Strategies for Enhancement in Food Production

Chapter 5

(1) INTRODUCTION

With ever-increasing population of the world, enhancement of food production is a major necessity. Biological principles as applied to animal husbandry and plant breeding have a major role in our efforts to increase food production. Several new techniques such as embryo transfer and tissue culture play vital role in enhancing food production.

(2) PLANT BREEDING

- Green revolution was dependent to a large extent on plant breeding techniques for development of high yielding and disease resistant varieties in wheat, rice, maize etc.

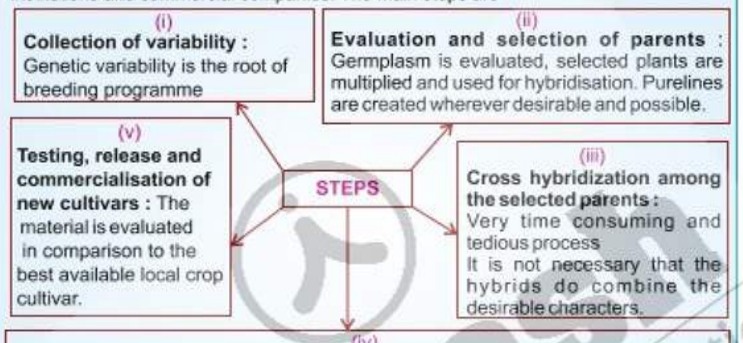
What is plant breeding?

- Plant breeding is the purposeful manipulation of plant species in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant.
- Today, all our major food crops are derived from domesticated varieties.
- Classical plant breeding involves crossing or hybridization of pure lines, followed by artificial selection to produce plants with desirable traits of higher yields, nutrition and resistant to diseases. With advancement in genetics, molecular biology and tissue culture, plant breeding is now increasingly being carried out by using molecular genetic tools.

Characters that breeders want to incorporate into the crops plants are increased crop yield, improved quality, increased tolerance to environmental stresses like salinity, drought, extreme temperature, resistance to pathogens and increased tolerance to insect pests.

(3)

Plant breeding programmes are carried out in systematic way worldwide in government institutions and commercial companies. The main steps are



The entire collection of plants/seeds having all the diverse alleles for all genes in a given crops is called germplasm collection.

(5) PLANT BREEDING FOR DISEASE RESISTANCE

- Cultivars resistant to disease, enhance food production and also helps to reduce the dependence on use of fungicides and bacteriocides.
- **Method of breeding for disease resistance :** Breeding is carried out by the conventional breeding techniques or by mutation breeding.

Crop	Variety	Resistance to Disease
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

Resistance of the host plant is the ability to prevent the pathogen from causing disease and is determined by the genetic constitution of the host plant

(4)

- Agriculture accounts for approximately 33 percent of India's GDP.
- The development of several high yielding varieties of wheat and rice in the mid 1960s, as a result of various plant breeding techniques led to dramatic increase in food production in our country. This phase is often referred to as the **Green Revolution**.

Wheat and Rice :

- During the period 1960 to 2000, wheat production increased from 11 million tonnes to 75 million tonnes while rice production went up from 35 million tonnes to 89.5 million tonnes. This was due to the development of semi-dwarf varieties of wheat and rice.
- Nobel laureate Norman E. Borlaug, at International Centre for Wheat and Maize Improvement in Mexico, developed semi-dwarf wheat.
- In 1963, several varieties such as Sonalika and Kalyan Sona, which were high yielding and disease resistant, were introduced all over the wheat-growing belt of India.
- Semi-dwarf rice varieties were derived from IR-8, (developed at International Rice Research Institute (IRRI), Philippines) and Taichung Native-1 (from Taiwan). The derivatives were introduced in 1966. Later better-yielding semidwarf rice varieties Jaya and Ratna were developed in India.

Sugarcane:

- *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 success-fully crossed to get sugar cane varieties combining the desirable qualities of high yield, thick stems, high sugar content 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.

(6)

- Conventional breeding is often constrained by the availability of limited number of disease resistance genes that are present and identified in various crop varieties or wild relatives.
- Inducing mutations in plants through diverse means and then screening the plant materials for resistance sometimes leads to desirable genes being identified.
- It is possible to induce mutations artificially through use of chemicals or 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 whereas in Bhindi (*Abelmoschus esculantus*) resistance to yellow mosaic virus was transferred from a wild species and resulted in a new variety of *Abelmoschus esculentus* called **Parbhani Kranti**.

(7) PLANT BREEDING FOR DEVELOPING RESISTANCE TO INSECT PESTS

- Another major cause for large scale destruction of crop plant and crop produce is insect and pest infestation.
- Insect resistance in host crop plants may be due to morphological, biochemical or physiological characteristics.
- Source of resistance genes may be cultivated varieties, germplasm collections of the crop or wild relatives.

