action
  - Helps plants to stay greener for longer time.
  - Increases efficiency and enhances soil health.
  - Reduces frequent application of fertilizer

9. Environmentally Friendly Fertilizers (EFFs):

- ✓ Fertilizers that can reduce environmental pollution from nutrient loss by retarding, or even controlling, the release of nutrients into soil.
- ✓ Also include organic fertilizers such as Biocompost, Vermicompost, etc.
- ✓ Initiatives for EFFs in India –
  - PM PRANAM (Programme for Restoration, Awareness, Nourishment, and Amelioration of Mother Earth) Scheme
  - Pradhan Mantri Kisan Samruddhi Kendras (PMKSK): Development of Nano Urea and Neem Coated Urea
  - GOBARdhan (Galvanizing Organic Bio-Agro Resources Dhan), helps in preparing organic manure.



10. State Food Safety Index:

- ✓ A dynamic quantitative and qualitative benchmarking model that provides an objective framework for evaluating food safety.
- ✓ An annual index launched on the occasion of World Food Safety Day (7th June) since 2019.
- ✓ Released by – Food Safety and Standards Authority of India (FSSAI)
- ✓ Based on the information submitted by States/UTs.
- ✓ Aim – To measure the performance of states on parameters of food safety.
- ✓ Parameters – Originally it had 5 but 6th one was added in 5th report for the period 2022-23.
- ✓ Findings of State Food Safety Index 2022-2023:
  - Top-Ranking Large States: Kerala followed by Punjab and Tamil Nadu.
  - Top-Ranking Small states: Goa followed by Manipur and Sikkim.
  - Top-Ranking UTs: Jammu & Kashmir followed by Delhi and Chandigarh.

11. Krishi Sakhis initiative

- ✓ Ministry of Rural Development (MoRD) and the Ministry of Agriculture and Farmers' Welfare (MoA&FW) launched the training of Krishi Sakhis for the promotion of Natural Farming.
- ✓ Krishi Sakhis – They are practicing farmers and trained para-extension professionals in agriculture at the grassroots level.
- ✓ They encourage the adoption of environmentally friendly and economically viable agricultural methods by raising awareness.
- ✓ Aim – To train and certify 50,000 Krishi Sakhis in a phased manner by the National Centre for Organic and Natural Farming (NCONF).
- ✓ NCONF – a subordinate office of the Ministry of Agriculture and Farmers' Welfare.
- ✓ Training under Deendayal Antyodaya Yojana- National Rural Livelihoods Mission (DAY–NRLM).
- ✓ Natural farming:

- A chemical-free farming system with an understanding of ecology, resource recycling, and on-farm resource optimization.
- It relies on –
  - Adoption of diversified multi-cropping systems.
  - Desi cow based on-farm inputs for nutrient and soil enrichment.
  - Various botanical concoctions for plant protection.
  - It aims at restoring soil health, maintaining diversity, ensuring animal welfare, stressing on efficient use of natural/local resources, and promoting ecological fairness.
- Originally introduced by – Agriculturist Subhash Palekar
- Promotes low-cost inputs such as the use of Cow dung, aged cow urine, jaggery, pulse flour and other plant-based extracts.
- 4 Pillars –
  - Bijamrit – It is the microbial coating of seeds with formulations of cow urine and cow dung.
  - Jivamrit – It is the enhancement of soil microbes using a mixture of cow dung, cow urine and jaggery.
  - Acchadana (Mulching) – It is the covering soil with crops or crops residue.
  - Waaphasa – It is the building up of soil humus to increase soil aeration.
- Insect and pest management methods – Agniastra, Brahmastra and Neemastra.

12. Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) Scheme:

- ✓ Under the scheme, the Centre transfers an amount of ₹6,000 per year, in 3 equal instalments.
- ✓ Directly into the bank accounts of all landholding farmers irrespective of the size of their land holdings.
- ✓ Launched: 2019
- ✓ Central Sector Scheme (100% funding from the GoI)
- ✓ Ministry – Ministry of Agriculture and Farmers Welfare.
- ✓ The entire responsibility of identification of beneficiary farmer families rests with the State / UT Governments.
- ✓ Ineligibility for the PM-Kisan scheme –
  - Income tax payers.
  - Farmer families holding constitutional posts.
  - Serving or retired officers and employees of state or Central government.
  - Those working in public sector undertakings and autonomous government bodies.
  - Those earning a monthly pension of over ₹10,000.

13. Minimum Export Price (MEP)

- ✓ MEP aims to keep onion prices affordable by ensuring adequate domestic supply, as stock from the Rabi Season Onion crop is decreasing.
- ✓ What is Minimum Export Price?
- ✓ Minimum Export Price is set for a particular product below which it cannot be exported.
- ✓ It is declared under the Foreign Trade (Development & Regulation) Act, 1992.
- ✓ DGFT is an attached office of Ministry of Commerce and Industry.

14. National Turmeric Board

- ✓ Focus – Development and growth of turmeric and turmeric products in the country.
- ✓ Composition –

- A Chairperson (appointed by the Central Government)
- Members from the Ministry of AYUSH, Departments of Pharmaceuticals, Agriculture & Farmers Welfare, Commerce & Industry, etc.

✓ Mandate –
- Facilitate greater coordination with the Spices Board and other Government agencies.
- Increase awareness and consumption, develop new markets internationally to increase exports.
- Develop on traditional knowledge for value-added turmeric products.

✓ About Turmeric:
- Belongs to ginger family.
- Native to Southeast Asia.
- Climatic and Soil – Diverse tropical conditions, 20–35 degree Celsius
- Annual rainfall of 1500 mm or more.
- Well-drained sandy or clay loam soils.
- Curcumin – A major component of turmeric that gives turmeric its yellow color.
- Used in traditional Indian medical systems, cosmetic industries, to detoxify the liver etc.
- Medicinal Properties – Such as antiviral, analgesic, antibacterial, anti-inflammatory etc.
- Treatment – As a dietary supplement for arthritis, digestive disorders, respiratory infections, allergies, liver disease, depression etc.

✓ Status of Turmeric in India:
- India is the largest producer, consumer and exporter of turmeric in the world.
- Accounts over 75% of global turmeric production.
- India has more than 62% share of world trade in turmeric.
- Largest producing states – Maharashtra, Telangana, Karnataka and Tamil Nadu.
- Kandhamal Haldi, indigenous to Odisha, has a GI Tag.
- Leading export markets – Bangladesh, UAE, USA and Malaysia

15. Dr. M.S. Swaminathan:

✓ father of the Indian Green Revolution

✓ Agricultural scientist, plant geneticist, administrator, and humanitarian

✓ Leading a large-scale movement alongside farmers and fellow scientists, and with the support of public policies, helped avert famine-like situations in India and Pakistan during the 1960s.

✓ Served as the Director General of the Indian Council of Agricultural Research and headed the International Rice Research Institute in the Philippines.

✓ The United Nations Environment Programme has called him "the Father of Economic Ecology".

✓ Coined the term 'Evergreen Revolution' - "productivity in perpetuity without associated ecological harm".

✓ Swaminathan's contribution to the Green Revolution:
- The Green Revolution was a period that began in the 1960s during which agriculture in India was converted into a modern industrial system by the adoption of technology
  - High-yielding variety (HYV) seeds,
  - Mechanized farm tools,
  - Irrigation facilities, pesticides and fertilizers.

- This time period was mostly led by agricultural scientist M. S. Swaminathan in India.
- It was part of the larger Green Revolution project started by Norman E. Borlaug, which used technology and research in agriculture to boost agricultural productivity in developing countries.
- Swaminathan and Borlaug developed numerous rice and grain varieties.- Swaminathan and Norman Borlaug worked together to deliver supplies for various Mexican dwarf wheat cultivars to be crossed with Japanese kinds.
- Swaminathan focused on advanced agricultural instruments for farming.
- Dwarf strains have a higher Harvest Index – the plant puts more of its energy resources into seeds rather than leaves or other plant structures.

