Chapter 9

Unit X: Economic Botany

Plant Breeding

Learning Objectives

The learner will be able to

- Appreciate the relationship between humans and plants.
- Recognise the origin of agriculture.
- Perceive the importance of organic agriculture.
- Understand the different conventional methods of plant breeding.
- Realize the importance of seed protection and seed storage.
- Compare the traditional methods of seed storage with modern methods.

Chapter outline

Q4VYTG

Economic botany is the study of the relationship between people and economically important plants. It explores the ways by which humans use plants for food, medicines and other uses. Economic botany intersects many fields including established disciplines such as agronomy, anthropology, archaeology, chemistry, trade and commerce.

9.1 Relationship between humans and plants

From the very early times, human beings have co-existed with plants which played a vital role in their survival. Through a long process of trial and error, our ancestors have selected hundreds of wild plants from the various parts of the world for their specific use. The knowledge of the plants and its applications have led to the development of the humans and their civilization in many ways.

9.2 Domestication of plants

Domestication is the process of bringing a plant species under the control of humans and gradually changing it through careful selection, genetic alteration and handling so that it is more useful to people. The domesticated species are renewable sources that have provided food and other benefits to human.

The possible changes in the plant species due to domestication are listed below;

- Adaptation to a greater diversity of environments and a wider geographical range.
- Simultaneous /uniform flowering and fruiting.

- Lack of shattering or scattering of seeds.
- Increased size of fruits and seeds.
- Change from a perennial to annual habit.
- Change in breeding system.
- Increased yield.
- Increased resistance for disease and pest.
- Developing seedless parthenocarpic fruit.
- Enhancing colour, appearance, palatability and nutritional composition.

9.3 Origin of Agriculture

Archeological evidence for earliest record of agriculture is found in the fertile crescent region in and around Tigris and Euphrates river valleys, approximately about 12,000 years ago.

The earlier Greek and Roman naturalists like Theophrastus, Dioscorides, Pliny the elder and Galen laid down the scientific foundation in understanding origin and domestication of cultivated plants.

9.4 History of Agriculture

1807 Alexander Von Humboldt considered the original sources of most useful plants and their origin is an impenetrable secret.

1868 Darwin's evolutionary theory proposed that origin of useful cultivated plants have existed through natural selection and hybridisation.

1883 De Candolle in his "Origin of cultivated plants" studied 247 cultivated plant species and attempted to solve the mystery about the ancestral form, region of domestication and history.

1887- 1943 Nikolai Ivanovich Vavilov made an inventory of the diverse forms of our most important cultivated plants and their distribution based on variety of facts obtained from morphology, anatomy, cytology, genetics and plant geography. Vavilov has given the centre of diversity of a crop species which may be the centre of origin for that species.

Vavilov initially proposed eight main geographic centres of origin originally in 1926. Later (1935) he named 11 centres of origin by dividing few centres into two and three centres and added a new centre USA thus making the 8 centres of origin into 12.

1968 Zhukovsky put forward the concept of mega gene centre for the origin of cultivated plants. He divided the whole world into 12 mega gene centres.

1971 According to Harlan, agriculture originated independently in three different areas in different times or simultaneously. Hence a crop may not have a single centre of origin. Harlan says that the centre of crop plant means the places of agricultural origin of the crop plants. The non-centre denotes the place where agriculture of the crop was introduced and spread. Thus centre and non-centre interact with each other.

