# STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

## I. ANIMAL HUSBANDRY

- It is the scientific agricultural practice of breeding and raising livestock.
- It deals with the care & breeding of **livestock** (buffaloes, cows, pigs, horses, cattle, sheep, camels, goats etc.), **poultry farming** and **fisheries.**
- More than **70%** of the world livestock population is in **India** & **China.** However, the contribution to the world farm produce is only **25%,** i.e., the productivity per unit is very low. Hence new technologies should be applied to achieve improvement in quality and productivity.

### Management of Farms & Farm Animals

#### 1. Dairy Farm Management (Dairying)

- It is the management of animals for increasing yield and quality of milk and its products.
- Milk yield depends on the quality of breeds in the farm.
- It is important to select good breeds having high yielding potential and resistance to diseases.
- **Ways for the yield potential:**
  - Look after the cattle (housing well, give adequate water and maintain disease free).
  - Feeding of cattle in a scientific manner – emphasis on the quality and quantity of fodder.
  - Stringent cleanliness and hygiene of cattle & handlers while milking, storage and transport of the milk.
- Nowadays, these processes have mechanized. It reduces chance of direct contact of the produce with the handler.
- To ensure these stringent measures there should be
  - Regular inspections to identify and rectify problems.
  - Regular visits by a veterinary doctor.

#### 2. Poultry Farm Management

- Poultry is the domesticated birds used for food or eggs. E.g. chicken, ducks, turkey and geese.
- **Components of poultry farm management:**
  - Selection of disease free and suitable breeds.
  - Proper and safe farm conditions.
  - Proper feed and water.
  - Hygiene and health care.

### Animal Breeding

- A **breed** is a group of organisms related by descent and similar general appearance, features, size etc.
- **Breeding** is the modification of genotype of an organism to make that organism more useful to humans. E.g. Jersey (improved cattle breed), Leghorn (improved chicken breed).
- Animal breeding aims at increasing the yield of animals and improving the desirable qualities of the produce.
- Breeding is 2 types: **Inbreeding** and **out-breeding.**

#### a. Inbreeding

It is the mating of more closely related individuals within the same breed for 4-6 generations. This strategy is as follows:

- Identify and mate superior males & females of same breed.
- Evaluate the progeny obtained and identify superior males and females among them for further mating.

In cattle, a superior female produces more milk per lactation. A superior male (bull) gives rise to superior progeny.

**Advantages of Inbreeding:**

- It increases **homozygosity** to evolve a pure line animal.
- It exposes **harmful recessive genes** that are eliminated by selection.
- It helps in accumulation of **superior genes** and elimination of less desirable genes. This increases the productivity of inbred population.

Continued inbreeding, especially close inbreeding, may reduce fertility and productivity. This is called **inbreeding depression**. To solve this problem, selected animals should be mated with unrelated superior animals of the same breed.

#### b. Out-breeding

It is the breeding of the unrelated animals. It includes out-crossing, cross-breeding and inter-specific hybridization.

**i) 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 of such a mating is known as **out-cross.**
- It is the best method for animals having low milk productivity, growth rate in beef cattle, etc.
- It helps to overcome inbreeding depression.

**ii) Cross-breeding:**

- It is the mating of superior males of one breed with superior females of another breed.
- The desirable qualities of 2 different breeds are combined.
- The progeny hybrid animals may be used for commercial production or may be subjected to inbreeding and selection to develop new stable superior breeds.
- E.g. **Hisardale** (sheep) developed in Punjab by crossing **Bikaneri ewes** and **Merino rams.**

**iii) Interspecific hybridization:**

- It is the mating of male and female of two different species.
- In some cases, the progeny may combine desirable features of both the parents, and may be of considerable economic value. E.g. Mule (male ass x female horse).

#### Controlled breeding experiments

**1. Artificial insemination**

- The semen collected from male parent is injected into the reproductive tract of selected female by the breeder.
- Semen is used immediately or is frozen and used later. Frozen semen can also be transported.
- Success rate of crossing mature male & female is low even though artificial insemination is carried out.

**2. Multiple Ovulation Embryo Transfer Technology (MOET)**

- It is a programme for herd improvement. It improves chances of successful production of hybrids.