16. International Year of Millets:

✓ Millet is an umbrella term used to describe a variety of grains that are grown as cereal crops for human and animal consumption all over the world. Owing to their ability to thrive well in poor soil types and adverse weather conditions, millets were amongst the first few crops to be domesticated and cultivated in Asia.

✓ Hailed as a 'super food,' people all over the world are increasingly becoming aware of the priceless health benefits of millet consumption

✓ **BENEFITS OF PRODUCING MILLETS TO FARMERS** Millets are a staple cereal crop for many smallholder farmers in dryland areas of India. Millets are fabled for

- Short Cropping season
- Ability to grow in poor soils, hilly terrains, and deficient rainfall
- Minimal requirement of chemical fertilizers or pesticides
- Meagre investment, easy storage, and prolonged shelf life
- Offering a variety of economic benefits such as assured income, and sustainable livelihood

✓ **HEALTH BENEFITS TO CONSUMERS:** Millets are known to be rich in antioxidants and micronutrients. They may:

- Aid Weight Loss
- Boost Immunity
- Improve Digestion
- Control Diabetes
- Lower Cholesterol Levels

✓ Millets as Smart-Foods: Significance and Benefits5

- Nutritionally Rich: Millets are nutritionally superior to wheat and rice owing to their higher levels of protein with a more balanced amino acid profile. Similarly, the dietary fibre content of millet is also higher compared to some of the staple cereals. Millets also contain various phytochemicals which exert therapeutic properties owing to their anti-inflammatory and anti-oxidative properties.
- Climate Resilient: Millets are the backbone for dry land agriculture. They are hardy, resilient crops that have a low carbon and water footprint, can withstand high temperatures, grow on poor soils with little or no external inputs and are thus termed as the 'miracle grains' or 'crops of the future'. In times of climate change, they are the most secure crops to small farmers as they are the hardiest, most resilient and climate adaptable crops in harsh, hot (up to 50 degrees Celsius) and drought environments

- Ecologically Sustainable: Millet production is not dependent on the use of chemical fertilizers. These crops do not attract pests, and most of the millets are not affected by storage pests. Thus, the use of pesticides is also not mandated.

24.18 SCHEMES – AGRICULTURE

a. Chief Minister's Mannuyir Kaathu Mannuyir Kaappom Scheme (CM MK MKS)

- ✓ Has 22 components
- ✓ aims to preserve soil fertility through the promotion of Green Manure usage among farmers
- ✓ to produce vermicompost and to improve the soil fertility
- ✓ Comprehensive Soil Health campaigns are slated to be organized across all villages in Tamil Nadu, fostering awareness on the importance of balanced fertilizer application and Integrated nutrient management
- ✓ Reclamation of acidic and alkaline soil
- ✓ Use of Liquid Bio-Fertilisers
- ✓ Field level Surveillances
- ✓ To promote the cultivation of neem trees as Neem leaves are also utilised as green leaf manure
- ✓ Plant species like Adathoda and Nochi which have natural Bio-Insecticidal properties will be promoted for cultivation in fallow lands
- ✓ To promote a healthy lifestyle, the cultivation of traditional varieties with medicinal properties, such as Seevan Samba known for its diabetes-controlling attributes, will be actively promoted.
- ✓ Under Nel Jayaraman Mission on Conservation of Traditional Paddy Varieties, seeds of traditional varieties like Arupadham Kuruvai, Poonkar, Thooyamalli, Seeraka Samba, Mappillai Samba, Seevan Samba, Karuppu Kavuni are being produced in State Seed Farms and distributed to farmers.
- ✓ developing new varieties and improving the existing varieties of millets and pulses
- ✓ In order to promote the concept of Organic Farming among all farmers, One model Organic Farm will be created in each block of the State. T
- ✓ To encourage farmer groups interested in production and sale of organic inputs like Panchakavya, Jeevamirtham, Vermicompost, Amirthakaraisal, Meen Amilam etc., which are necessary for organic production, 100 Organic Input Production Centres will be established
- ✓ The agroforestry initiative on the farmer's land is designed not only to establish a permanent green cover but also to serve as a profitable agribusiness
- ✓ Under Integrated Farming System, farmers are encouraged to diversify their agricultural practices by incorporating crop cultivation with complementary activities such as dairy farming, goat rearing, fruit tree cultivation, honey bee rearing, and vermicompost production. This approach aims to achieve self-sustaining livelihoods through holistic development
- ✓ There is a noted shortfall in the consumption of fruits and vegetables among consumers. To encourage the cultivation of nutritious fruit crops in home gardens, kits comprising