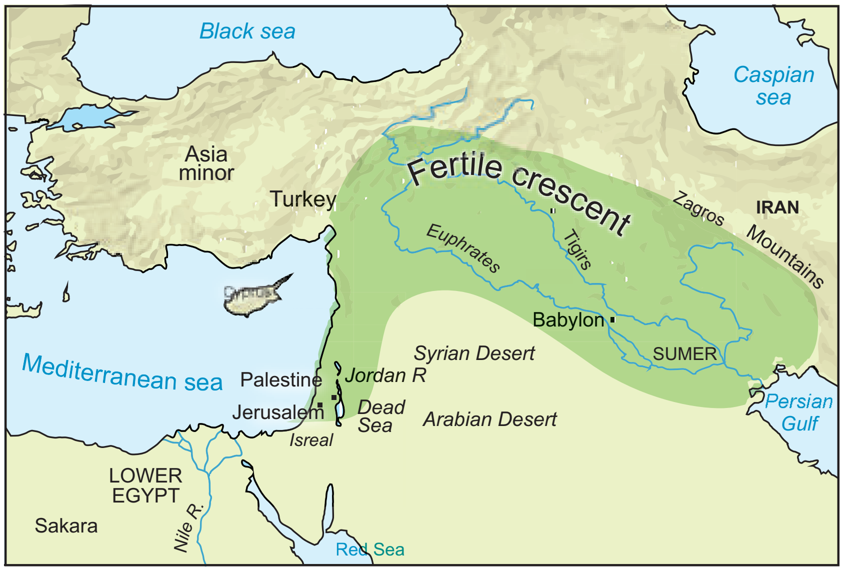

Figure 9.1: Map shows Fertile crescent region

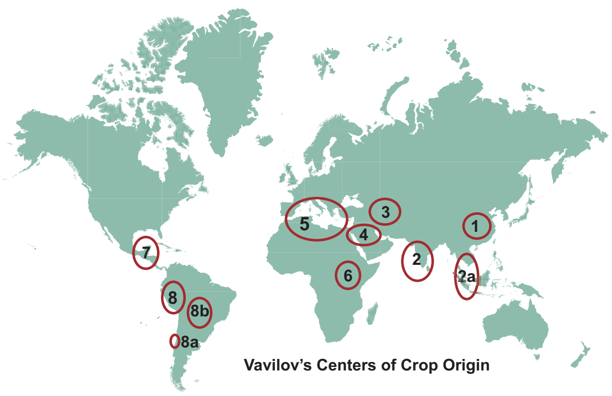

Figure 9.2: Vavilov's centres of crop origin and crops domesticated

Vavilov's Centre of Crop Origin		Crops domesticated
1	China	Foxtail millet, soybean, bamboo, onion, crucifers.
2	India	Rice, sugarcane, mango, orange, eggplant, sesame.
2 a	South East Asia	Rice, banana, coconut, clove , hemp.
3	Central East	Wheat, pea, hemp, cotton etc.
4	The Near East	Wheat, rye, many subtropical and tropical fruits.
5	Mediterranean	Olive, vegetables, oil yielding plants, wheats
6	Ethiopia (Abyssinian)	Wheat, barley, sesame, castor, coffee.
7	Mesoamerica (South Mexican & Central American Centre)	Maize, bean, sweet potato, papaya, guava, tobacco.
8	South America	Tomato, pine-apple
8 a	The Chiloe Centre	Potato
8 b	The Brazilian –Paraguayan Centre	Groundnut, cashew nut, pine apple, peppers, rubber.

9.5 Organic Agriculture

Organic farming is an alternative agricultural system which originated early in the twentieth century in reaction to rapidly changing farming practices. It is a production system that sustains the health of the soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions rather than the use of inputs with adverse effects.

DO YOU KNOW?

Indian Plant Breeders

a. **Dr. M. S. Swaminathan** – He is pioneer mutation breeder.

b. **Sir. T.S. Venkataraman** – An eminent sugarcane breeder.

c. **Dr. B.P. Pal** – Famous wheat breeder, developed superior disease resistant varieties of wheat.

d. **Dr. K. Ramiah** – Eminent rice breeder, developed several high yielding varieties of rice.

e. **N.G.P. Rao** – An eminent sorghum breeder, developed world's first hybrid of Sorghum (CSH-1).

f. **C.T. Patel** – Who developed world's first cotton hybrid.

g. **Choudhary Ram Dhan** – Wheat breeder, who is famous for C-591 variety of wheat, which is made Punjab as wheat granary of India.

9.5.1. Biofertilizers

Biofertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. Biofertilizers could be also called as microbial cultures, bioinoculants, bacterial inoculants or bacterial fertilizers.

They are efficient in fixing nitrogen, solubilising phosphate and decomposing cellulose. They are designed to improve the soil fertility, plant growth, and also the number and biological activity of beneficial microorganisms in the soil. They are eco-friendly organic agro inputs and are more efficient and cost effective than chemical fertilizers.

S.N	Groups		Examples
A	N_2 fixing Biofertilize		
	1.	Free-living	*Azotobacter, Clostridium, Anabaena, Nostoc,*
		Symbiotic	*Rhizobium, Anabaena azollae*
	3.	Associative Symbiotic	*Azospirillum*
B	P Solubilizing Biofertilizer		
	1.	Bacteria	*Bacillus subtilis, Pseudomonas striata*
	2.	Fungi	*Penicillium, Aspergillus.*
C	P Mobilizing Biofertilizers		
	1.	Arbuscular Mycorrhiza	*Glomus, Scutellospora.*
	2.	Ectomycorrhiza	*Amanita.*
D	Biofertilizer for Micro nutrients		
	1.	Silicate and Zinc solubilizers	*Bacillus.*
E	Plant Growth Promoting Rhizobacteria		
	2.	Pseudomonas	*Pseudomonas fluorescence*

Figure 9.3: Classification of Biofertilizers

Rhizobium

Bio-fertilisers containing rhizobium bacteria are called rhizobium bio-fertilizer culture. Symbiotic bacteria that reside inside the root nodules convert the atmospheric nitrogen into a bio available form to the plants. This nitrogen fixing bacterium when applied to the soil undergoes multiplication in billions and fixes the atmospheric nitrogen in the soil. Rhizobium is best suited for the paddy fields which increase the yield by 15 – 40%.

