CHAPTER - 9

STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

Animal Husbandry:

- Animal husbandry is a branch of agriculture which deals with the feeding, breeding, housing and healthcare of livestock for getting maximum benefits.
- It is estimated that more than **70%** of the world livestock is in India and China, but its contribution to the world farm produce is only **25%.**
- Livestock refers to the farm or domesticated animals such as cow, sheep etc kept for commercial purpose.

Role of animal husbandry in human welfare:

- Mammalian livestock can be used as a source of milk and diary products.
- It is also used for production of meat which is an useful form of dietary protein and energy.
- The grazing of livestock sometimes used as a way to control weeds and undergrowth and hence helps in land management.
- Livestock like sheep and goats produce a range of fibers for textile industries.
- Manure of livestock can be used as fertilizer to increase crop yield.

Management of farms and farm animals:

- It is an art and science of combining the ideas, facilities, processes, materials to produce market worthy products.

Diary farm management:

- Dairying is a management of animals for milk and its product for human consumption. So animals like cow, buffalo, goat and sheep are expected.

- The principle is primarily based on the quality of breed. So both male and female animals selected for breeding should be of **superior quality** (disease resistivity and high productivity).
- Feeding of the cattle should be done in a scientific manner, considering the **quality and quantity of fodder**. Sufficient quantity of water should be provided.
- The animal should be provided with **proper shelter**. Adequate ventilation, suitable temperature, sufficient light, air and well drained housing accommodation should be provided.
- Besides, stringent **cleanliness and hygiene** are the paramount importance while milking, storage and transport of milk and its products.
- The animal must be maintained **disease free**.
- The all above mentioned measures would be of course require regular inspections, with proper record keeping.
- Regular visits by a **veterinary doctor** would be mandatory.
- Example of cattle breeds: **indigenous-Sahiwal, Red Sindhi, exotic- Jersy, Holstein-Friesian.**

Poultry farm management:

- The word poultry is used for birds which can be raised and domesticated mainly for eggs and meat. They typically include chicken, ducks, turkey, geese etc.
- Selection of **disease free** and **suitable breeds** is required.
- Brooder house should be **crowd free, rain proof, properly ventilated** and protected from predators.
- Feeding constituents like carbohydrate, proteins, fats, minerals should be properly managed.
- **Hygiene and health care** are very important components. Negligence may cause infections like bird flu.

Animal breeding:

- Animal breeding aims at increasing the yield of animals improving the desirable qualities of the product.

Breed:

- Breed is defined as a **group of animals related by descent and similar** in most characters like appearance, features, size, configuration etc.

Inbreeding:

- When breeding is between animals of same breed it is called as inbreeding. This breeding refers to the mating of more closely related individuals within the **same breed for 4-6 generations**.
- This strategy includes superior males and superior female of the same breed and both are mated. The progeny obtained from such mate are evaluated and superior ones are again selected for next round of mating.

Advantages:

- Superior progenies are obtained and this type of mating increases **homozygosity. Purelines** can be obtained by inbreeding which increases productivity.
- Inbreeding **exposes harmful recessive genes** that are eliminated by selection, which helps in accumulation of superior genes and elimination of less desirable genes.

Disadvantages:

- Continued inbreeding, especially close inbreeding usually reduced fertility and even productivity. This is called **inbreeding depression**.

Out-breeding:

- To overcome inbreeding depression out-breeding is carried out. Out-breeding is the breeding of unrelated animals which may be between individuals of the same breed but having **no common ancestors for 4-6 generations** or between **different breeds** or **different species**.

Out-crossing:

- It is the mating of animals within the same breed but having no common ancestors on either side of their pedigree up to 4-6 generations. The Offspring is known as outcross.
- A single out cross helps to overcome inbreeding depression. Out crossing is the best breeding method for animals that are below average in productivity of milk production, growth rate in cattle.

Cross-breeding:

- In cross-breeding superior males of one breed are mated with superior female of another breed. It gives better breeds.
- Ex. ***Hisardale*** is a new breed of sheep developed in Punjab by crossing ***Bikaneri ewes*** and ***Marino rams.***

Interspecific hybrisization:

- In this approach, male and female animals of two different species are mated. The progeny obtained from such a mating are usually different from the parental species. In some cases the progeny may combine desirable characters of the both the parents.
- Ex. **Mule** is produced from cross between **female horse** and **male donkey**. Mules are harder than their parents and suited for hard work but are sterile.

