Strategies for Enhancement in Food Production

Animal Husbandry

Introduction

- The practice of breeding and raising livestock is called animal husbandry.
- It includes breeding of livestock (cows, buffaloes, pigs, etc.), poultry farming, and fisheries.

Farm Management

- **Dairy Farm Management**
- Milk yield is dependent upon the quality of breed selected. Quality encompasses yielding potential and disease resistance.
- Care of cattle – Proper accommodation, adequate water, feeding in a scientific manner (quality of fodder), hygiene, visits by a veterinary doctor
- All these processes nowadays have become mechanised and proper record keeping is followed.
- **Poultry Farm Management**
- Poultry includes meat from birds such as chicken, ducks, and turkey.
- The main emphasis in poultry farming is selection of a disease-free and healthy breed.
- Safe farm conditions, proper feed, water, and hygiene are also necessary.

Animal Breeding

- Breed – A group of animals related by descent and similar in most characters such as general appearance, features, size, etc.
- Aims of breeding:
- To increase yield of animals
- To improve desirable qualities in produce
- Breeding is of two types – inbreeding and out-breeding.
- **Inbreeding**

- Mating of more closely related individuals of same breed for four generations
- Superior females and superior males are identified and mated.
- Superior females – Produce more milk per lactation
- Superior males – Give rise to a superior progeny
- Inbreeding increases homozygosity. It evolves a pure line.
- It accumulates superior genes, but also threatens to accumulate harmful recessive genes.

- Continuous inbreeding may reduce fertility and productivity. This problem is called inbreeding depression.
- Out-breeding provides a solution to inbreeding depression.
- Out-breeding – It includes out-crossing, cross-breeding, and interspecific hybridisation.
- **Out-crossing** – It is the mating between animals of same breed, but not having common ancestors for 4 – 5 generations. It is usually used for animals, which have below average productivity and growth rate.
- **Cross-breeding** – It is the mating between superior male of one breed with superior female of another breed. Superior qualities of both the breeds combine and this is known as hybrid vigour. The progeny so formed is called hybrid. A hybrid may be used as it is or may be further subjected to inbreeding.
  Example: *Hisardale* sheep is a hybrid of Bikaneri ewes and Marino rams.
- **Interspecific Hybridization** – Males and females of different, but related species are mated. Progeny has desirable features of both the species.
  Example – Mule is an interspecific hybrid of donkey and horse.

Controlled Breeding Techniques

- **Artificial Insemination**

  Semen is collected from the male and injected into the reproductive tract of the female.

  Semen can be frozen for later use or used immediately.

- **Multiple Ovulation Embryo Transfer (MOET) Technology**
- Cow is administered with FSH-like hormone, which induces follicular maturity and super ovulation.

- In super ovulation, instead of one egg/cycle, 6 – 8 eggs are produced per cycle.
- The cow is either naturally mated with a superior bull or artificially inseminated.
- Fertilized egg is recovered at 8 – 32 cell stages non-surgically and transferred to a surrogate mother.
- Using this technique, high milk-yielding breeds of females and lean meat-yielding bulls have been bred successfully.

Apiculture

- Apiculture is the practice of bee-keeping. It includes maintenance of beehives for production of honey.
- Uses of apiculture:
- Honey has a high nutritive value and medicinal value.
- Honeybees also produce beeswax that is used in preparation of polishes and cosmetics.
- Most commonly reared species of honeybee is *Apis indica*.
- Bee-keeping is not labour intensive. It is relatively easy, but requires some specialized knowledge about
- nature and habits of bees
- selection of suitable location for keeping beehives
- catching and hiving of swarms
- beehive management during different seasons
- handling and collection of honey and beeswax

Fisheries

- Include catching, processing, and selling of fishes, shellfishes, and other aquatic animals (prawn, crab, lobster, etc.)
- Edible freshwater fishes – *Catla* and *Rohu*
- Edible Marine fishes – *Hilsa*, pomfrets, and sardines
- Aquaculture and pisciculture are the technologies to commercially rear fishes.

- The fisheries industry is flourishing in our country and 'Blue Revolution' is on the verge of being implemented.