saplings of banana, papaya, moringa, curryleaf will be distributed. This initiative aims to provide access to pesticide-free, non-toxic fruits and vegetables

- ✓ "Recognizing the significance of beekeeping for public health, a 'Honey Production Hub' will be established in Kanyakumari district
- ✓ Development of climate smart villages
- ✓ To facilitate the easy access of quality agricultural produce and value-added products, to urban consumers, 100 Uzhavar Angadis will be established along the lines of Uzhavar Sandhais

b. GRAINS (Grower Online Registration of Agriculture Inputs System)

- ✓ Comprehensive Centralized Farmers Database with Dynamic linkage of Land Records.
- ✓ Enhance planning, monitoring, and strategy formulation for improved agricultural management.
- ✓ Ensure the smooth implementation of the Direct Benefit Transfer (DBT) Scheme.
- ✓ Establish a state-level Digital Agriculture Ecosystem.
- ✓ Enable farmers to access digital services, fostering increased returns and efficiency.
- ✓ Elevate the Agriculture Sector to higher levels of productivity and efficiency

Tamil Nadu - Position in Area of various Horticultural crops at National Level

First	Second	Third
1. Tapioca 2. Clove 3. Tamarind 4. Jasmine	1. Banana 2. Watermelon 3. Cocoa 4. Chrysanthemum 5. Tuberose	1. Coconut 2. Aonla 3. Elephant foot yam 4. Black pepper
Source: Final Estimates 2022-23, Horticulture Statistics Division, Department of Agriculture & Farmers Welfare, New Delhi		

24.19 AGRICULTURE RESEARCH INSTITUTIONS AND THEIR FUNCTIONS

24.19.1 INDIAN COUNCIL OF AGRICULTURAL RESEARCH

1) ICAR - Indian Council of Agricultural Research
2) Apex body for coordinating, guiding, and managing research and education in agriculture in the entire country
3) Works under the aegis of DARE, Ministry of Agriculture and Farmers Welfare.
4) Formerly known as Imperial Council of Agricultural Research, it was established on 16 July 192
5) **Functions/Mandates:**

- ✓ To plan, undertake, aid, promote and co-ordinate education, research and its application in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- ✓ To act as a clearing house of research and general information relating to agriculture,

animal husbandry, home science and allied sciences, and fisheries through its publications and information system; and instituting and promoting transfer of technology programmes.

- ✓ To provide, undertake and promote consultancy services in the fields of education, research, training and dissemination of information in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- ✓ To look into the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology by developing co-operative programmes with other organizations such as the Indian Council of Social Science Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre and the universities.
- ✓ To do other things considered necessary to attain the objectives of the Society

