AGRICULTURE

the science, art, or occupation concerned with cultivating land, raising crops, and feeding, breeding, and raising livestock.

IMPORTANCE OF AGRICULTURE

- People depend on a wide range of agricultural products in almost all aspects of life, e.g,
    - nutrition is a key determinant of human health
    - provider of energy-fuel-wood and medicinal plants
    - Fiber
- Agriculture is key to a healthy biosphere.
- Agriculture is a key economic driver. It is central to:
    - Individual livelihoods
    - Poverty alleviation
    - Nation ' s economic growth, e.g., agriculture contributes between 40 and 60% of the GDP of many African countries.

CROP PRODUCTION; ART, SCIENCE AND BUSINESS

Crop Production is the art and science of the genetic improvement of crops to produce new varieties with increased productivity and quality.

The advanced genetic and molecular techniques have resulted in new varieties of crop plants, medicinal plants and ornamentals.

METHODS OF PLANT BREEDING

1. DOMESTICATION OF PLANTS

In nature, the origin of plants took place in the wild conditions. During the course of evolution of agricultural practices, man began to grow some plants under his control. This process of bringing wild plants under cultivation is called plant domestication.

2. INTRODUCTION OF PLANTS

Introduction of plants from other continents, countries, geographical regions etc to new areas of cultivation is an important process in plant breeding. The process of introducing new plants from the place of its origin or cultivation to a place with different climatic conditions is called plant introduction.

3. ACCLIMATIZATION

The physiological adaptation of plants to climatic or environmental changes such as light, soil, temperature or altitude is known as acclimatization.

4. SELECTION OF PLANTS

Plants, both domesticated as well as introduced, show considerable degrees of variations with respect to different characters. Some of these plants are superior whereas the others are inferior in performance. The process of selection of superior plants is an important method for the improvement of cultivated plants, which lead to the development of new varieties with more advantageous and superior characters.

5. PLANT HYBRIDIZATION

Domestication, introduction, acclimatization and selection of plants help to locate the most promising cultivars from the available diversity. But superior and economically important characters are scattered in different cultivars. Hybridization is the technique of bringing superior characters into a single variety by way of cross-pollinating them artificially.

6. MUTATION BREEDING

Desirable characters that are scattered in different varieties can be brought together by hybridization. But, sometimes, induction of new variability (new characters and character forms) may become necessary since no cultivars with such traits are available. The most common method used to induce new variation is mutation breeding for which seeds or propagules of plants are treated with some chemicals or physical agents that are called mutagens.

7. POLYPLOIDY BREEDING

Usually, plants and animals carry chromosomes in pairs in their somatic cells. But, in some cases, more than two sets (multiple sets) of chromosomes (three sets, four sets, etc) can be seen. Such organisms are called polyploids and the condition is called polyploidy. In the case of some cultivated plants, polyploids show superiority in characters. Breeding of such cultivated plants is called polyploidy breeding.

8. BIOTECHNOLOGICAL BREEDING

Biotechnology is the latest branch of biology that makes use of enzymes as tools to accelerate or manipulate biochemical pathways so as to generate new goods and services based on life and biomolecules. *in vitro* culture technology, marker assisted selection, somatic hybridization, transgenesis etc are the major tools of biotechnology used in plant breeding.

Genetic Engineering of Organisms

- The basic structure of DNA is identical in all living things. In all organisms, different characteristics are determined by the sequence of the DNA base pairs. Biotechnology has developed to the point where researchers can take one or more specific genes from nearly any organism, including plants, animals, bacteria, or viruses, and introduce those genes into the **genome** of another organism. This is called **recombinant DNA technology** (Watson *et al*. 1992). In 1978, the first commercial product arising from the use of recombinant DNA technology gene transfer was synthetic **insulin**. Pig and cattle pancreatic glands were previously the only way of producing insulin for human use. In 1988, chymosin (known as Rennin) was the first enzyme produced from a genetically modified source-yeast-to be approved for use in food. Previously this enzyme for cheese production was obtained from cows' stomach linings.

  In agricultural biotechnology, changes are made directly to the plant's genome. Once the gene that determines a desirable trait is identified, it can be selected, extracted, and transferred directly into another plant genome (Figure 3). Plants that have genes from other organisms are referred to as transgenic. The presence of the desired gene, controlling the trait, can be tested for at any stage of growth, such as in small seedlings in a greenhouse tray. A breeder can thus quickly evaluate the plants that are produced and then select those that best express the desired trait. Producing new varieties of crops through genetic engineering takes about 10 years on average.

Applications of Plant Biotechnology in Agriculture

A. Crop Improvement

1. The following traits are potentially useful to plant genetic engineering: controlling insects, manipulating petal color, production of industrially important compounds, and plant growth in harsh conditions.