Sericulture

You must have seen your mother wearing rich silk *sarees*. But do you know that the silk used to make these *sarees* is actually obtained from an insect?
The silk is obtained from the cocoon (pupa stage) of an insect commonly known as silkworm. The artificial rearing of silkworm and obtaining silk from them is known as **sericulture**.

These silkworms feed on the leaves of mulberry tree. While entering the pupa stage, they develop a cocoon around them by secreting a fibre from the silk glands found in their mouth. It is from this cocoon from where the silk fibre is obtained. To obtain the silk, cocoons are first treated with boiling water to kill the living pupa inside them. The silk thread is then obtained from the killed cocoons through a process called reeling. The silk fibre thus obtained is then treated and used for commercial purposes.

Plant Breeding

What is Plant Breeding?

- It is the purposeful manipulation of plant species in order to create desired plant types which are better suited for cultivation, give better yields, and are disease resistant.
- **Classical plant breeding**: It includes crossing of superior pure lines and selection of plants with desired characteristics.
- **Modern plant breeding**: It includes the use of molecular biology and genetics.
- Desirable plant traits wished to be incorporated by plant breeding –
- Increased crop yield
- Improved quality
- Tolerance to environmental stresses
- Pathogen resistance
- Tolerance to insects and pests

Steps Involved in Breeding a New Genetic Variety of a Crop

- **Collection of genetic variability**
- Genetic variability is availed from the wild relatives of the crop.
- Hence, all the wild varieties and relatives of the crop are collected and preserved.
- The natural genes available in a population are utilised by this method.
- Entire collection of plants/seeds (wild types/relatives) of the given crop, which has all the diverse alleles for all genes, is called germplasm collection.
- **Evaluation and selection of parents**
- From the available genetic variability, the germplasm is analysed and evaluated to identify the plants with desirable traits.
- **Crop hybridisation among selected parents**
- Two selected parents are crossed (hybridised). This facilitates the combination of desired traits from two different plants.
- Pollen grains from one plant are dusted over the stigma of the other plant.
- **Selection of superior recombinants**
- Among the hybrid progeny, those plants are selected which have the desired character combination.
- Careful scientific evaluation of progeny is required for selection.
- This step yields the plant that is superior to both the parents.
- **Testing, release and commercialisation**
- Selected yields are evaluated for traits like quality, disease resistance, insect resistance, etc.
- These crops are grown in research fields and their performance is recorded under ideal conditions.
- This crop is then grown by farmers at several locations, for at least three growing seasons.
- The crop is evaluated by comparing with the best available local crop cultivar (which acts as a reference).

Indian Hybrid Crops

Wheat and Rice

- In 1960s, wheat and rice production increased tremendously.
- Norman E. Borlang developed semi-dwarf varieties of wheat.
- *Sonalika* and *Kalyan sona* are two of the hybrid wheat varieties grown in India.
- Semi-dwarf rice varieties were taken from IR−86 (International Rice Research Institute) and Taichung native−I (from Taiwan).
- *Jaya* and *Ratna* are the better-yielding, semi-dwarf rice varieties that were later introduced.

Sugarcane

- *Saccharum barberi* is a native of North India and *S. officinarum* belongs to South India.
- *S. officinarum* has thicker stems and higher sugar content, but it does not grow well in North India.
- These two varieties were crossed to get the desirable qualities of both (Higher sugar content, thicker stems and the ability to grow in North India).

Millets

- Hybrid maize, *jowar* and *bajra* have been successfully developed in India.
- These varieties are high yielding and resistant to water stress.

Biofortification

- It involves the breeding of crops to increase their nutritional value.
- It is a strategy for dealing with micronutrient deficiencies in developing countries.

Methodology
It involves two methods;

- **Selective Breeding**
- Breeders search for crop varieties naturally rich in nutrients. These are then cross-bred with high-yielding varieties.
- **Genetic Modification**
- **Golden rice** is an example of a crop genetically modified for increasing its nutritional value.
- The golden rice carries genes from the common soil bacterium, *Erwinia* and maize.
- It contains increased amounts of beta-carotene which is converted by the body into vitamin A.
- It was developed as a measure to cope with vitamin A deficiency in developing countries.