24.19.2 IARI - INDIAN AGRICULTURAL RESEARCH INSTITUTE

1) Popularly known as Pusa Institute
2) Began in 1905 at Pusa (Bihar)
3) With the generous grant of 30,000 pounds from an American philanthropist, Mr. Henry Phipps.
4) Then known as Agricultural Research Institute (ARI) which functioned with five departments, namely
    a. Agriculture,
    b. Cattle Breeding,
    c. Chemistry,
    d. Economic Botany and
    e. Mycology.
5) Bacteriology unit was added in 1907.
6) The name of ARI was changed to Imperial Institute of Agricultural Research in 1911
7) In 1919 it was renamed as Imperial Agricultural Research Institute.
8) Following a devastating earth quake on 15th January 1934, the institute was shifted to Delhi on 29th July 1936.
9) Post-independence, the institute has been renamed as Indian Agricultural Research Institute (IARI)
10) **Vision:** To provide leadership for Science-led sustainable and globally competitive agriculture for food, nutrition and livelihood security
11) **Mission:** To explore new frontiers of science and develop human resources to provide the leadership in technology development and policy guidance for vibrant and resilient agriculture, which should be productive, eco-friendly, sustainable, economically profitable and socially equitable. In order to accomplish this mission, the Institute has adopted the following **mandates:**

- ✓ **Basic, strategic and anticipatory research** in field and horticultural crops for enhanced productivity and quality.
- ✓ **Research in frontier areas** to develop resource use efficient integrated crop management technologies for the sustainable agricultural production system.
- ✓ **Serve as a centre for academic excellence** in the areas of post-graduate education and human resources development in agricultural science.
- ✓ **Provide national leadership** in agricultural research, education, extension and technology assessment and transfer by developing new concepts and approaches and serving as a national reference point for quality and standards.

Goals and Objectives:

Research:

1) **Emphasize utilization of plant genetic resources**, including conservation of agriculturally important microbial, cyano-bacterial and insect resources, to produce efficient, productive and stable genotypes of crops, especially hybrids, and improve bioenergetics.
2) **Generate knowledge** related to the processes of production and productivity of agricultural crops leading to the development of research philosophies, concepts, methodologies, materials and technologies.
3) **Develop and use systems approach**, crop modeling, bio-indicators, nuclear tools, remote sensing and GIS to achieve a greater understanding of the production systems and to modify them to reduce the environmental and human health risk to make them more sustainable in the context of holistic ecological and socio-economic aspects.
4) **Pay greater attention to the problems of agriculture** under unfavorable conditions and to the orphan commodities.
5) **Foster excellence in agriculture**-related to basic and social sciences, strengthen synergism between traditional knowledge and modern science, and harness management sciences and communication systems for improving the overall efficiency.
6) **Develop capabilities in post-harvest technology**, agro-processing, product development, and value addition and utilization research on agricultural commodities, by-products, agricultural wastes and renewable energy resources.
7) **Concentrate on new and emerging cutting edge technologies** such as molecular biology and biotechnology and develop inter-disciplinary centers of excellence with modern instrumentation and foster system research.

Education:

1) **Promote excellence, foster high standard and orient the educational programme** towards future needs and opportunities.
2) **Strengthen physical, biological and social sciences** in the curricula, and frontier areas such as biotechnology, computer application and information technology, environmental science, management science, post-harvest technology, and agricultural biodiversity and genetic resources.
3) **Provide opportunities for post-doctoral research**, continuing education, faculty upgradation and development of human resources in new and cutting-edge technology areas, especially through international collaboration.
4) **Strengthen non-formal training** to promote entrepreneurial skills and commercialization of agriculture.

Extension:

1) **Generate innovative extension models**, dovetail them to developmental models, and disseminate them through regional stations, universities and state extension systems
2) **Promote client oriented on-farm research** and technology assessment, refinement and transfer through participatory approaches and by promoting the Institute-Village Linkage Programme
3) **Foster development of communication research** and linkages with rural development programmes and strengthen micro-planning through inter

departmental and participatory approaches.

