STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

PLANT BREEDING

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INTRODUCTION

- It is the genetic improvement of the crop for better yields, disease resistant.
- Green Revolution was responsible for our country not only to meet our requirements in food production but also helped us to export it. The former mainly depended on plant breeding techniques for high yielding and disease resistant varieties in wheat, rice, maize, etc.
- Traditional or classical plant breeding involves hybridization of pure lines, artificial selection to produce plants with desirable characters of higher yield, nutrition and resistance to diseases.

MAIN STEPS IN PLANT BREEDING:

Collection of variability:

- Wild relatives of the crop bear pre-existing genetic variability. Collection and preservation of all the different wild species, varieties are useful to control the exploitation of natural genes available in the population.
- **Germplasm** represents sum total of all the alleles of the genes present in a crop and its related species.
- The entire collection of plants / seeds containing all the diverse alleles for all genes in a given crop is called **germplasm collection**. The latter is required for a successful breeding programme.
- Germplasm is usually collected in the form of **seeds** from within the country or from other countries. Seeds are maintained at a low temperature. The stored seeds are grown periodically in the field to obtain fresh seeds. In case of fruit trees, the germplasm is maintained as trees grown in the field or in test tubes as shoot cultures by plant tissue culture.

Evaluation and Selection of Parents:

- The seeds of those plants are picked up for multiplication that have the desired traits. The selection is classified into two groups.

1. **Selection in self-pollinated crops**
2. **Selection in cross-pollinated crops**.

1. Selection in self-pollinated crops:

- Superior homozygous genotypes are obtained by repeated self pollination. The self-pollinated progeny of homozygous plant constitutes a pure line. The plants of latter bear identical genotype. **e.g. wheat variety HUW 468**.

2. Selection in cross-pollinated crops:

- Cross-pollinated crops are heterozygous for most of their genes thus they bear several different genotypes out of them, some genotypes are superior and many are inferior. Heterozygosity is maintained by the selection of superior genotypic plants and allowed them to perform crossbreed.

Cross or Hybridization among the selected Parents:

- Hybridization involves crossing of two or more types of plants for bringing their traits together in the progeny. The former includes a single cross (two plants) or multiple cross (more than two plants).

Hybridization is of following types.

(i) **Intravarietal :** It is performed between two plants of a variety **e.g. Cross between two plants of Brassica oleracea var. capitata (cabbage).**

(ii) **Intervarietal (intra specific) :** It is performed between two varieties of a plant species **e.g. Cross between Brassica oleracea var. capitata (cabbage) and Brassica oleracea var. botrytis (cauliflower).**

(iii) **Interspecific :** It is performed between two species of a genera **e.g. development of rice variety ADT–37 from a cross between Oryza japonica and O. indica**.

(iv) **Intergeneric :** It is performed between two different genera **e.g. Raphanobrassica, Triticale**.

Selection and Testing of superior Recombinations:

- The plants that have the desired character combination are selected among the progeny of the hybrids. These plants are self-pollinated for several generation to obtain homozygosity so that the characters will not separate in the progeny.

Testing, Release and Commercialization of New Cultivars:

- The newly selected lines are evaluated in the research field and recording their performance in ideal fertiliser, irrigation, etc. for their yield and other agronomic traits of quality, disease resistance, etc. After that the testing of the materials is performed in the farmer's fields, for at least three growing seasons at different locations in the country, the material is evaluated in comparison to the best available crop cultivar.

GREEN REVOLUTION IN INDIA

- **Agriculture** contributes about **33 percent of India's GDP** and gives employment of about **62 percent** of the population. After India's independence, one of the main challenges faced by the country was enough food production for the increasing population. The development of several high yielding varieties of wheat and rice in 1960 increased yields per unit area. This phase is often called the **Green Revolution. Dr. Borlaug** is known as **'Father of Green Revolution'** while **Dr. M.S. Swaminathan** is known as **'Father of Green Revolution in india'**.