Applications of Plant Breeding

- If resistance to a particular disease is already present in a plant, it reduces the dependence of the plant on fungicides and bacteriocides.
- Before breeding, one must know the causative agent of a disease, and its mode of transmission.
- Some common diseases:
- Fungal – brown rust of wheat, red rot of sugarcane and late blight of potato
- Bacterial – black rot of crucifers
- Viral – tobacco mosaic
- Disease resistance can be provided by conventional breeding, mutational breeding or genetic engineering.
- **Conventional breeding**: It includes the basic steps of screening, germplasm, hybridisation, selection, testing and release.
- Example – wheat variety, *Himgiri* (resistant to leaf/stripe rust and hill bunt) and *Brassica* variety, *Pusa swarnim* (resistant to white rust) are bred by conventional breeding.
- One limitation of this method is that the genes for disease resistance are limited in number.
- **Mutational breeding**:In this method, genetic variations are created, which then result in the creation of traits not found in the parental type.
- Mutations are induced with the help of mutagens (like chemicals) or irradiation.
- The plants in which the desired character (in this case, the desired resistance) has come through mutation are selected.
- **Genetic engineering**:
- Certain wild varieties have disease-resistant characteristics, but they are low yielding.
- Disease-resistant genes from such varieties are introduced in high-yielding varieties through recombinant DNA technology.
- Example – resistance to the yellow mosaic virus in *bhindi* was transferred from a wild species to produce a new disease-resistant variety of *bhindi*, *Parbhani Kranti*.

Pest-Resistant Crops

- Certain morphological characters (like hairy leaves, solid stems of wheat) naturally provide resistance from insects and pests.

- Similarly, biochemical characters provide resistance from insects and pests. For example, the high aspartic acid and low nitrogen and sugar content in maize lead to resistance against maize stem borers.
- Such varieties are bred with non-resistant varieties to produce pest-resistant hybrids.
- Example – *Pusa Gaurav* variety of *Brassica* is resistant to aphids.

Improvement in Food Quality

- A large number of people all over the world suffer from micronutrient, protein and vitamin deficiencies (hidden hunger) since they cannot afford to buy food rich in these nutrients.
- Such deficiencies lead to diseases, mental retardation and reduced lifespan.
- An alternative to this problem is to breed crops that are rich in nutrients.
- This approach is called bio-fortification of crops. Objectives of bio-fortification are to improve –
- Protein content and quality
- Oil content and quality
- Vitamin content
- Micronutrient and mineral content
- Examples –
- Maize hybrids developed in the year 2000 have twice the amount of lysine and tryptophan compared to other maize hybrids.
- Atlas 66 (a wheat variety having higher protein content)

Single-Cell Protein & Tissue Culture

Single-Cell Protein (SCP)

- Single-cell protein means that microbes are used as a source of protein.
- Microorganisms, despite being very small, are capable of producing tonnes of proteins due to their higher rates of biomass production.
- Just like mushroom culture, it is expected that microbes will soon be accepted as a source of food.

- Presently, *Spirulina*, an alga is widely accepted as a source of SCP. It is economical and eco-friendly as well.

- It can be grown on economical substrates like waste water from potato processing plant, straw, molasses or even sewage.

Tissue Culture

- Tissue culture is the process of developing a complete plant from a part of a plant. The plant part is called an explant.

- Explants can be grown in sterile conditions in special nutrient media to regenerate complete plants.

- Nutrient media contain a carbon source (such as sucrose), inorganic salts, vitamins, amino acids and phytohormones.

- Hence, propagation is achieved for a large number of plants in a short duration. This process is called micropropagation.

- **Somaclones** – All the plants obtained by tissue culture are called somaclones since they are genetically identical to each other as well as the parent plant.

- **Somatic hybridisation** – It refers to the hybridisation of the somatic parts of two plants. Protoplasts are isolated and fused to get a hybrid protoplast, which grows further to form a new plant. This new plant is called a somatic hybrid.

    E.g., protoplasts of potato and tomato have been actually fused to form a Pomato, but this plant is not commercially viable.

- **Applications of tissue culture**

- Many important plants like apple, banana and tomato have been grown on laboratory scale by using this method.

- This method can be used to recover a healthy plant from a diseased plant. Example – a plant inflicted with virus may not have virus in its apical and axillary meristems. Hence, these parts can be cultured to obtain a healthy plant.