- In this, a cow is administered hormones such as **FSH** to induce **follicular maturation & super ovulation** (production of 6-8 eggs per cycle instead of one egg).
- The animal is either mated with an elite bull or artificially inseminated. Fertilised eggs at 8–32 cells stage are recovered non-surgically and transferred to surrogate mothers.
- MOET 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.

## Bee-keeping (apiculture)

- It is the maintenance of hives of honeybees to produce honey and beeswax.
- Most common species that can be reared is ***Apis indica.***
- Honey is a food of high nutritive and medicinal value.
- Beeswax is used in preparation of cosmetics, polishes etc.
- Apiculture can be practiced in an area having **bee pastures** of some wild shrubs, fruit orchards and cultivated crops.
- **Important points for successful bee-keeping:**
  (i) Knowledge of the nature and habits of bees.
  (ii) Selection of suitable location for keeping beehives.
  (iii) Catching and hiving of swarms (group of bees).
  (iv) Management of beehives during different seasons.
  (v) Handling and collection of honey and beeswax.
- Bees are the pollinators of crop species such as sunflower, *Brassica*, apple and pear.
- Keeping beehives in crop fields during flowering period increases pollination. It improves crop and honey yield.

## Fisheries

- Fishery is an industry of catching, processing or selling of fish, shellfish or other aquatic animals (prawn, crab, lobster, edible oyster etc.).
- **Freshwater fishes:** *Catla*, *Rohu*, common carp etc.
  **Marine fishes:** *Hilsa*, Sardines, Mackerel, Pomfrets etc.
- Fisheries provide income and employment to millions of fishermen and farmers.
- **Aquaculture** (farming of aquatic organisms) & **pisciculture** (farming of fishes) are the techniques to increase the production of aquatic plants and animals.
- **Blue Revolution:** The development and flourishing of the fishery industry.

# II. PLANT BREEDING

- It is the manipulation of plant species to create desired plant types suitable for better cultivation, better yields and disease resistance.
- **Green Revolution:** The development and flourishing of the agriculture. It was dependent on plant breeding.
- **Classical plant breeding** involves hybridization of pure lines and artificial selection to produce desirable traits.
- Now molecular genetic tools are used for plant breeding.

**Desirable traits for plant breeding:**

- Increased crop yield and quality.
- Increased tolerance to environmental stresses (salinity, extreme temperatures & drought).
- Increased resistance to insect pests and pathogens.

## Steps of Plant breeding

### (i) Collection of genetic variability

- In wild relatives of many crops, pre-existing genetic variability is available.
- Collection and preservation of wild varieties, species and relatives of the cultivated species is a pre-requisite for effective exploitation of natural genes.
- The entire collection of plants/seeds having all the alleles for all genes in a given crop is called **germplasm collection.**

### (ii) Evaluation and selection of parents

- The germplasm is evaluated for identifying plants with desirable characters.
- Selected plants are multiplied and used for hybridisation.
- Pure lines are created wherever desirable and possible.

### (iii) Cross hybridisation of the selected parents

- In this, desired characters are genetically combined from 2 different parents to produce hybrid plant.
- E.g. high protein quality of one parent is combined with disease resistance from another parent.
- **Limitations:**
  - Very time-consuming and tedious process.
  - Hybrids may not combine the desirable characters. Usually only hundreds to a thousand crosses show the desirable combination.

### (iv) Selection & testing of superior recombinants

- It is crucial to the success of the breeding objective and requires careful scientific evaluation of the progeny.
- It yields plants that are superior to both parents.
- These are self-pollinated for several generations till they reach a state of uniformity (homozygosity), so that the characters will not segregate in the progeny.

### (v) Testing, release & commercialization

- The newly selected lines are evaluated for their yield and other agronomic traits of quality, disease resistance, etc.
- This is done by growing them in research fields and recording their performance under ideal fertiliser application irrigation and other crop management practices.
- The evaluation is followed by testing the materials in farmers' fields, for at least 3 growing seasons at several locations in the country, representing all the agro-climatic zones. The material is evaluated in comparison to the best available local crop cultivar (a check or reference cultivar).

**Wheat and Rice:**

- In India, food production has increased by the development of high yielding varieties of wheat and rice in the mid-1960s **(Green Revolution)**.
- During 1960-2000, wheat production increased from 11 million tons to 75 million tons. The rice production increased from 35 million tons to 89.5 million tons.