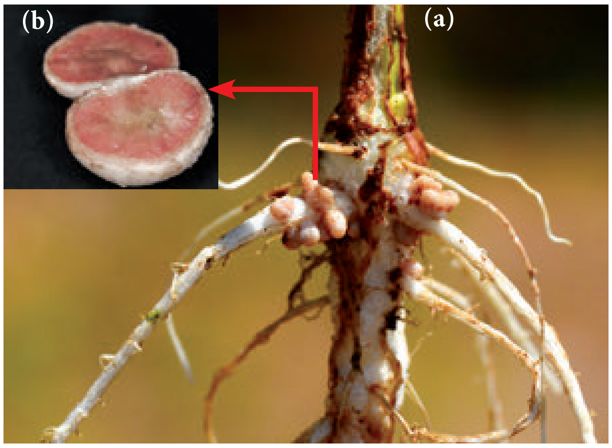

Figure 9.4 (a) : Root nodules occur on root **(b)** C.S. of Root nodule

Azolla

Azolla is a free-floating water fern that fixes the atmospheric nitrogen in association with nitrogen fixing blue green alga *Anabaena azolla*. It is used as a bio-fertilizer for wetland rice cultivation and is known to contribute 40 – 60 kg/ha/crop. The agronomic potential of Azolla is quite significant particularly for increasing the yield of rice crop, as it quickly decompose in soil.

Figure 9.5: (a) *Azolla* in paddy field (b) *Azolla*

Arbuscular mycorrhizae

Arbuscular mycorrhizae (AM) is formed by the symbiotic association between certain phycomycetous fungi and angiosperm roots. They have the ability to dissolve the phosphates found in abundance in the soil.

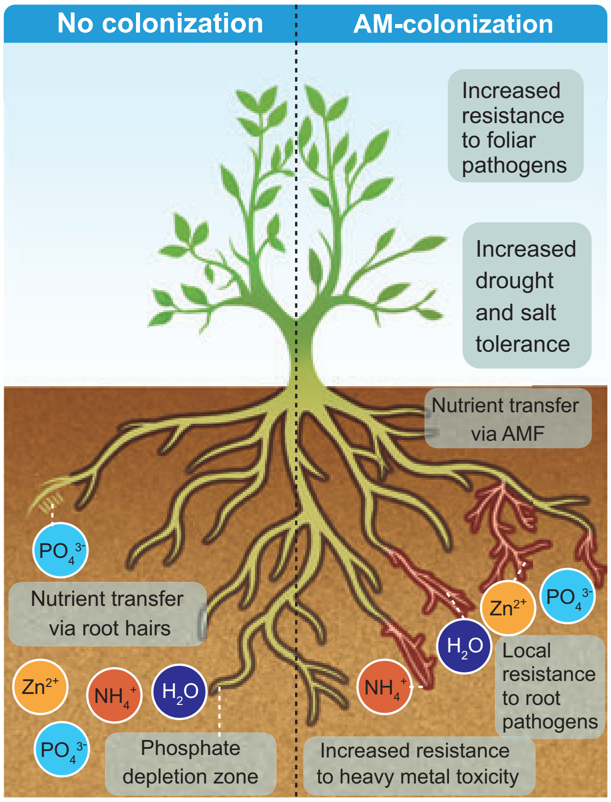

Figure 9.6 Benefits of AM colonisation

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Apart from increasing the availability of phosphorus, AM provides necessary strength to resist disease, germs and unfavourable weather conditions. It also assures water availability.

Seaweed Liquid Fertilizer

Seaweed liquid fertilizer (SLF) contains cytokinin, gibberellins and auxin apart from macro and micro nutrients. Most seaweed based fertilizers are made from kelp(brown algae) which grows to length of 150 metres. Liquid seaweed fertilizer is not only organic but also eco-friendly. The alginates in the seaweed that reacts with metals in the soil and form long, cross-linked polymers in the soil. These polymers improve the crumbing in the soil, swell up when they get wet and retain moisture for a long time. They are especially useful in organic gardening which provides carbohydrates for plants. Seaweed has more than 70 minerals, vitamins and enzymes. It promotes vigorous growth. Improves resistance of plants to frost and disease. Seeds soaked in seaweed extract germinate much rapidly and develop a better root system.

Figure 9.7 : Seaweed – Kelp

Bio-Pesticides

Bio-pesticides are biologically based agents used for the control of plant pests. They are in high use due to their non-toxic, cheaper and eco-friendly characteristics as compared to chemical or synthetic pesticides. Bio-pesticides have become an integral component of pest management in terms of the environmental and health issues attributed to the use of chemicals in agriculture.

Trichoderma species are free-living fungi that are common in soil and root ecosystem. They have been recognized as bio-control agent for (1) the control of plant disease (2) ability to enhance root growth development (3) crop productivity (4) resistance to abiotic stress and (5) uptake and use of nutrients.