Crop	Resistance to insect/pest	Reason of resistance	Type of resistance
Wheat	Stem saw fly	Solid stem	Morphological
Wheat	Leaf beetle	Hairly leaves	Morphological
Cotton	Jassids	Hairly leaves	Morphological
Cotton	Bollworms	Smooth leaves and absence of nectar	Morphological and Biochemical
Maize	Stem borers	Low nitrogen, sugar and high aspartic acid	Biochemical

Some released crop varieties bred by hybridisation and selection for insect pest resistance are given below:

Crop	Variety	Insect Peststt
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

(9) SINGLE CELL PROTEINS (SCP)

- More than 25 per cent of human population is suffering from hunger and malnutrition. One of the alternate sources of proteins for animal and human nutrition is single cell protein (SCP)
- Organisms / Microbes grown as a source of good protein are *Spirulina*, *Methylophilus methylotrophus*, mushrooms and some fungi.
- Microbes like *Spirulina* can be grown easily on waste water from potato processing plants, such utilisation reduces environmental pollution.

(8) 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. They suffer from hidden hunger .

Biofortification : Breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats – It is the most practical means to improved public health.

Biofortification is done with the objectives of improving

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

- In 2000, maize hybrids that had twice the amount of the amino acids, lysine and tryptophan were developed. Wheat variety, Atlas 66 having a high protein content, has been used as a donor for improving cultivated wheat.
- IARI (Indian Agricultural Research Institute, New Delhi) has developed/released several vegetable crops that are rich in vitamins and minerals and proteins. e.g.

Vitamin A enriched carrots, spinach, pumpkin, vitamin C enriched bitter gourd, bathua, mustard, tomato. Iron and calcium enriched spinach and bathua and protein enriched beans (Broad, lablab and french) and garden peas.

(10) TISSUE CULTURE

- As traditional breeding techniques failed to keep pace with demand and to provide sufficiently fast and efficient systems for crop improvement, another technology called tissue culture got developed.
- **Explant** : Any plant part taken out and grown in a test tube under sterile conditions in special nutrient media.
- The capacity to generate whole plant from explant is called **totipotency**.
- It is possible to achieve propagation of a large number of plants through tissue culture called micropropagation.
- Each of these plants will be genetically identical to the original plant from which they grown i.e. they are somaclones.
- Many important plants like tomato, banana, apple etc. have been produced on commercial scale by using this method.
- Another important application of the method is the recovery of healthy plants from diseased plants. Even if the plants is infected with the virus, the meristem is free of virus.
- Scientists have even isolated single cells from plants and after digesting their cell walls have been able to isolate naked protoplasts.
- Isolated protoplasts from two different varieties of plants can be fused to get hybrid protoplasts which can be further grown to form a new plant. These hybrids are called **somatic hybrids** while the process is called **somatic hybridization**.
- Protoplast hybrid of potato and tomato called pomato was created but unfortunately this plant did not have all the desired combination of characteristics for its commercial utilization.

One can remove the meristem and grow it *in vitro* to obtain virus free plants.

Sharpen Your Understanding

1. Classical plant breeding involves [NCERT Pg. 170]
   (1) Mutation breeding
   (2) Hybridisation or crossing of pure lines
   (3) Genetic engineering
   (4) Both (2) and (3)
2. All of the following are environmental stresses to plants, **except** [NCERT Pg. 170]
   (1) Salinity
   (2) Higher productivity
   (3) Extreme temperature
   (4) Drought
3. Which of the following is very time consuming and tedious process? [NCERT Pg. 171]
   (1) Evaluation and selection of parents
   (2) Cross hybridization among the selected parents
   (3) Testing of superior recombinants
   (4) Release and commercialization of new cultivars
4. Plants are self pollinated for several generations till they reach a state of uniformity (homozygosity) so that [NCERT Pg. 171]
   (1) Plants become resistant to all fungal diseases
   (2) All recessive alleles can be expressed
   (3) Alleles/characters can segregate from each other
   (4) The characters will not segregate in the progeny
5. The use of certain chemicals and radiations to change the base sequences of genes of plants is called [NCERT Pg. 174]
   (1) Classical breeding
   (2) Conventional breeding
   (3) Transgenic breeding
   (4) Mutation breeding
6. Breeding of crops for improved nutritional quality is called [NCERT Pg. 176]
   (1) Bioremediation
   (2) Biofortification
   (3) Eutrophication
   (4) Biomagnification
7. Term 'Totipotency' in plants refers to the capacity of a [NCERT Pg. 177]
   (1) Cell to generate whole plant
   (2) Axillary bud to generate only roots of plant
   (3) Cell to increase in size
   (4) Cell to remain dormant