Wheat and Rice:

- In 1960 to 2000 wheat production increased from 11 million tonnes to 75 million tonnes while rice production increased from 35 million tonnes to 89.5 million tonnes. It was due to the development of semi-dwarf varieties of wheat and rice.

Wheat:

Dwarfing gene **Norin -10** was noticed in Japan. It was picked up by American breeders. In 1963, **Borlaug** was able to breed high yielding triple dwarf or **Mexican wheats** which were resistant to lodging, common pathogens and pests. Two of these, **sonora-64 and Lerma Roja-64** were brought to India and modified by gamma radiations.

Rice:

Dwarfing gene **dee-geo-woo-gen** was noticed in **Taiwan**. It was introduced in **Rice varieties** by **IRRI, Philippines** and developed high yielding early maturing **IR-8 and IR-24 varieties**. Later on, semidwarf varieties 'jaya' and 'Ratna' were developed in Indian **(AIPMT Pre. - 2011)**

Sugarcane:

- **Saccharum barberi** was originally grown in North India, but had poor sugar content and yield, However, **Saccharum officinarum** had higher sugar content and thicker stems but did not grow well in North India. These two species were crossed to have sugarcane varieties combining the desirable qualities of high sugar, high yield, thick stems and ability to grow in the sugarcane belt of North India.

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 were taken over.

TABLE

S.No.	Name of disease	Causal organism
1	Black rust of wheat	Puccinia graminis-tritici
2	Loose smut of wheat	Ustilago tritici
3	Late Blight of Potato	Phytophthora infestans
4	Bean Mosaic Disease	Common Mosaic Virus (CMV) and Yellow Mosaic Virus (YMV)
5	Bacterial Leaf Blight of Rice	Xanthomonas oryzae
6	Black rot of crucifers	Xanthomonas campestris
7	Root Knot of Brinjal and Tomato	Meloidogyne incognita

Plant Breeding for Disease Resistance :

Cultivated crops are affected by various types of pathogens like fungi, bacteria, virus Nematodes resulting Crop losses upto 20–30%. In this condition the developement of disease resistance in crop plants will increase food production and the use of fungicides and bacteriocides would be reduced.

Some important diseases of plants are as follow.

(i) Black rust of wheat :

Causal organism : This disease is due to **Puccinia graminis-tritici.** The latter is **heterocious fungi** (It completes its life cycle in two hosts–**wheat and Barberry).**

Symptoms : Brownish to blackish spore rich pustules developed on the leaves and stem surface of wheat. Brownish pustules represent **uredospores** while blackish pustules represent **teleutospores** which form basidia that produce haploid **basidiospores** which infect barberry it produces pycnidia on upper surface and aecidia on lower surface. Aecidia form **aecidiospores** for infecting wheat.

Control :

(a) Use of rust resistant varieties like **Sonora 63, Sonora 64 and Lerma Rojo.**
(b) Use of variety of fungicides.

(ii) Loose smut of wheat :

Causal organism : Ustilago tritici is responsible for this disease.

Symptoms : It attacks on **ear (inflorescence)** resulting it is converted into a black powdery mass of spores **(chlamydospores)** as every grain is internally changed into a ball of spores covered by a thin membrane which rupture. Plants become stunted with reduced height and a number of tillers. Flag leaves turn yellow and later get shedded.

Control :

(a) Use of **fungicide like vitavax, baristan.**
(b) Hot water treatment, solar treatment.
(c) Use of Disease resistant varieties.

(iii) Late Blight of Potato :

Causal organism :

It is due to **Phytophthora infestans**. Famous irish famine was due to it in 1845. The disease kills the foliage, reducing yield of tubers.

Symptoms :

Water soaked areas appear along the margin and tips of lower leaflets. The former enlarge, become necrotic and turn brown and then blackish or blighted. Leaflets become coiled and withered. Infected leaves soon become limped, and rot away producing a characteristic odour.