Controlled breeding experiments:

These experiments are carried out using **Artificial Insemination** and **Multiple Ovulation Embryo Transfer Technology (MOET).**

Artificial Insemination:

- Artificial insemination helps to overcome several problems of normal matings.
- The semen of superior male is collected and injected into the reproductive tract of the selected female.
- The semen can be used immediately or can be frozen for future use.
- Little amount of semen is enough to achieve the mating procedure.
- This method also prevents the spread contagious diseases in animals.
- Often the success rate of animals is fairly low even though artificial insemination.

Multiple Ovulation Embryo Transfer Technology (MOET):

- To improve chances of successful production of hybrids and to overcome the problem of artificial insemination MOET is carried out.
- In this method, a cow is administered hormones, with **FSH**-like activity, to induce follicular maturation and **super ovulation**. Super ovulation means instead of one egg, which cow normally yield per cycle; **6-8 eggs** are produced.
- The animal is either mated with an **elite bull** or is **artificially inseminated**.
- The fertilized eggs at **8-32 cell stages** are recovered **non-surgically**.
- The embryo then is transferred to **surrogate mothers**.
- The genetic mother (biological mother) is available for next round of super ovulation.
- This technique has been demonstrated for cattle, sheep, rabbits, buffaloes, mares etc.
- **High milk yielding** breeds of females and **high quality (lean meat with less lipid)** meat –yielding bulls have been bred successfully to increase herd size in a short time.

Apiculture:

- The honey bees are mainly maintained for the production of honey and bee wax.
- Honey is used as food of high nutritive value and medicine in Ayurveda.
- Bee wax is used in industry for the preparation of cosmetics and polishes.
- The most common species of honey bee is ***Apis indica.***
- The honey bees possess most developed social life as they live in colonies. Queen is the fertile female which lays eggs. Drones are males which mate with the queen. Workers are the sterile females which perform various duties in the colony.
- The honey bees are reared in wooden boxes having a large brood chamber placed on a wooden platform with an opening for the entry and exit of the bees. A number of frames coated with wax sheet having hexagonal imprints are placed in the chamber vertically. It provides the foundation for the bees to make combs.

- Bee keeping can be practiced in any area where there are sufficient wild shrubs, cultivated crops and fruit orchids.
- Beehives can be kept in any place like courtyard, verandah or on the roof of the house.

For bee keeping there are following considerations:

- Knowledge of the nature and habits of Bee.
- Selection of suitable location of keeping beehives.
- Catching and hiving of swarms.
- Management of beehives during different seasons.
- Handling and collection of honey and bee wax.
- Bees are pollinators of many crop plants (apple, pear, sunflower, brassica etc) and hence keeping beehives in crop fields during flowering season increases pollination efficiency and thereby improve the yield.

Fisheries:

- It is an industry that includes rearing, catching, processing or selling of fishes, shellfish (mollusca, crustaceans, prawn, crab) or other aquatic animals.
- This fishing industry has brought a lot of income to the farmers in particular and the country in general. This large scale production of fishes is known as Blue Revolution.
- A large part of human population depends on fish and fish products.
- Fish liver oil is also used as medicines.
- Some common fresh water fishes are ***Catla, Rohu*** and **common crap**.
- Some edible marine fishes are ***Hilsa,*** **Sardines, Mackerel and Pomfrets.**

Aquaculture	Pisciculture
This involves farming of all types of aquatic organisms.	This involves farming of only fishes.
There is a little requirement of special feed from outside.	Fish feed has to be provided from outside.

Introduction:

- Conventional or classical or traditional plant breeding has been practiced for thousands of years and most of our present day crops are the result of domestication.
- Traditional farming can only yield limited food for human and animals. Better management can increase yield but only to a limited extent.

Green revolution:

- But plant breeding responsible for our country to not only meets our requirements in food production but also helped also to export it and that is known as **green revolution**.
- It is a movement launched in India in 1960's. It was dependent to a large extent on plant breeding techniques to raise high yielding and disease resistant varieties in wheat, rice, maize etc.
- Agriculture accounts for 33%of India's GDP and employs 62%of the population.

Plant breeding:

- Plant breeding is the genetic improvement of the crop in order to create desired plant types that are better suited for cultivation. Now advancement in techniques like molecular biology tools, tissue culture techniques, and genetics improved the method of plant breeding. The technique introduces various desirable characteristics into the crop plants.
- When the breeders wish to incorporate desired characters (trait) into the crop plants, they should increase yield and improve the quality. Increased tolerance to salinity, extreme temperatures, drought, resistance to viruses, fungi, bacteria and increased tolerance to insect pests should also be the desired traits in these crop plants.