B. Genetically Engineered Traits: The Big Six.

1. Herbicide Resistance

- **Genetically engineered plants resistant to several herbicides (glyphosate) have been developed and are in commercial cultivation.**
- **Example involve Glyphosate Tolerant Soybean, Tobacco.**
- **Transgenic soybean has undergone a rapid expansion.**

Herbicide Resistance (Glyphosate Tolerant Crops)

Applications of Plant Biotechnology

2. Insect Resistance

The Bt toxin isolated from Bacillus thuringiensis has been used in plants. Monsanto Chemical Company – 1991Trials

- **BT → into cotton plants using A. tumefaciens vector**
- **First crops – 1996**
  - **Corn**
  - **Cotton**
  - **Seed potatoes**
  - **Soybean**
  - **Others**

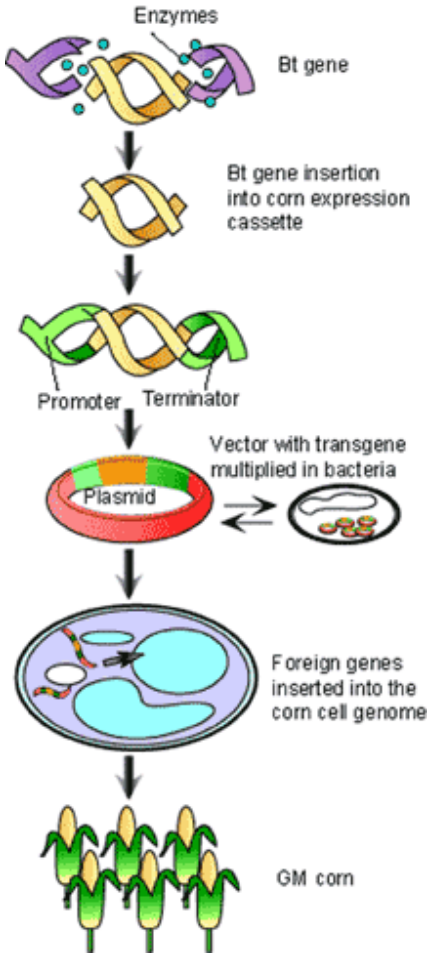
- **The level of toxin expression is very high thus delivering sufficient dosage to the pest.**
- **The toxin expression is contained within the plant system and hence only those insects that feed on the crop perish.**
- **The toxin expression replaces the use of synthetic pesticides in the environment.**

Applications of Plant Biotechnology

3. **Virus Resistance**
   a) **Chemicals are used to control the insect vectors of viruses, but controlling the disease itself is difficult because the disease spreads quickly.**
   b) **Plants may be engineered with genes for resistance to viruses, bacteria, and fungi.**
   c) **Virus-resistant plants have a viral protein coat gene that is overproduced, preventing the virus from reproducing in the host cell, because the plant shuts off the virus' protein coat gene in response to the overproduction.**

INSECTICIDAL PROPERTIES OF Bt

- ***Bacillus thuringiensis*** **(or Bt) is a Gram-positive, soil-dwelling bacterium, which produces crystalline insecticidal proteins.**
- **Bt crystal protein gene added/transferred into plant genome.**
- **Expression of this gene results insect resistant crop.**



Applications of Plant Biotechnology

4. Altered Oil Content

a) Done in plants by modifying an enzyme in the fatty acid synthesis pathway (oils are lipids, which fatty acids are a part of).

b) Varieties of canola and soybean plants have been genetically engineered to produce oils with better cooking and nutritional properties.

c) Genetically engineered plants may also be able to produce oils that are used in detergents, soaps, cosmetics, lubricants, and paints.

5. Delayed Fruit Ripening

a) Allow for crops, such as tomatoes, to have a higher shelf life.

b) Tomatoes generally ripen and become soft during shipment to a store.

c) Tomatoes are usually picked and sprayed with the plant hormone ethylene to induce ripening, although this does not

Applications of Plant Biotechnology

6. Pollen Control

a) Hybrid crops are created by crossing two distantly related varieties of the same crop plant.

b) The method may generate plants with favorable traits, such as tall soybean plants that make more seeds and are resistant to environmental pressures.

c) For success, plant pollination must be controlled. This is usually done by removing the male flower parts by hand before pollen is released. Also, sterilized plants have been genetically engineered with a gene from the bacteria Bacillus amyloliqueifaciens.

Applications of Plant Biotechnology

C. Biotech Revolution: Cold and Drought Tolerance and WeatherGard Genes.

1. Plants such fruits are subject to frost damage at low temperatures, as well as from loss of water. They can be genetically engineered to resist these conditions, and increase crop yields as a result.
2. To resist cold weather, cold-regulated (COR) genes are also called "antifreeze genes,", which encode proteins that protect plant cells from frost damage.
3. A transcription factor for a group of COR genes called "CBF" was patented as WeatherGard in 1997 by a group at Michigan State University. The genes also provide drought tolerance and tolerance to high-salt soils.
4. All major crop species, including corn, soybean, and rice contain CBF genes.
5. Genetically engineering plants with CBF genes survive temperatures as much as 4 to 50C lower than non-engineered plants.

Edible Vaccines
Transgenic Plants Serving Human Health Needs

- Works like any vaccine
- A transgenic plant with a pathogen protein gene is developed
- Potato, banana, and tomato are targets
- Humans eat the plant
- The body produces antibodies against pathogen protein
- Humans are “immunized” against the pathogen
- Examples:
    - ✓Diarrhea
    - ✓Hepatitis B
    - ✓Measles