STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

ANIMAL HUSBANDRY

- The agricultural practice of breeding and raising livestock.
- Deals with the care and breeding of livestock like buffaloes, cows, pigs, horses etc.
- Also includes poultry farming and fisheries.

- **Fisheries** include rearing, catching, selling, etc., of fish, molluscs (shell-fish) and crustaceans (prawns, crabs, etc.).

ANIMAL HUSBANDRY Contd….

- 70 per cent of the world livestock population is in India and China.
- But the contribution to the world farm produce is only 25 per cent.
- Hence, application of newer technologies is a must have to achieve improvement in quality and productivity.

Management of Farms and Farm Animals

Dairy Farm Management

- Deals with processes and systems that increase yield and improve quality of milk.

Important Components of Diary Farm Management

1. **Selection of good breeds**
2. **Cattle have to be well looked after**
3. **Feeding**
4. **Cleanliness and hygiene**
5. **Regular visits by a veterinary doctor**

Poultry Farm Management

- Poultry is the class of domesticated fowl (birds) used for food or for their eggs.

- Include chicken and ducks, and sometimes turkey and geese.

Important components of poultry farm management

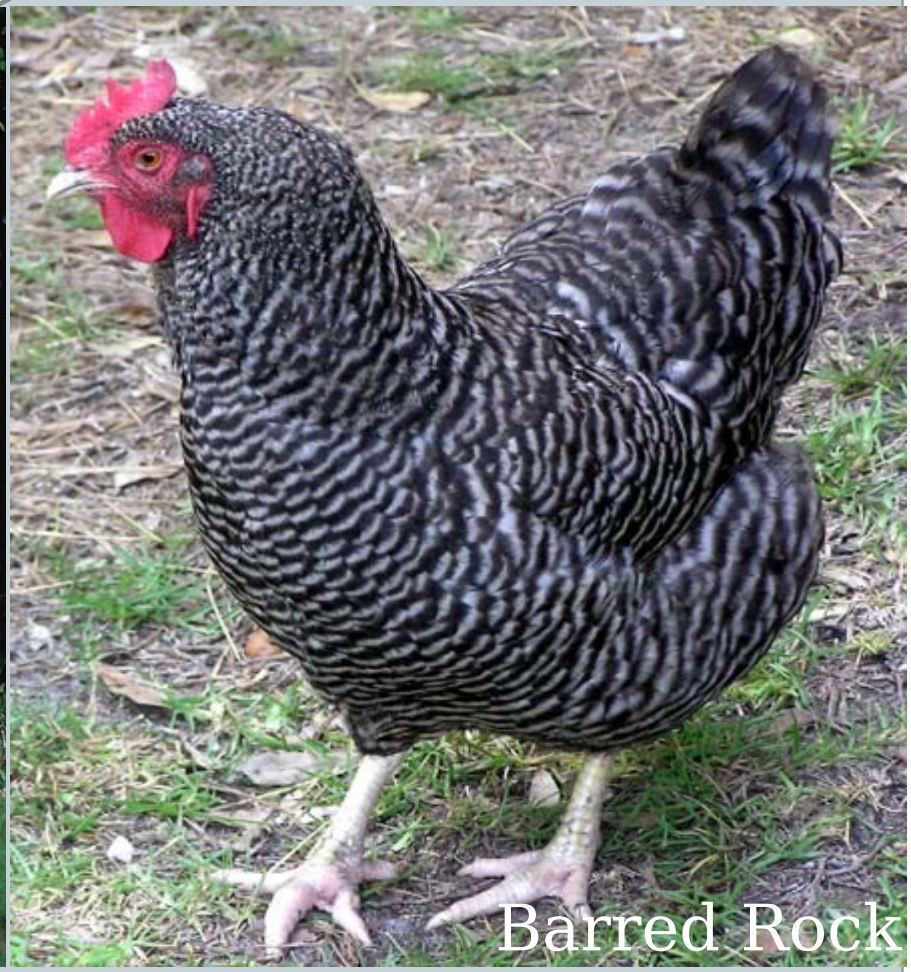
1. Selection of disease free and suitable breeds
2. Proper and safe farm conditions
3. Proper feed and water
4. Hygiene and health care

Animal Breeding

- Aims at increasing the yield of animals and improving the desirable qualities of the produce.
- **Breed**:-A group of animals related by descent and similar in most characters.
- When breeding is between animals of the same breed it is called **inbreeding**, while crosses between different breeds are called **out breeding**.