Steps involved in plant breeding:

The various steps involved for development of new variety in plant breeding:

(i)Collection of variability: Genetic variability is the root of any breeding programme. Collection and preservation of all the different wild variability, species and relatives of the cultivated species is a pre-requisite for effective exploitation of natural genes available in the population. This based on proper evaluation.

The entire collection (of plants/seeds) having all diverse alleles for all genes in a given crop is called **germplasm collection**.

(ii)Evaluation and selection of parents: The germplasm is evaluated to identify plants with **desirable combination of characters**.

Selection of parents is picked up seeds of only those plants for multiplication which have the desired traits. Sometimes pure lines are created whenever desired and possible.

(iii)Cross hybridization among the selected parents: The selected parents are hybridized, so that the traits in them can be combined in the hybrid progeny. It is a very time consuming and tedious job.

The desired pollen is collected and is dusted upon the stigma of a selected female plant (includes the process like **selfing, emasculation, bagging, tagging**). It is not necessary that the hybrids do combine the desirable characters; only one in the few show desirable trait.

(iv)Selection and testing of superior recombination: First the individuals with desired combination of characters have to be selected from among the progeny of hybrids.

Such hybrids are **superior** to both of the parents **(hybrid vigour)**. They are self pollinated for several generations till they reach a **state of homozygosity** (pure lines), so that there will be no segregation of characters in the progeny.

(v)Testing, release and commercialization of new cultivars: The newly selected lines are **evaluated for their yield and other agronomic traits of quality, disease resistance etc.**

This evaluation is done by growing these in the research field and recording their performance under ideal irrigation and fertilizer (application).

After evaluation the testing of the material is done in the farmer's field for at least three growing seasons at several locations in the country, representing different **agroclimatic zones** where the crop is normally grown.

The material is evaluated in comparison to the best available local **cultivar** crop- a reference cultivar.

High yielding varieties:

Wheat:

- In 1960 -2000 **wheat** production increased from **11 million tons to 75 million tons** while **rice** production increased from **35 million tons to 89.5 million tons.**
- It was due to development of semi dwarf varieties of wheat and rice. Nobel Prize winner **Norman E. Borlaug** of **International Center for Wheat and Maize improvement in Mexico developed semi dwarf Wheat.**
- In 1963, many lines like ***Sonalika*** and ***Kalyan sona*** were selected from these that were high yielding and disease resistant.

Rice:

- Semi-dwarf rice varieties were developed from **IR-8** at **International Rice Research Institute (IRRI**), **Philippines and Taichung Native -1 from Taiwan**.
- The developed varieties were introduced in 1966. Later on better yielding semi-dwarf varieties ***Jaya*** and ***Ratna*** were developed in **India.**

Sugarcane:

- ***Saccharum barberi***, originally grown in **North India**, but had poor sugar content.
- ***Saccharum officinarum***, grown in **South India**, has thicker stems and higher sugar content.
- A cross has been made between these species and the hybrid variety, combining the desirable qualities like thick stem, high sugar content and higher yield, is being grown in North India.

Millets:

- Plants producing a large crop of small seeds are called millets. Hybrid **bajara, jowar and maize** have been developed in India. From hybrid varieties, the development of several high yielding varieties **resistant to water stress** has been possible.

Plant breeding for disease resistance and insect pest resistance:

- Plant breeding for disease resistance has two advantages:
  (i) Enhanced food production by reducing losses due to diseases.
  (ii) Reduced dependence on use of fungicides and bacteriocides.
- Resistance of a plant to a disease is genetically determined and it is the ability of the host plant to prevent the pathogen from causing the disease.
- Diseases in crop plants are caused by viruses, bacteria and fungi.
- Some examples are as follows:
  (i) **Viral diseases**-Tobacco mosaic virus, Turnip mosaic.
  (ii) **Bacterial diseases**-Black rot of crucifers, Citrus canker, Blight of rice.
  (iii) **Fungal diseases**-Rust of wheat, Red rot of sugarcane, Late blight of potato.
- The conventional method of breeding for resistance includes the following steps:
  (i) Screening the germ plasma for resistance sources.
  (ii) Hybridisation of selected parents.
  (iii) Selection and evaluation of the hybrid.
  (iv) Testing and release of new cultivar.
- The resistant gene may be present in the wild relatives, which are low yielding; hence the gene for resistance has to be incorporated into the better-yielding variety by hybridization, e.g., the gene for resistance to yellow mosaic virus found in a wild species of bhindi (***Abelmoschus maniholtand***) has been transferred to raise a new variety of ***Abelmoschus esculentus,*** called **Parbhani Kranti.**
- Some of the crop variety that is resistant to diseases that have been raised by hybridization and selected. The following represents few examples:

Crop	Variety	Resistance to diseases
Wheat	*Himgiri*	*Leaf and stripe rust, hill bunt*
Brassica	*Pusa swarnim (Karan rai)*	*White rust*
Cauliflower	*Pusa Shubhra, Pusa Snowball K-1*	*Black rot and Curd blight black rot*
Cowpea	*Pusa Komal*	*Bacterial blight*
Chilli	*Pusa Sadabahar*	*Chilly mosaic virus, Tobacco mosaic virus and Leaf curl*

Mutation breeding:

- Inducing mutations in plants through diverse means and then screening the plant materials for resistance sometimes leads to desirable genes being identified. Plants having these desirable characters can then be either multiplied directly or can be used in breeding.
- Mutation is the process by which genetic variations are created through changes in the base sequence within genes resulting in the creation of a new character or trait not found in the parental type.
- Mutation is induced artificially through use of chemicals or radiations (like **gamma rays, X-rays** etc), and selecting and using the plants with desirable characters as a source of breeding.
- In **mung bean**, **resistance to yellow mosaic virus and powdery mildew** were induced by mutation.
- Mutation always cannot develop a new developed variety as mutation breeding is not a controlled method. Mutation may give rise to unwanted change to a plant.

Explain plant breeding for developing resistance against insects and pests:

- Resistance to insect pests is also genetically controlled and manifest in the form of morphological, physiological or biochemical characteristics.
- **Hairy leaves** in several plants are associated with resistance to insect pests, e.g**. resistance to jassids in cotton and cereal leaf beetle in wheat.**
- In wheat **solid stem** leads to non-preference by the **stem sawfly** and **smooth leaved** and **nectar-less cotton** varieties do not attract bollworms.
- **High aspartic acid, low nitrogen and sugar content** in maize leads to resistance to **maize stem borers**.
- Breeding methods for insect pest resistance involve the same steps as those for any other agronomic trait.
- Some released crop varieties bred by hybridization and selection for insect pest resistance are given below:

Crop	Variety	Insect Pests
Brassica (rapeseed mustard)	*Pusa Gaurav*	*Aphids*
Flat bean	*Pusa Sem 2, Pusa Sem 3*	*Jassids, aphids and fruit borer*
Okra (Bhindi)	*Pusa Sawani Pusa A-4*	*Shoot and Fruit borer*

Plant breeding for improved food quality:

Hidden hunger:

- It is estimated that more than 840 million people in the world do not have adequate food to meet their daily requirements. Near about three million people in the world suffer from protein, vitamins and micro -nutrient deficiencies which is called "**hidden hunger**".

- That group of individuals cannot afford to buy enough fruits, vegetables, legumes, fish and meat. Diet lacks essential micronutrients –particularly iron, vitamin-A, iodine and Zinc- increase the risk for disease, reduce life span, and reduce mental abilities.

Biofortification:

- Breeding of crop with higher levels of vitamins or minerals or higher proteins and healthier fats is called **biofortification**.
- Plant breeding is undertaken for improved nutritional quality of the plants. Following are the objectives of improving:
    - Protein content and quality
    - Oil content and quality
    - Vitamin content
    - Micronutrient and mineral content
- Some examples of crop varieties, with increased nutritional qualities, that have been developed and released in India are given below:
    (i) Lysine and tryptophan rich varieties of maize.
    (ii) High protein variety of wheat.(Atlas-66)
    (iii) Iron fortified variety of Rice
- IARI, New Delhi also developed vegetable crops that are rich in minerals and vitamins.
    (iv) Vitamin C-enriched variety of bitter gourd, tomato, mustard, bathua.
    (v) Iron and Calcium –enriched variety of spinach and bathua.
    (vi) Protein-enriched variety of beans like French beans, Lablab beans, broad beans and garden beans.
    (vii) Vitamin A –enriched variety of carrots, spinach and pumpkin.

Single cell protein:

- AS we know demand of food is increasing due to increase in human and animal population, the shift from grain to meat diets does not solve the problem as it takes 3-10kg of grain to produce 1kg of meat from animal farming.