NCERT Based MCQs

8. An explant during tissue culture can be [NCERT Pg. 177]
   (1) Only old part of the plant
   (2) Any part of the plant
   (3) Any dead part of the plant
   (4) Meristematic tissue only
9. 33% of India's GDP comes from [NCERT Pg. 172]
   (1) Fishery (2) Apiculture
   (3) Agriculture (4) Horticulture
10. Germplasm collection is the collection of [NCERT Pg. 171]
    (1) Plants/seeds with all the diverse alleles for all genes
    (2) Germ cells only
    (3) Protoplasm of differentiated cells only
    (4) Dormant seeds only
11. Jaya and Ratna are the semi-dwarf varieties of [NCERT Pg. 173]
    (1) Wheat (2) Rice
    (3) Cowpea (4) Mustard
12. Select the **incorrect** match. [NCERT Pg. 173]
    (1) Black rot of crucifers – Bacteria
    (2) Late blight of potato – Bacteria
    (3) Brown rust of wheat – Fungi
    (4) Red rot of sugarcane – Fungi

13. Pusa Sadabahar is a variety of [NCERT Pg. 174]
(1) Chilli (2) Potato
(3) Cowpea (4) Mustard

14. 'Parbhani-Kranti' is resistant to yellow mosaic virus. It is a variety of [NCERT Pg. 174]
(1) Bhindi (2) Mustard
(3) Chilli (4) Rice

15. Resistance to Jassids in cotton plants and to cereal leaf beetle in wheat plant is due to [NCERT Pg. 175]
(1) Biochemical characters
(2) Morphological characters
(3) Physiological characters
(4) Anatomical characters

16. Sonalika and Kalyan Sona are varieties of [NCERT Pg. 173]
(1) Wheat
(2) Tobacco
(3) Millets
(4) Bajra

17. Select the **incorrect** about *Saccharum barberi* [NCERT Pg. 173]
(1) Was originally grown in North India
(2) Had higher sugar content
(3) Had poor yield
(4) Is a variety of sugarcane

18. All of the following are millets, **except** [NCERT Pg. 173]
(1) Hybrid maize (2) Jowar
(3) Bajra (4) Rice

19. Select the **incorrect** one for SCP? [NCERT Pg. 176]
(1) Prokaryotes can be source of SCP
(2) BGA can be grown easily on materials like waste water
(3) Only single celled organisms are used
(4) BGA, when grown on sewage reduces environmental pollution

20. Atlas 66, having a high protein content is a variety of [NCERT Pg. 176]
(1) Rice
(2) Wheat
(3) Cowpea
(4) Chilli

Thinking in Context

1. Semi-dwarf rice varieties were derived from _____ developed at IRRI and _____ from Taiwan. [NCERT Pg. 173]

2. Himgiri is a variety of wheat crop and it is resistant to _____ [NCERT Pg. 174]

3. In 2000, maize hybrids that had twice the amount of _____ and _____ compared to existing maize hybrids were developed. [NCERT Pg. 176]

4. Scientists have isolated single cells from plants and after digesting their cell walls have been able to isolate naked _____ [NCERT Pg. 177]

5. IARI released variety of carrots that are _____ enriched [NCERT Pg. 176]

6. Method of producing thousands of plants through tissue culture is called _____ [NCERT Pg. 177]

7. Plants developed in tissue culture are genetically identical to each other and are called _____ [NCERT Pg. 177]

8. Somatic hybridization between tomato and potato results in formation of _____ [NCERT Pg. 177]

9. Although the plant is infected with a virus, the _____ is free of virus. [NCERT Pg. 177]

10. During tissue culture the plant growth regulators like _____ are used [NCERT Pg. 177]
11. Turnip mosaic disease is caused by _____ [NCERT Pg. 173]
12. Black rust of wheat is caused by _____ [NCERT Pg. 173]
13. _____ is the root of any breeding programme. [NCERT Pg.171]
14. Pusa Komal is a variety of _____ [NCERT Pg. 174]
15. Pusa Swarnim is _____ a variety of *Brassica*. [NCERT Pg. 174]
16. In mung bean resistance to yellow mosaic virus and powdery mildew were induced by _____ [NCERT Pg. 174]
17. Method of recovery of healthy plants from diseased plant is _____ [NCERT Pg. 177]
18. High aspartic acid, low nitrogen and sugar content in maize leads to resistance to _____ [NCERT Pg. 175]
19. _____ is the most practical means to improve public health. [NCERT Pg. 176]
20. P1542 is a variety of _____ [NCERT Pg. 172]

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