Improved Breeds

Jersey



Barred Rock

Inbreeding

- When breeding is between animals of the same breed it is called **Inbreeding.**

- Mating of more closely related individuals within the same breed for 4-6 generations.

Inbreeding Strategy

- Identification of superior males and superior females of the same breed.
- Selected parents are mated in pairs.
- Evaluation of progenies and selection of superior males and females for further mating.
- A **superior female**, in the case of cattle, is the cow or buffalo that produces more milk per lactation.
- A **superior male** is the bull, which gives rise to superior progeny as compared to those of other males.

Significance of Inbreeding

1. Inbreeding increases homozygosity (used to evolve a pureline in any animal).
2. Inbreeding exposes harmful recessive genes that are eliminated by selection.
3. Helps in the accumulation of superior genes and elimination of less desirable genes.
4. Continued inbreeding, especially close inbreeding, usually reduces fertility and even productivity (Inbreeding Depression).

How to overcome Inbreeding Depression

- To overcome **Inbreeding Depression** selected animals of the breeding population should be mated with unrelated superior animals of the same breed.

- This usually helps restore fertility and yield.

Out-breeding

- The breeding of the unrelated animals, which may be between

1. Individuals of the same breed (but having no common ancestors - out crossing)
2. Different breeds (cross-breeding)
3. Different species (inter-specific hybridisation)

Out-crossing

- 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.
- The offspring of such a mating is known as an out-cross.

Significance

1. Best breeding method for animals that are below average in productivity in milk production, growth rate in beef cattle, etc.
2. A single outcross often helps to overcome inbreeding depression.

Cross-breeding

- Superior males of one breed are mated with superior females of another breed.

1. Allows the desirable qualities of two different breeds to be combined.
2. Alternatively, they may be subjected to some form of inbreeding and selection to develop new stable breeds that may be superior to the existing breeds.
3. Many new animal breeds have been developed by this approach.

- **Hisardale** is developed in Punjab by crossing Bikaneri ewes and Marino rams.

Parents of Hisardale

Interspecific hybridisation

- Mating between the members of different species.
- The progeny combine desirable features of both the parents
- E.g., the mule.

Controlled breeding experiments

- Artificial insemination.
- Multiple Ovulation and Embryo Transfer Technonogy (MOET)

Artificial insemination

- The semen collected from chosen male parent is injected into the reproductive tract of the selected female.

- Artificial insemination helps us overcome several problems of normal matings.

Multiple Ovulation Embryo Transfer Technology (MOET)

- Used to improve chances of successful production of hybrids.
- Induced super ovulation in female by giving hormones with FSH-like activity (produce 6-8 eggs).
- The female is mated with an elite bull or artificially inseminated.
- The fertilised eggs at 8–32 cells stages, are recovered non-surgically and transferred to surrogate mothers.
- This technology 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

- Bee-keeping or apiculture is the maintenance of hives of honeybees for the production of honey.
- Also produces beeswax, used in the preparation of cosmetics and polishes of various kinds.

Points For Successful Bee-Keeping

- The following points are important for successful bee-keeping:

1. Knowledge of the nature and habits of bees,
2. Selection of suitable location for keeping the beehives,
3. Catching and hiving of swarms (group of bees),
4. Management of beehives during different seasons, and
5. Handling and collection of honey and of beeswax.

- Bees are the pollinators of many of our crop species such as sunflower, Brassica, apple and pear.

- Keeping beehives in crop fields during flowering period increases pollination efficiency and improves the yield– beneficial both from the point of view of crop yield and honey yield.

Other Advantages of Bee Keeping

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Fisheries

- Fishery is an industry devoted to the catching, processing or selling of fish, shellfish or other aquatic animals.
- A large number of our population is dependent on fish, fish products and other aquatic animals such as prawn, crab, lobster, edible oyster, etc., for food.
- Common freshwater fishes - Catla, Rohu and common carp.
- Common edible marine fishes – Hilsa, Sardines, Mackerel and Pomfrets.

PLANT BREEDING

- The purposeful manipulation of plant species in order to create desired plant types that are better suited for cultivation, give better in yields and are disease resistant.
- Classical plant breeding - crossing or hybridisation of pure lines, followed by artificial selection to produce plants with desirable traits of higher yield, nutrition and resistance to diseases.
- Plant breeding is now increasingly being carried out by using molecular genetic tools.