- Nobel laureate **Norman E. Borlaug** (International Centre for Wheat & Maize Improvement, Mexico) developed semi-dwarf wheat.
- In 1963, high yielding and disease resistant wheat varieties like ***Sonalika*** & ***Kalyan Sona*** were introduced in India.
- **Semi-dwarf rice varieties** were derived from **IR-8,** (developed at International Rice Research Institute (IRRI), Philippines) and **Taichung Native-1** (from Taiwan). Later better-yielding semi dwarf varieties ***Jaya*** and ***Ratna*** were developed in India.

**Sugar cane**: ***Saccharum barberi*** (grown in north India, but poor sugar content & yield) was crossed with ***Saccharum officinarum*** (tropical canes in south India, thicker stems and higher sugar content but do not grow well in north India) and got a hybrid sugar cane having desirable qualities like high yield, thick stems, high sugar and ability to grow in north India.

**Millets**: **Hybrid maize, jowar** & **bajra** developed in India. It includes high yielding varieties resistant to water stress.

## Plant Breeding for Disease Resistance

- Plant diseases cause crop losses up to 20-30% or even total.
- Disease-resistant cultivars enhance food production and helps to reduce the use of fungicides and bactericides.
- Resistance of the host plant is the genetic ability to prevent the pathogens from disease.
- **Some plant diseases:**
  - **Fungal: Rusts.** E.g. brown rust of wheat, red rot of sugarcane and late blight of potato.
  - **Bacterial:** Black rot of crucifers.
  - **Viral:** Tobacco mosaic, turnip mosaic, etc.

### Methods of breeding for disease resistance

**1. Conventional breeding:** The steps are:

- Screening germplasm for resistance sources.
- Hybridisation of selected parents.
- Selection and evaluation of the hybrids.
- Testing and release of new varieties.

**Some crop varieties bred by Conventional method:**

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

- Conventional breeding is constrained by the availability of limited number of disease resistance genes.
- Inducing mutations in plants and screening them for resistance help to identify desirable genes. Such plants can be multiplied directly or can be used in breeding.
- Other breeding methods are selection amongst **somaclonal variants** and **genetic engineering.**

**2. Mutation breeding:**

**Mutation** (sudden genetic change) can create new desirable characters not found in the parental type.

**Mutation breeding** is the breeding by mutation using chemicals or radiations (e.g. gamma rays) to produce plants with desirable characters. Such plants are selected and multiplied directly or used as a source in breeding. E.g. In **mung bean,** resistance to **yellow mosaic virus** and **powdery mildew** were induced by mutations.

- **Resistant genes** from wild species have introduced into the high-yielding cultivated varieties. E.g. In ***bhindi (Abelmoschus esculentus),*** resistance to yellow mosaic virus was transferred from a wild species. It resulted in a new variety of ***A. esculentus*** called ***Parbhani kranti.***
- Resistance genes can be transferred by **sexual hybridisation** between the **target** and the **source plant.**

## Plant Breeding for Developing Resistance to Insect Pests

- Morphological, biochemical or physiological characteristics give insect resistance in host crop plants. E.g.
  - **Hairy leaves**: E.g. resistance to jassids in cotton and cereal leaf beetle in wheat.
  - **Solid stems in wheat** lead to non-preference by the stem sawfly.
  - **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.
- Sources of resistance genes for breeding are cultivated varieties, germplasm collections of crop or wild relatives.

**Some crop varieties bred for insect pest resistance:**

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

## Plant Breeding for Improved Food Quality

- More than 840 million people in the world do not have adequate food. 3 billion people suffer from micronutrient, protein and vitamin deficiencies **('hidden hunger').**
- Breeding crops with higher levels of nutrients is called **Biofortification.** It helps to improve public health.

**Objectives of breeding for improved nutritional quality:**

- To improve Protein content and quality.
- To improve Oil content and quality.
- To improve Vitamin content.
- To improve Micronutrient and mineral content.