24.19.3 ICRISAT 50TH ANNIVERSARY

1. ICRISAT was established under a Memorandum of Agreement between the Government of India and the CGIAR on the 28 March 1972.
2. ICRISAT's headquarters are located in Asia (India), and the organization maintains offices across Eastern and Southern Africa, West and Central Africa.
3. **Vision:** ICRISAT's vision is a prosperous, food-secure, and resilient dryland tropics
4. **Mission:** ICRISAT's mission is to reduce poverty, hunger, malnutrition and environmental degradation in the dryland tropics
5. **Values:**
    a. Inclusive culture
    b. "We" not "me"
    c. Leadership by example - inspiring yourself & others
    d. Strategic & systems thinking to change, grow & improve
6. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization
7. Conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world.
8. By bringing scientific and evidence-based robust solutions, ICRISAT and its partners help empower the people to overcome the following **major issues**:

I. **Poverty and Hunger:** Creating long-term solutions by helping people grow their own crops, making farming profitable, enabling farming technologies and techniques, better linkages to markets to sell, helping build new agri-businesses

II. **Malnutrition:** Bringing highly nutritious foods that are rich in iron, zinc, calcium and proteins into the farms

III. **Environmental Degradation:** Working with rural communities to intensify their production in ways that combats degradation of the environment

IV. **Empowering Women:** Providing rural women training, making available affordable processing equipment and connecting women to credit facilities and markets, helping them set-up agribusiness ventures

V. **Climate Change:** Finding solutions to help communities cope with dry land stresses, understanding the impact of dry land stresses, undertaking crop simulation models, developing value chains for crops, better farm management, providing climate modeling and decision making tools

VI. **Digital Agriculture:** Delivering targeted and timely information to farmers, leading to better, faster and cheaper delivery through digital technology

24.19.4 TAMIL NADU RICE RESEARCH INSTITUTE

History:

1) Started as Research Station at Manganallur 1912
2) Shifted to Aduthurai in 1922 as Agricultural Research Station
3) Upgraded as Regional Research Station in 1962
4) Started University Research Centre (TNAU) in 1971
5) State Regional Research Station and University Research Centre merged and named as Tamil Nadu Rice Research Institute in the year 1981 and brought under TNAU

6) Elevated as Directorate in the year 1985 and research activities strengthened in Plant Breeding and Genetics, Agronomy, Soil Science, Agriculture Economics, Agriculture Entomology, Plant Pathology, Crop Physiology, Seed Technology, Agriculture Microbiology, Agriculture Engineering and Social Sciences.
7) Acts as Co-ordinating Research Centre for rice in Tamil Nadu State, Directorate of Rice Research (Hyderabad), Central Rice Research Institute (Cuttack) and International Rice Research Institute (Philippines)

Objectives:

1) To perform lead function for rice and rice-based cropping system research in Tamil Nadu
2) To serve as testing and verification center for the technologies developed at other stations and applicable to the region
3) To supply first generation seeds for seed supply chain for the varieties released

24.19.5 INTERNATIONAL RICE RESEARCH INSTITUTE

The International Rice Research Institute (IRRI) is the world's premier research organization dedicated to (Aims)

i. reducing poverty and hunger through rice science;
ii. improving the health and welfare of rice farmers and consumers; and
iii. Protecting the rice-growing environment for future generations.

IRRI is an independent, nonprofit, research and educational institute, founded in 1960 by the Ford and Rockefeller foundations with support from the Philippine government. The institute, headquartered in Los Baños, Philippines, has offices in 17 rice-growing countries in Asia and Africa

IRRI is well known for its contribution to the "Green Revolution" movement in Asia during the late 1960s and 1970s, which involved the breeding of "semi-dwarf" varieties of rice that were less likely to lodge (fall over). IRRI's semi-dwarf varieties, including the famous IR8, saved India from famine in the 1960s. The varieties developed at IRRI, known as IR varieties, are well accepted in many Asian countries. In 2005, it was estimated that 60% of the world's rice area was planted to IRRI-bred rice varieties or their progenies

24.20 CLIMATE-SMART AGRICULTURE (CSA)

Climate-Smart Agriculture, is an approach that incorporates a set of agricultural practices and technologies. Its goals are to boost productivity (e.g., precision farming, smart crops), enhance resilience (e.g., zero budget natural farming, agroforestry), and reduce greenhouse gas emissions (e.g., zero tillage, permaculture, organic farming).