TRAITS USED BY PLANT BREEDERS

1. Increased crop yield and improved quality
2. Increased tolerance to environmental stresses (salinity, extreme temperatures, drought)
3. Resistance to pathogens (viruses, fungi and bacteria)
4. Increased tolerance to insect pests

STEPS IN BREEDING

1. Collection of variability
2. Evaluation and selection of parents
3. Cross hybridisation among the selected parents
4. Selection and testing of superior recombinants
5. Testing, release and commercialisation of new cultivars

Collection of variability

- Collection and preservation of all the different wild varieties, species and relatives of the cultivated species is essential for successful Plant Hybridisation.

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

Evaluation and selection of parents

- The germplasm is evaluated so as to identify plants with desirable combination of characters.
- The selected plants are multiplied and used in the process of hybridisation.

Cross hybridisation among the selected parents

- The pollen grains from the desirable plant chosen as male parent are collected and placed on the stigma of the flowers selected as female parent.

- Usually only one in few hundred to a thousand crosses shows the desirable combination.

Selection and testing of superior recombinants

- Selection among the progeny for the desired character combination.
- This step yields plants that are superior to both of the parents
- These are self-pollinated for several generations till they reach a state of uniformity (homozygosity).

Testing, release and commercialisation of new cultivars

- The newly selected lines are evaluated for their yield and other agronomic traits.
- This evaluation is done by growing these in the research fields and recording their performance under ideal fertiliser application, irrigation, and other crop management practices.
- The evaluation in research fields is followed by testing the materials in farmers' fields, for at least three growing seasons at several locations in the country.
- The material is evaluated in comparison to the best available local crop cultivar – a check or reference cultivar.

Improved Varieties of Wheat and Rice

- Semi-dwarf varieties Sonalika and Kalyan Sona , (Developed by Nobel laureate Norman E. Borlaug, at International Centre for Wheat and Maize Improvement in Mexico) - high yielding and disease resistant, 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).
- Better-yielding semi-dwarf varieties Jaya and Ratna were developed in India.

Sugar cane

- *Saccharum barberi* was originally grown in north India, but had poor sugar content and yield.
- Tropical canes grown in south India *Saccharum officinarum* had thicker stems and higher sugar content but did not grow well in north India.
- These two species were successfully crossed to get sugar cane varieties combining the desirable qualities of high yield, thick stems, high sugar and ability to grow in the sugar cane areas of north India.

Millets

- Hybrid maize, jowar and bajra have been successfully developed in India.

- Hybrid breeding have led to the development of several high yielding varieties resistant to water stress.

Plant Breeding for Disease Resistance

- Crop losses due to plant diseases is up to 20-30 per cent, or sometimes even total.
- Breeding and development of cultivars resistant to disease enhances food production.
- Also helps reduce the dependence on use of fungicides and bactericides.
- Some of the diseases caused by fungi are rusts, e.g., brown rust of wheat, red rot of sugarcane and late blight of potato; by bacteria – black rot of crucifers; and by viruses – tobacco mosaic, turnip mosaic, etc.

Methods of breeding for disease resistance

- Breeding is carried out by the conventional breeding techniques (described earlier) or by mutation breeding.

1. Screening germplasm for resistance sources
2. Hybridisation of selected parents,
3. Selection and evaluation of the hybrids
4. Testing and release of new varieties

Disease Resistant Varieties

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 Curl blight black rot*
Cowpea	*Pusa Komal*	*Bacterial blight*
Chilli	*Pusa Sadabahar*	*Chilly mosaic virus, Tobacco mosaic virus and Leaf curl*

Limitations of Conventional Breeding

- Constrained by the availability of limited number of disease resistance genes that are present and identified in various crop varieties or wild relatives.

Other Methods of Plant Breeding

- Mutation Breeding
- Selection among Somaclonal Variants
- Genetic Engineering

- 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 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.
- It is possible to induce mutations artificially through use of chemicals or radiations (like gamma radiations), and selecting and using the plants that have the desirable character as a source in breeding – this process is called mutation breeding.
- In mung bean, resistance to yellow mosaic virus and powdery mildew were induced by mutations.