**Examples for hybrids with improved nutritional quality:**

- **Maize hybrids** having twice the amount of amino acids, **lysine & tryptophan** compared to existing maize hybrids.
- **Wheat** variety, **Atlas 66**, having high protein content.
- **Iron-fortified rice variety** containing over five times as much iron as in common varieties.
- **Vitamins & mineral rich vegetable crops:** Released by Indian Agricultural Research Institute, New Delhi.
  - Vitamin A enriched carrots, spinach, pumpkin.
  - Vitamin C enriched bitter gourd, *bathua*, mustard, tomato.
  - Iron & calcium enriched spinach & *bathua.*
  - Protein enriched beans (broad, lablab, French & garden peas).

## III. SINGLE CELL PROTEIN (SCP)

- It is the protein derived from single-celled organisms.
- It is an alternate source of proteins for animal and human nutrition. E.g. ***Spirulina*** (a blue green alga), ***Methylophilus methylotrophus*** (a bacterium).
- ***Spirulina*** is rich in protein, minerals, fats, carbohydrate & vitamins. It is grown on materials like waste water from potato processing plants, straw, molasses, animal manure & sewage. This also reduces environmental pollution.
- A 250 Kg cow produces only 200 g protein/day. But 250 g ***Methylophilus methylotrophus*** produces **25 tonnes** protein. It is due to high rate of biomass production and growth.

## IV. TISSUE CULTURE

- A technique of growing plant cells/tissues/organs in sterile culture medium under controlled aseptic conditions.
- The ability to generate a whole plant from any cell/explant is called **totipotency**. An **explant** is any part of a plant that is grown in a test tube under sterile nutrient media.
- The nutrient medium must provide a carbon source (such as sucrose), inorganic salts, vitamins, amino acids and growth regulators like auxins, cytokinins etc.
- The method of producing thousands of plants in very short time through tissue culture is called **micropropagation**.
- These plants will be genetically identical to original plant, i.e., they are **somaclones**.
- Tomato, banana, apple etc. are produced by this method.
- Tissue culture is also used to recover healthy plants from diseased plants. The **meristem** (it will be virus-free) from infected plant is removed and grown *in vitro* to obtain virus-free plants. Scientists have cultured meristems of banana, sugarcane, potato, etc.
- **Somatic hybridization:** It is the fusion of protoplasts from two different varieties of plants (with desirable characters) to get hybrid protoplasts. It can be grown to form a new plant called **somatic hybrids.** Protoplasts can be isolated after digesting the cell walls of plant cells.
  E.g. Protoplast of tomato + protoplast of potato → **pomato.** This hybrid plant has the characteristics of tomato & potato. But it has no all desired characteristics for its commercial utilization.

## MODEL QUESTIONS

1. Find the odd one out by stating the reasons
   (a) Jaya, Ratna, Kalyan Sona, IR 8
2. One of the aims of plant breeding is to produce high yielding, disease resistant crop plants.
   (a) Describe the main steps in plant breeding.
   (b) Name the variety of bhindi which is resistant to yellow mosaic virus.
3. Some released crop varieties produced by hybridization and selection for insect pest resistant are given below. Complete the table.

| Crop | Variety | Insect pests |
|---|---|---|
| Brassica | PUSA GAURAV | ---------- |
| ---------- | PUSA SEM-2, PUSA SEM-3 | Jassids, aphids and fruit borer |
| Okra | ---------- | ---------- |

4. MOET is a controlled breed experiment
   (a) Expand MOET (b) Mention any one hormone used in MOET
5. You are appointed as an Agricultural officer in the Rice breeding station. What are the criteria you will choose for producing a high yielding variety?
6. In a poultry farm, some of the chickens found to be infected with bird flu. Enumerate the measures to be taken to prevent the spread of the disease.
7. Keeping beehives in crop fields during flowering period proves economically good. Evaluate.
8. Artificial insemination is a controlled breeding. Justify
9. Your neighbour wishes to start a dairy farm. As a biology student, give some advice for a healthy dairy farm management.
10. In animal breeding programme the inbreeding techniques create pure lines in animals, but continuous usage cause inbreeding depression in animals.
    (a) What is inbreeding depression? (b) Suggest a remedial measure for inbreeding depression.
11. In a Tissue Culture lab, thousands of healthy disease-free banana plants were produced from a high yielding variety infected with virus. Name the culture method adopted here.
12. Expand the abbreviations given: a) IARI b) IRRI c) SCP d) ICWMI