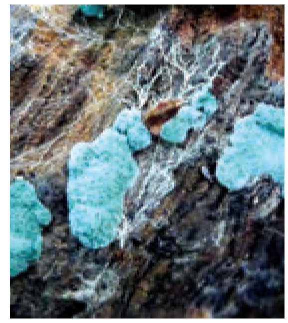

Figure 9.8:
(a) *Trichoderma* fungi

Figure 9.8:
(b) Biopesticide

Beauveria species is an entomo-pathogenic fungus that grows naturally in soils throughout the world. It acts as a parasite on various arthropod species causing white muscardine disease without affecting the plant health and growth. It also controls damping off of tomato caused by *Rhizoctonia solani*.

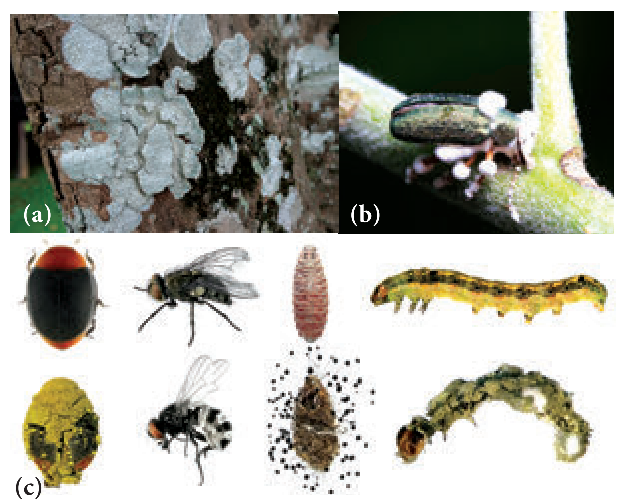

Figure 9.9 : (a) *Beauveria* Fungi
(b) *Beauveria* sps infected insect on green plant
(c)Entomopathogenic fungi on insets

Green Manuring

Green manuring is defined as the growing of green manure crops and use of these crops directly in the field by ploughing. One of the main objectives of the green manuring is to increase the content of nitrogen in the soil. Also it helps in improving the structure and physical properties of the soil. The most important green manure crops are *Crotalaria juncea, Tephrosia purpurea, Indigofera tinctoria*

The green manuring can be practised as Green in-situ manuring or Green leaf manuring. Green in-situ manuring refers to the growing of green manuring crops in the border rows or as intercrops along with the main crops. Example: Sun hemp, Cowpea, Green gram etc. whereas green leaf manuring is the application of green leaves and twigs of trees, shrubs, plants growing in wastelands and field bunds. The important plant species useful for green leaf manure are *Cassia fistula*, *Sesbania grandiflora*, *Azadirachta indica*, *Delonix regia*, *Pongamia pinnata* etc.,

9.6 Plant Breeding

Plant breeding is the science of improvement of crop varieties with higher yield, better quality, resistance to diseases and shorter durations which are suitable to particular environment. In other words, it is a purposeful manipulation of plant species in order to create desired genotype and phenotype for the benefit of humans. In early days, plant breeding activities were based mainly on skills and ability of person involved. But as the principles of genetics and cytogenetics have elucidated breeding methods such as selection, introduction, hybridization, ploidy, mutation, tissue culture and biotechnology techniques were designed to develop improved crop varieties.

9.6.1. Objectives of Plant Breeding

- To increase yield, vigour and fertility of the crop
- To increase tolerance to environmental condition, salinity, temperature and drought.
- To prevent the premature falling of buds, fruits etc.
- To improve synchronous maturity.
- To develop resistance to pathogens and pests.
- To develop photosensitive and thermos-sensitive varieties.