Control :

(a) Sowing early varieties, disease resistant varieties, pathogen free tubers.
(b) Spray of fungicides.
(c) Rogueing, sanitation.

(iv) Bean Mosaic Disease :

Causal organism : It is caused by two viruses, **Common Mosaic Virus (CMV) and Yellow Mosaic Virus (YMV).** They bear coiled strand of RNA surrounded by a coat of protein capsomeres. It is found in beans (Soyabean, winged bean, French bean, Broad bean, Mung bean, Urd bean).

Symptoms :

Plants become stunted and bunchy. Leaves show yellowing, mottling, malformations, Mosaic appearance seeds are small, malformed or aborted.

Control :

(a) Use of Virus free seeds.
(b) Sowing resistant varieties.
(c) Soil treatment with insecticide like aldicarb and foliar spray to restrict vectors.

(v) Bacterial Leaf Blight of Rice :

Causal organism :

It is due to **Xanthononas oryzae**.

Symptoms :

Development of water soaked spots, yellow or green yellow broad stripe on young leaves, water soaked areas enlarge and covered the entire leaves. These infected leaves dry up and get rolled. The stems and the leaves of infected plant give blighted appearance.

Control :

(a) Spraying antibiotics over the nursery beds.
(b) Use of disease resistant varieties.
(c) Burning of crop residue.
(d) Dipping the seedlings in copper and zinc compounds.
(e) Chlorination of irrigated water.

(vi) Plant Diseases Caused by Nematodes :

(1) Root Knot of Brinjal and Tomato :

Causal organism :

It is due to nematode **Meloidogyne incognita**.

Symptoms :

Spherical to elliptical swellings or galls are formed near the site of infection due to cell proliferation. Galls devitalize root tips, reduce flow of water and minerals of arial parts and therefore, yield and quality are impaired.

Control :

(a) Spraying nematicides (methyl bromide, ethylene dibromide, methyl isothiocyanate, trichloronitromethane).
(b) Crop rotation.
(c) Deep ploughing.
(d) Flooding the fields.
(e) Use of transgenic and resistant crops.

Point of Remember

1. **Quarantine :** All introductions (either exotic or indigenous) are carefully examined for the presence of weeds, insects and disease-causing organisms. It is called **quarantine**. Only those introductions that are free from the above, are permitted to be used, and the rest are destroyed.
2. **Inbreeding Depression :** Mating of closely related individuals by ancestry. Inbreeding is useful in self pollinated plants. Loss of vigour and appearance of number of defective traits associated with inbreeding, is called **inbreeding depression**. The latter promotes homozygosity in recessive alleles that express their harmful effects.
3. **Heterosis or hybrid Vigour :** It is phenotypic superiority of the hybrid over either of its parents in one or more traits.

METHODS OF BREEDING FOR DISEASE RESISTANCE:

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

Conventional breeding

The conventional method of breeding for disease resistance is that of hybridisation and selection. It's steps are essentially identical to those for breeding of any other agronomic characters such as high yield. The various sequential steps are - screening germplasm for resistance sources, hybridisation of selected parents, selection and evaluation of the hybrids and testing and release of new varieties. Some crop varieties bred by hybridisation and selection, for disease resistance to fungi, bacteria and viral disease are released.

S.No.	Crop	Variety	Resistance to diseases
1	Wheat	Himgiri	Leaf and stripe rust, hill bunt
2	Brassica	Pusa swarnim (Karan rai)	White rust
3	Cauliflower	Pusa shubhra, Pusa Snowball K-1	Black rot and Curl blight black rot
4	Cowpea	Pusa Komal	Bacterial blight
5	Chilli	Pusa sadabahar	Chilly mosaic virus, Tobacco mosaic virus and Leaf curl

Mutation Breeding:

- Sudden and inheritable change in a character of an organism is called mutation.
- Various types of mutagens like Chemical mutagens, Physical mutagens cause mutations. The latter are called **induced mutations** firstly produced by **Muller (1927)** with the help of **X-rays on Drosophila** and by **Stadler in maize**.
- The development of improved varieties by the use of induced mutations in plant breeding is called **mutation breeding**.