Examples of Climate-Smart Agriculture Practices:

1) **Cultivating Climate-Resilient Crop Varieties:** Growing crops resistant to temperature changes, pests, and diseases. Example: Drought-tolerant maize in sub-Saharan Africa benefits smallholder farmers.

2) **Conservation Agriculture:** No-till and reduced-tillage cultivation for soil coverage,
3) **Agroforestry:** Integrating trees and shrubs with crops and livestock.
4) **Precision Irrigation:** E.g., Drip and sprinkler irrigation maximize water use efficiency

Benefits of Climate-Smart Agriculture (CSA):

1) Increased Agricultural Productivity
- ✓ Addresses resource-efficient farming for climate variability.
- ✓ Counters climate-induced crop yield decline in India, contributing to adaptation, mitigation, and food security.
- ✓ Various climate-smart techniques enhance production, sustainability, and reliability, while reducing GHG emissions.
- ✓ Site-specific no-tillage in the Indo-Gangetic Plain boosts wheat production, nutrient efficiency, and profitability, and lowers GHG emissions.

2) GHG Emission Reduction
- ✓ Crucial for lowering the agricultural sector's 17% share in GHG emissions Enhances farmland carbon storage.

3) Support for Small and Marginal Farmers
- ✓ **Significant** role in increasing profits for the majority of Indian small and marginal farmers.

4) Biodiversity Conservation
- ✓ Ecosystem-based approach and diverse crop varieties promote the coexistence of cropland and wild animals
- ✓ Safeguards native plant species, stabilizes pollinator populations and mitigates habitat degradation effects.

5) Reduced Impact of Climate Change
- ✓ Promotes crop diversification, and water efficiency, and integrates drought-resistant crop types.
- ✓ It lessens the disruptive effects of climate change and increases resilience to longer-term stressors.

24.21 DIGITAL AGRICULTURE

Digital Agriculture refers to the use of Information and Communication Technologies (ICT) and data ecosystems to provide timely, targeted information and services to enhance the profitability, sustainability, and efficiency of farming practices. Examples of digital agriculture include:

1) Agricultural Biotechnology: E.g., developing microorganisms for specific agricultural purposes.
2) Precision Agriculture (PA): It relies on the use of ICT to optimize resource application.
3) Digital and Wireless Technologies: e.g., weather monitoring systems, robotics, drones, and other wireless devices

Benefits of Digital Agriculture:

Increases agriculture productivity	Digital tools and data-driven insights can lead to better crop management, optimizing yields and overall production.
Prevents soil degradation	Precision farming techniques can help reduce soil erosion and nutrient loss, preserving soil health.
Reduces chemical application in crop production	Targeted application of inputs like fertilizers and pesticides can minimize environmental impact.
Efficient use of water resources	Digital sensors and data can aid in precise irrigation, minimizing water wastage and enhancing water efficiency.

Disseminates modern farm practices	Information dissemination through digital platforms empowers farmers to adopt best practices and innovations
Changes in the socioeconomic status of farmers	Increased productivity and reduced costs can lead to improved income and livelihoods for farmers.

24.22 STUBBLE BURNING

1) A method of removing paddy crop residues from the field to sow wheat from the last week of September to November, coinciding with the withdrawal of southwest monsoon.
2) A process of setting on fire the straw stubble, left after the harvesting of grains, like paddy, wheat, etc. It is usually required in areas that use the combined harvesting method which leaves crop residue behind.
3) A common practice in October and November across North West India, but primarily in Punjab, Haryana, and Uttar Pradesh.