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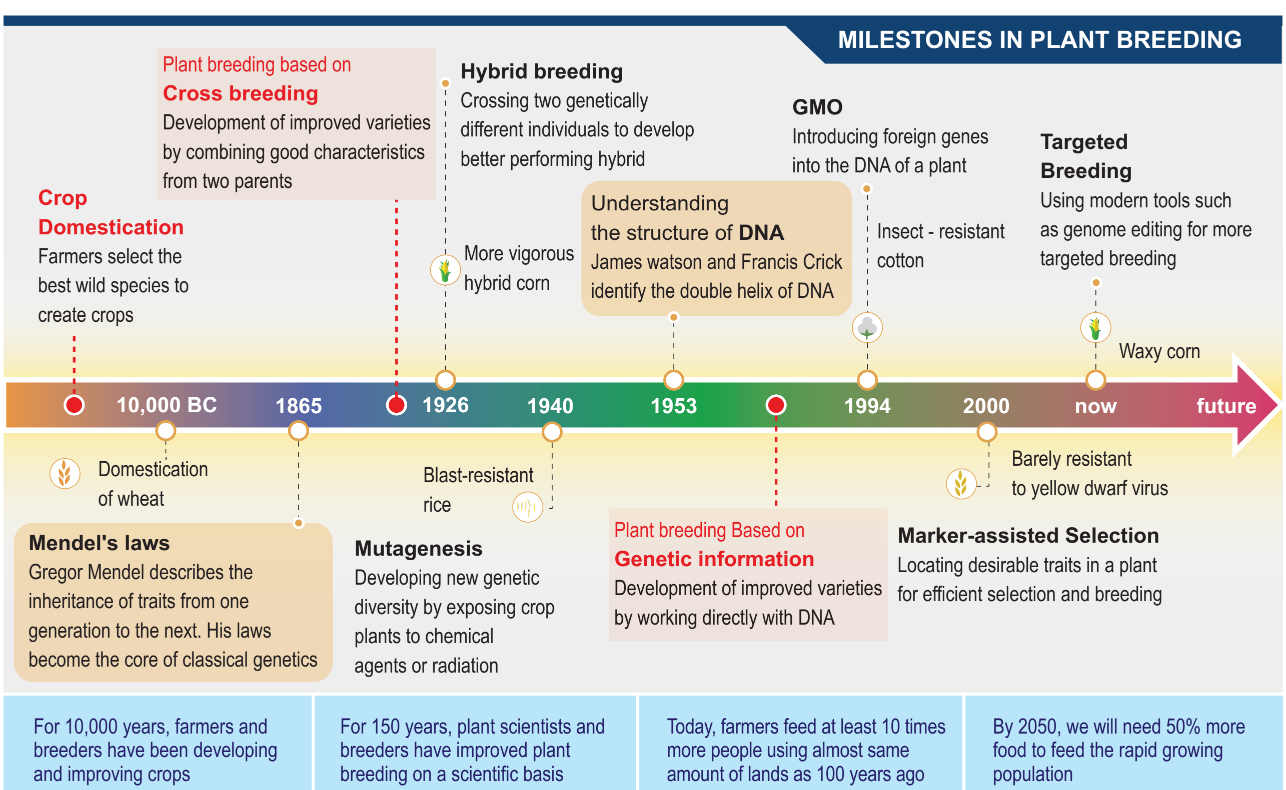


Figure 9.10 : Milestones in Plant Breeding

9.6.2. Steps in Plant Breeding

The main steps in plant breeding are given below

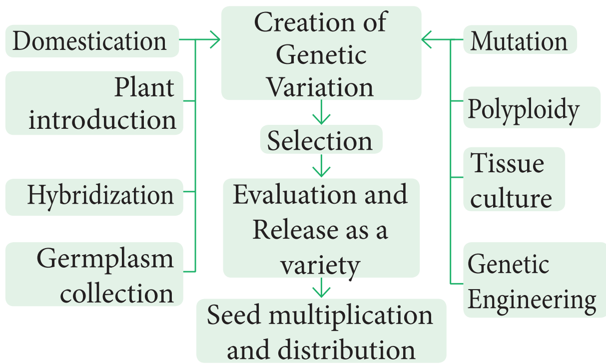


Figure 9.11 : Steps in Plant Breeding

9.7 Conventional Plant Breeding Methods

Conventional plant breeding methods resulting in hybrid varieties had a tremendous impact on agricultural productivity over the last decades. It develops new plant varieties by the process of selection and seeks to achieve expression of genetic material which is already present within the species. In this chapter we will discuss about some of the conventional methods of plant breeding.

9.7.1. Plant Introduction

Plant introduction may be defined as the introduction of genotypes from a place where it is normally grown to a new place or environment. Rice variety of IR8 introduced from Philippines and Wheat varieties of Sonora 63, Sonora 64 from Mexico.

The newly introduced plant has to adapt itself to the new environment. This adjustment or adaptation of the introduced plant in the changed environment is called **acclimatization.** All the introductions must be free from presence of weeds, insects and disease causing organisms. This has to be carefully examined by the process called **quarantine**, a strict isolation imposed to prevent the spread of disease.

Introduction may be classified as Primary introduction and Secondary introduction

(1) **Primary introduction** - When the introduced variety is well adapted to the new environment without any alternation to the original genotype.

(2) **Secondary introduction** - When the introduced variety is subjected to selection to isolate a superior variety and hybridized with a local variety to transfer one or a few characters to them. The botanical garden in different parts of the world also played a significant role in plant introduction. Example : Tea varieties collected from China and North East India initially grown in Botanical Garden of Kolkata from which appropriate clones have selected and introduced to different parts of India.

DO YOU KNOW?