Some useful acheivements of mutation breeding are as follow.

(a) Red grained high yielding Mexican wheat varieties like **Sonora - 64 and Lerma Rojo - 64** treated with gamma radiations and developed amber grained varieties **Sharbati Sonora and Pusa Lerma** respectively.

(b) **Gamma ray** treatment of **'Pelita-1' rice** lines in indonesia has produced a high yielding variety called **alomita- 2** which is also resistant to **brown plant hopper**. **'Reimei'** is another high yielding Rice variety produced through **gamma irradiation**.

(c) **Aruna variety of castor**.

(d) In mungbean, resistance to yellow mosaic virus and Powderly mildew were introduced by mutations.

(e) **NP 836 variety of** wheat.

PLANT BREEDING FOR DEVELOPING RESISTANCE TO INSECT PESTS:

- Large scale destruction of crop plant and crop is due to two major causes-insects and pest infection. Morphological, biochemical or physiological characters are responsible for insect resistance in host crop plants. **e.g. Solid stems in wheat lead to nonpreference by the stem saw fly and smooth leaved and nectar-less cotton varieties does not attract boll worms. Low nitrogen, sugar and high aspartic acid in maize develops resistance to maize stem borers**.

S.No.	Crop	Variety	Insect Pests
1	Brassica (rapeseed)	Pusa Gaurav	Aphids
2	Flat bean	Pusa sem 2, Pusa sem 3	Jassids, aphids and fruit borer
3	Okra (Bhindi)	Pusa Sawani Pusa A-4	Shoot and fruit borer

Cultivated varieties, germplasm collection of the crops or wild relatives of the crop are the sources of resistant genes.

PLANT BREEDING FOR IMPROVED FOOD QUALITY:

- More than 840 million people in the world do not have adequate food to meet their daily requirements. Three billion people suffer from protein, vitamins and micronutrient

deficiencies or 'hidden hunger' because these people cannot afford to buy adequate vegetables, fruits, legumes, fish and meat.

- Breeding of crops with higher levels of vitamins and minerals or higher protein and healthier fats is called **Biofortification.**
- Objectives of improving nutritional quality of the plants by plant breeding are as follow.

(i) **Protein content and quality.**

(ii) **Oil content and quality.**

(iii) **Vitamin content.**

(iv) **Micronutrient and mineral content**.

- Wheat variety with high protein content **Atlas 66** has been used as a donor for improving cultivated wheat.
- **Maize hybrids** that had twice the amount of the **amino acids – lysine and tryptophan**, compared to existing maize hybrids were developed in 2000.
- **Indian Agricultural Research Institute (IARI)**, New Delhi, has also developed many vegetable crops that are rich in minerals and vitamins. For example, vitamin A enriched carrots, pumpkin, spinach, vitamin C enriched bitter gourd, Bathua, tomato, mustard, calcium and iron enriched spinach and bathua; and protein enriched beans (broad Iablab, French and garden peas).

Point of Remember

- **Antinutritional factors :** These are biochemicals found in food articles that have an adverse effect on health, growth and development of human/animals.

  Ex: (1) Red Kidney Bean and French Bean bear Toxic proteins lectins that is responsible for agglutination of RBCs.

  Ex : (2) Khesari, (Lathyrus sativus) contains neurotoxin cyanoalanine which causes muscular weakness, tremor (lathyrism–a type of paralysis).

  (3) Rape seed (Brassica napus) contains erucic acid and glucosinolates that are harmful to human health. Some new varieties of **Rape seed** like **Canola and Hoya** have been developed that are free from both erucic acid and glucosinolates.