- It has been estimated that a 250kg cow produces 200gmof protein per day. In the same period 250gm of a microbe like ***Methylophilus methylotrophus*** because of its high content of biomass production and growth, can produce about 25tons of protein.
- So one of the alternate sources of proteins for animal and human nutrition is Single Cell Protein (SCP).
- Micro organisms are used for preparation of fermented foods (cheese, butter, idli). Some like BGA and mushrooms are being used as human food.
- Now efforts are being made to produce microbial biomass using low cost substrates. Microbes like ***Spirulina*** can be grown on waste water from potato processing plants, straw, molasses, animal manure and even sewage, to produce food rich in protein, minerals, fats, carbohydrates and vitamins
- The cells from micro organisms such as bacteria, yeasts, filamentous algae treated in various ways and used as food; called as SCP.
- The term SCP does not indicate its actual meaning because the biomass is not only obtained from unicellular microbes but also from multicellular microbes.

Plant tissue culture:

- It is the technique of maintaining and growing plant cells, tissues or organs especially on artificial medium in suitable container under suitable conditions.
- Any part of the plant taken out and growth in a test tube, under sterile conditions to get a new plantlet is called explants. This ability to generate the whole plant from the explants is called **cellular totipotency**.
- **Gottlieb Haberlandt** first initiated tissue culture technique in 1902 and hence known as father of plant tissue culture.

Requirement for plant tissue culture:

- The nutrient medium consists of inorganic salts, a carbon source, vitamins, amino acids and growth regulators.
- Growth regulators are Auxin, Gibberellins, Abscisic acid, Cytokinin etc.
- The nutrient medium and the containers like conical flask, culture tubes must be sterilized to maintain proper aseptic condition.

- Proper aeration of the cultured tissue is also an important aspect which is achieved by stirring the medium by automatic shaker.

Advantages:

- The explants inside the container consume the medium, divides rapidly to produce unorganized undifferentiated mass of actively dividing cells called as **callus**. This callus is used to achieve regeneration of entire plantlet
- By this application it is possible to achieve propagation of large number of plants in a very short duration of time. This is called as **micropropagation**.
- Genetically similar plants are formed by this method. Each of these plants is called **somaclones**.
- Sterile plants or the plants which cannot maintain their character by sexual reproduction are multiplied by this method.
- A healthy plant can be recovered from a diseased plant. This is called **meristem culture**. Although the plant is infected from a virus but its **meristem (apical, auxillary) is free of virus**. Hence the meristem is removed and grown in vitro by plant tissue culture to obtain virus free plant. Scientists have succeeded in culturing meristems of **banana, sugarcane, potato etc.**
- Plant tissue culture is an easy, safe and economical method for plant propagation.

Somatic hybridization:

- Somatic hybridization is the process of **fusing protoplasts of somatic cells** derived from two different varieties or species of plants, on a suitable nutrient / cultured medium under aseptic condition.
- The process includes following steps:
  - (i) isolation of protoplasts(surrounded by plasma membranes) by digesting the cell wall by use of enzymes
  - (ii) Fusion of protoplasts of the elected varieties.
  - (iii) Growths of the protoplast in suitable conditions, where they develop cell wall, multiply and differentiate into **somatic hybrids**.One example of a somatic hybrid is **Pomato,** produced by fusion of **protoplasts of tomato and potato.** But this plant did not have all the desired qualities for its commercial scale production.

IMPORTANT TERMS

- **Breed:** It is the group of animals of the same species related by descent and is similar in most of their characters.
- **Inbreeding**: Inbreeding refers to the mating of more closely related individual within the same breed.
- **Inbreeding depression**: Inbreeding depression is defined as the loss in vigour associated with inbreeding.
- **Outcrossing**: It is the practice of mating of animals within the same breed but having no common ancestors on either side of their pedigree up to 4-6 generations.
- **Germplasm**: It refers to the sum total of all the alleles of the genes present in an individual organism and its related species.
- **Plant breeding**: It is a purposeful manipulation of plant species in order to create desired plant type that is better suited for cultivation.
- **Biofortification**: It refers to breeding of crops to produce varieties with higher levels of nutrients like vitamins and minerals or higher protein and healthier fats.
- **Plant tissue culture**: It refers to the regeneration of whole plants from any cell or tissue or organ of a plant on a suitable synthetic medium in vitro.
- **Explant**: An explant is the plant part excised from a specific location in a plant to be used for initiating a culture.
- **Micropropagation**: The method of producing thousands of plants through tissue culture is called micropropagation.
- **Somaclones**: These are the genetically identical plants developed from any part of a plant by tissue culture.
- **Somatic hybridization**: This is a process of fusing protoplasts of somatic cells derived from two different varieties or species of plants, on a suitable nutrient
- **Apiculture**: Apiculture is the maintenance of hives of honeybees for the production of honey.