National Bureau of plant Genetic Resources (NBPGR) The Bureau is responsible for introduction and maintenance of germ plasm of various agricultural and horticultural station in our country. It is also responsible for maintenance of plant materials of botanical and medicinal interest. It is located at Rangpuri, New Delhi and has four regional plant quarantine stations at Amristsar, Kolkata, Mumbai and Chennai at Meenambakkam

9.7.2. Selection

Selection is the choice of certain individuals from a mixed population for a one or more desirable traits. Selection is the oldest and basic method of plant breeding. There are two main types of Selection.

i. **Natural Selection:** This is a rule in the nature and results in evolution reflected in the Darwinian principle "survival of the fittest". It takes longer time in bringing about desired variation.

ii. **Artificial Selection:** It is a human involved process in having better crop from a mixed population where the individuals differ in character. The following are the three main types of artificial selection.

a. **Mass Selection:** In mass selection a large number of plants of similar phenotype or morphological characters are selected and their seeds are mixed together to constitute a new variety. The population obtained from the selected plants would be more uniform than the original population and are not individually tested. After repeated selection for about five to six years, selected seeds are multiplied and distributed to the farmers. The only disadvantage of mass selection is that it is difficult to distinguish the hereditary variation from environmental variation.

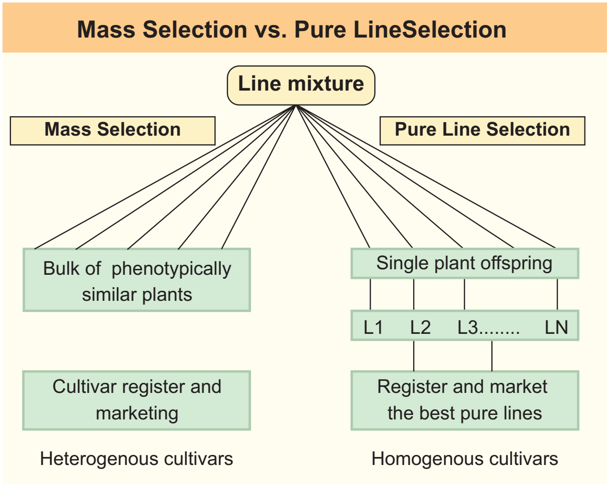


Figure 9.12 : Mass selection vs Pureline selection

b. Pureline selection: Johannsen in 1903 coined the word pureline. It is a collection of plants obtained as a result of repeated self-pollination from a single homozygous individual. Hence, a variety formed by this method shows more homozygosity with respect to all genes. The disadvantage of this type is that the new genotypes are never created and they are less adaptable and less stable to the environmental fluctuations.

c. Clonal Selection: In asexually propagated crop, progenies derived from a plant resemble in genetic constitution with the parent plant as they are mitotically divided. Based on their phenotypic appearance, clonal selection is employed to select improved variety from a mixed population (clones). The selected plants are multiplied through vegetative propagation to give rise to a clone. The genotype of a clone remains unchanged for a long period of time.

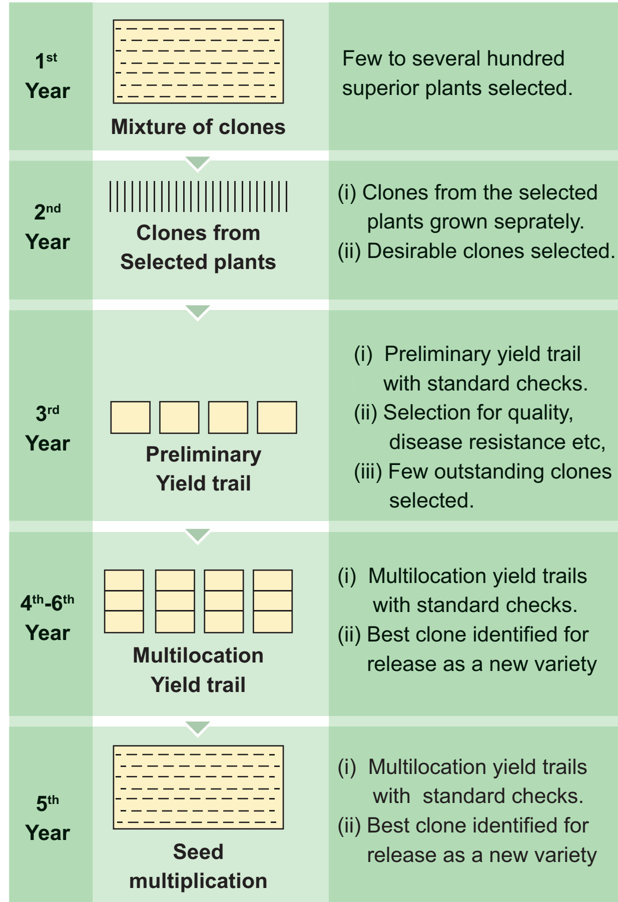


Figure 9.13 Clonal Selection

9.7.3. Hybridization

Hybridization is the method of producing new crop varieties in which two or more plants of unlike genetically constitution is crossed together that result in a progeny called hybrid. Hybridization offers improvement in crop and is the only effective means of combining together the desirable characters of two or more varieties or species. The first natural hybridization was observed by Cotton Mather in maize.

Steps in Hybridization

Steps involved in hybridization are as follows.