Effects of Stubble Burning:

1) Pollution:
✓ Emits large amounts of toxic pollutants in the atmosphere which contain harmful gases like methane (CH4), Carbon Monoxide (CO), Volatile Organic compounds (VOC) and carcinogenic polycyclic aromatic hydrocarbons.
✓ These pollutants disperse in the surroundings, may undergo a physical and chemical transformation and eventually adversely affect human health by causing a thick blanket of smog.
2) Soil Fertility:
✓ Burning husk on the ground destroys the nutrients in the soil, making it less fertile.
3) Heat Penetration:
✓ The heat generated by stubble burning penetrates into the soil, leading to the loss of moisture and useful microbes.

Alternatives to Stubble Burning:

Use of Technology- For example Turbo Happy Seeder (THS) machine, which can uproot the stubble and also sow seeds in the area cleared. The stubble can then be used as mulch for the field

Key reasons for persistence of stubble burning in India:

1) **Policy-Induced Mono-Cropping Patterns:** The MSP system prioritizes the production of wheat and rice, providing farmers with guaranteed income and reducing price risks, especially in states like Punjab, Haryana, and Uttar Pradesh. This discourages crop diversification and leads to the accumulation of paddy stubble, which farmers often burn to clear fields quickly for the next sowing season.
2) **Market Distortions and Price Pressures:** The agricultural marketing system in India is distorted, with farmers being reliant on middlemen who control crop prices, credit access, and market linkages. Farmers sell their produce at artificially low prices set by these middlemen, often leading to debt bondage. A RBI survey (May-July 2024) found that farmers received only 40-67% of consumer prices for major rabi crops. The stagnant MSP rates fail to cover rising cultivation costs, pushing farmers to adopt cost-effective, albeit harmful, practices like stubble burning.
3) **Deficit of Viable Alternatives**: While the state penalizes stubble burning, it fails to provide affordable and sustainable alternatives to manage crop residue. The lack of adequate government support and infrastructure forces farmers to rely on stubble burning as a quick and inexpensive solution.
4) **Climate Stress and Yield Volatility:** Unpredictable monsoons and rising temperatures due to climate change have

increased farming uncertainty. For instance, late rains in October 2023 delayed harvesting, pushing farmers to resort to stubble burning for quick field clearance amidst overlapping sowing schedules.

5) **Ineffective Implementation of Bio-Decomposers:** Bio-decomposers like the Pusa Decomposer face low field usage due to logistical delays, inconsistent results, and lack of follow-up.

Technological Measures to Tackle Stubble Burning

1) **Happy Seeder:** A tractor-mounted device that sows wheat directly into paddy fields while cutting and lifting straw, eliminating the need for burning. It saves time, reduces costs, and improves soil health.
2) **Pusa Decomposer:** A microbial formulation that decomposes paddy stubble into compost, enhancing soil fertility and reducing the need for stubble burning.
3) **Pelletization of Crop Residue**: Crop residues are converted into biomass pellets used for energy generation, reducing stubble burning and generating additional income for farmers.
4) **Biochar Production:** Crop residues are converted into biochar through pyrolysis, which enhances soil fertility, water retention, and microbial activity, while contributing to carbon sequestration.

General Measures to tackle stubble burning

1) Promote Sustainable Crop Diversification like low-residue, water-efficient crops like millets, maize, or pulses.
2) Guaranteed MSP, assured procurement, and private sector involvement
3) Market & Value Chain for Stubble Products: There is a need for creating a market for stubble-based products like fodder, pellets, and packaging materials.
4) Link stubble value chains with MGNREGA and promote FPOs for aggregation and market access, enhancing rural livelihoods.
5) Enhanced Regulatory Interventions
6) Fair Pricing for Farmers
7) Promote Biofuels, Fertilizers Production
8) Subsidize rental costs and synchronize them with harvest schedules, providing demand-driven mechanization for small and marginal farmers who cannot afford their own equipment.

Establish Joint Task Forces involving agriculture, environment, health, and rural development ministries across states