Importance of Wild Varieties

- Provide genes for disease resistance.
- Used to introduce the resistant genes into the high-yielding cultivated varieties.
- Resistance to yellow mosaic virus in bhindi (*Abelmoschus esculentus*) was transferred from a wild species and resulted in a new variety of *A. esculentus* called Parbhani kranti.

Plant Breeding for Developing Resistance to Insect Pests

- Insect and pest infestation cause large scale destruction of crop plant and crop produce.
- Insect resistance may be due to morphological, biochemical or physiological characteristics.

1. 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.
2. In wheat, solid stems lead to non-preference by the stem sawfly and smooth leaved and nectar-less cotton varieties do not attract bollworms.
3. High aspartic acid, low nitrogen and sugar content in maize leads to resistance to maize stem borers.

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Table 9.2

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

- More than 840 million people in the world do not have adequate food to meet their daily food and nutritional requirements.
- About three billion people suffer from micronutrient, protein and vitamin deficiencies or ‘hidden hunger’ because they cannot afford to buy enough fruits, vegetables, legumes, fish and meat.
- Diets lacking essential micronutrients – particularly iron, vitamin A, iodine and zinc – increase the risk for disease, reduce lifespan and reduce mental abilities.

Biofortification

- Breeding for improved nutritional quality is called Biofortification.
- This mainly aims at improving

1. Protein content and quality
2. Oil content and quality
3. Vitamin content
4. Micronutrient and mineral content

Biofortified Foods

- In 2000, maize hybrids that had twice the amount of the amino acids, lysine and tryptophan, compared to existing maize hybrids were developed.
- Wheat variety, Atlas 66, having a high protein content, has been used as a donor for improving cultivated wheat.
- It has been possible to develop an iron-fortified rice variety containing over five times as much iron as in commonly consumed varieties.

Biofortified Foods

- The Indian Agricultural Re search Institute, New Delhi has also released several vegetable crops that are rich in vitamins and minerals.

1. Vitamin A enriched carrots, spinach, pumpkin
2. Vitamin C enriched bitter gourd, bathua, mustard, tomato
3. Iron and calcium enriched spinach and bathua
4. Protein enriched beans – broad, lablab, French and garden peas

SINGLE CELL PROTEIN (SCP)

- Conventional agricultural production of cereals, pulses, vegetables, fruits, etc., may not be able to meet the demand of food at the rate at which human and animal population is increasing.

- The shift from grain to meat diets also creates more demand for cereals as it takes 3-10 Kg of grain to produce 1 Kg of meat by animal farming.

- One of the alternate sources of proteins for animal and human nutrition is Single Cell Protein (SCP).

SCP Contd.....

- When microbes are grown as sources of proteins and other nutrients called Single Cell Protein.
- E.g., Spirulina, *Methylophilus methylotrophus*
- Spirulina can be grown on materials like waste water from potato processing plants (containing starch), straw, molasses, animal manure and even sewage, to produce large quantities and can serve as food rich in protein, minerals, fats, carbohydrate and vitamins.
- It has been calculated that a 250 Kg cow produces 200 g of protein per day.
- In the same period, 250 g of a micro-organism like *Methylophilus methylotrophus*, because of its high rate of biomass production and growth, can be expected to produce 25 tonnes of protein.

TISSUE CULTURE

- The process of growing cells, tissues and plant parts in a nutrient medium to regenerate in to a whole plant is called tissue culture.
- Any plant part used for tissue culture is called an explant.
- The capacity to generate a whole plant from any cell/explant is called totipotency.
- The nutrient medium must provide a carbon source such as sucrose and also inorganic salts, vitamins, amino acids and growth regulators like auxins, cytokinins etc.

TISSUE CULTURE Contd…..

- The method of producing thousands of plants through tissue culture is called micro-propagation.
- Each of these plants will be genetically identical to the original plant from which they were grown, i.e., they are somaclones.

Significance of Tissue Culture

1. Many important food plants like tomato, banana, apple, etc., have been produced on commercial scale using this method.

2. Production of virus free plants through stem meristem culture. E.g., Banana, Sugarcane and Potato

3. Somatic Hybridisation and production of somatic hybrids. E.g., Pomato from Potato and Tomato

Somatic Hybridisation

- Fusion of isolated protoplasts of two different plants is called somatic hybridisation and such hybrids are called somatic hybrids.

- Scientists had succeeded in combining the protoplasts of potato and tomato to produce pomato but the hybrids did not give expected results.