1. **Selection of Parents:** Male and female plants of the desired characters are selected. It should be tested for their homozygosity.
2. **Emasculation:** It is a process of removal of anthers to prevent self pollination before anthesis (period of opening of a flower)
3. **Bagging:** The stigma of the flower is protected against any undesirable pollen grains, by covering it with a bag .

Figure 9.14 a & b: Emasculation and Bagging (Wheat)

4. **Crossing:** Transfer of pollen grains from selected male flower to the stigma of the female emasculated flower.
5. **Harvesting seeds and raising plants**: The pollination leads to fertilization and finally seed formation takes place. The seeds are grown into new generation which are called hybrid.

Types of Hybridization

According to the relationship between plants, the hybridization is divided into.

i. **Intravarietal hybridization** - The cross between the plants of same variety. Such crosses are useful only in the self-pollinated crops.

ii. **Intervarietal hybridization** - The cross between the plants belonging to two different varieties of the same species and is also known as intraspecific hybridization. This technique has been the basis of improving self-pollinated as well as cross pollinated crops

iii. **Interspecific hybridization** - The cross between the plants belonging to different species belonging to the same genus is also called intragenic hybridization. It is commonly used for transferring the genes of disease, insect, pest and drought resistance from one species to another. **Example:** Gossypium hirsutum x Gossypium arboreum – Deviraj.

Figure 9.15 Flower -
(a) *G. hirsutum* (b) *G. arboreum*

iv. **Intergeneric hybridization** – The crosses are made between the plants belonging to two different genera. The disadvantages are hybrid sterility, time consuming and expensive procedure. **Example:** Raphanobrassica, Triticale. (Refer chapter 4 for detail illustration)

9.7.4. Heterosis

Heterosis (hetero- different; sis - condition) G.H. Shull was the first scientist to use the term heterosis in 1912. The superiority of the F1 hybrid in performance over its parents is called heterosis or hybrid vigour. Vigour refers to increase in growth, yield, greater adaptability of resistance to diseases, pest and drought. Vegetative propagation is the best suited measure for maintaining hybrid vigour, since the desired characters are not lost and can persist over a period of time. Many breeders believe that its magnitude of heterosis is directly related to the degree of genetic diversity between the two parents. Depending on the nature, origin, adaptability and reproducing ability heterosis can be classified as:

i. Euheterosis- This is the true heterosis which is inherited and is further classified as:

a. Mutational Euheterosis - Simplest type of euheterosis and results from the sheltering or eliminating of the deleterious, unfavourable often lethal, recessive, mutant genes by their adaptively superior dominant alleles in cross pollinated crops.

b. Balanced Euheterosis – Well balanced gene combinations which is more adaptive to environmental conditions and agricultural usefulness.

ii. **Psuedoheterosis** – Also termed as luxuriance. Progeny possess superiority over parents in vegetative growth but not in yield and adaptation, usually sterile or poorly fertile.

9.7.5. Mutation Breeding

Muller and Stadler (1927- 1928) coined the term mutation breeding. It represents a new method of conventional breeding procedures as they have the advantage of improving the defect without losing agronomic and quality character in agriculture and crop improvement. Mutation means the sudden heritable changes in the genotype or phenotype of an organism. Gene mutations are of considerable importance in plant breeding as they provide essential inputs for evolution as well as for re-combination and selection. It is the only method for improving seedless crops.

Radiation such as UV short wave, X-ray, Alpha (α), Beta (β), Gamma waves and many chemicals such as cesium, EMS (ethyl methane sulfonate), nitromethyl, urea induces mutation to develop new variety of crops. **Example:** Triple gene dwarf wheat with increase in yield and height. Atomita 2 - rice with saline tolerance and pest resistance.

> DO YOU KNOW?
>
> **Gamma Garden or Atomic Garden**: Is a form of mutation breeding where plants are exposed to radioactive sources typically cobalt-60 or caesium-137 in order to generate desirable mutation in crop plants. The first Gamma garden in India is Bose Research Institute at Calcutta in 1959 and the second is IARI in 1960 which produced large variation in short type.

9.7.6. Polyploid Breeding

Majority of flowering plants are diploid (2n). The plants which possess more than two sets of chromosome are called polyploids. Polyploidy is a major force in the evolution of both wild and cultivated plants. Polyploidy often exhibit increased hybrid vigour increased heterozygosity, increase the tolerance to both biotic and abiotic stresses, buffering of deleterious mutations. In addition, polyploidy often results in reduced fertility due to meiotic error allowing the production of seedless varieties.

When chromosome number is doubled by itself in the same plant, is called autopolyploidy. Example: A triploid condition in sugarbeets, apples and pear has resulted in the increase in vigour and fruit size, large root size, large leaves, flower, more seeds and sugar content in them. It also resulted in seedless tomato, apple, watermelon and orange. Polyploidy can be induced by the use of colchicine to double the chromosome number. Allopolyploids are produced by multiplication of chromosome sets that are initially derived from two different species. Example: Triticale (Triticum durum x secale cereale) Raphanobrassica (Brassica oleraceae x Raphanus sativus).

9.7.7. Green Revolution

Green revolution the term was coined by William S.Gaud in (1968). It is defined as the cumulative result of a series of research, development, innovation and technology transfer initiatives. Agricultural production (especially wheat and rice) manifolds worldwide particularly in the developing countries between the 1940's and the late 1960's.

The Green revolution or third Agricultural Revolution is the intensive plan of 1960's to increase crop yield in developing countries by introducing the high yielding, resistant varieties, increased irrigation facilities, fertilizer application and better agricultural management. The scheme began in Mexico in 1940's and was successfully introduced in parts of India, Asia, Middle East and Latin America. Dr.B.P Pal the Director of IARI, requested M.S.Swaminathan to arrange for Dr.NE Borlaug visit to India and for obtaining a wide range of dwarf wheat possessing the Norin 10 dwarfing genes from Mexico.

In 1963 semi-dwarf wheat of Mexico was introduced from which India got five prolonged strategies for breeding a wide range of high varieties like Sonora 64, Sonalika and Kalyansona possessing a broad spectrum of resistance to major biotic and abiotic condition. Same as wheat M.S.Swaminathan produced the first semi-dwarf fertiliser responsive hybrid variety of rice TNI (Taichung Native-1) in 1956 from Taiwan. The derivatives were introduced in 1966. Later better yielding semi dwarf varieties of rice Jaya and Ratna developed in India.

DO YOU KNOW?

NORIN 10 – The cultivars found that Norin 10 dwarfing genes have high photosynthetic rate per unit leaf area and increase respiratory activity. Gonjiro Inazuka selected the semi-dwarf wheat variety that became Norin 10. He would have never thought that the semi dwarf genes would not only revolutionize the world of wheat but also helped to save more than one billion lives from hunger and starvation.

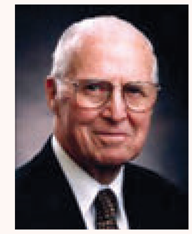
Plant Breeding for Developing Resistance to diseases

Some crop varieties bred by hybridization and selection, for disease resistance to fungi, bacteria and viral diseases are released (Table 9.1).

Crop	Variety	Resistance to diseases
Wheat	Himgiri	Leaf and Stripe rust, hill bunt
Brassica	Pusa swarnim (Kara 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.

Table 9.1 Disease resistance varieties

Norman E. Borlaug: The plant pathologist plant breeder devoted his life at the International Maize and Wheat improvement centre at Sonord in Mexico. He developed a new high yielding, rust resistant, non-lodging dwarf wheat varieties like Norin-10, Sonora-64, Lerma rojo-64, etc. which are now being cultivated in many countries. This formed the base for 'green revolution'. He was awarded a Nobel prize for Peace in 1970.



Dr. M. S. Swaminathan: He is pioneer mutation breeder. He has produced Sharbati Sonora, is the amber grain coloured variety of wheat by mutation, which is responsible for green revolution in India. Dr. Swaminathan is called "Father of green revolution in India".

Nel Jayaraman: Mr. Jayaraman, hails from Adirangam village in Tiruvarur district. He was a disciple of Dr.Nammalvar and state co-ordinator of 'Save our rice campaign, Tamil Nadu. He strived hard for conservation of traditional rice varieties. He had trained a team of farmers and regularly update them on the current issues that affect them.

In 2005, he organized a first ever traditional paddy seed festival in his farm as an individual. The seed festival in May 2016 at Adhirangam was 10th in a row and in which 156 different traditional varieties were distributed to more than 7000 farmers across Tamil Nadu. He was invited by the Philippines Government to give a talk at the International Rice Research Institute (IRRI) on his work and mission. In 2011, he received the State Award for best organic farmer for his contribution to organic farming, and in the year 2015, he received the National Award for best Genome Savior.

Biofortification – breeding crops with higher levels of vitamins and minerals or higher protein and healthier fats – is the most practical means to improve public health.

Breeding for improved nutritional quality is undertaken with the objectives of improving

- Protein content and quality
- Oil content and quality
- Vitamin content and
- Micronutrient and mineral content

In 2000, maize hybrids that had twice the amount of amino acids, lysine and tryptophan, compared to existing maize hybrids were developed. Wheat variety, Atlas 66 having a high protein content, has been used 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.

The Indian Agricultural Research Institute, New Delhi has also released several vegetable crops that are rich in vitamins and minerals, example: vitamin A enriched carrots, spinach, pumpkin; vitamin C enriched bitter gourd, bathua, mustard, tomato; iron and calcium enriched spinach and bathura; and protein enriched beans – broad, lablab, French and garden peas.

Sugar cane: *Saccharum bareri* 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 sugarcane areas of North India.

Resistance to yellow mosaic virus in bhindi (Abelmoschus escullentus) was transferred from a wild species and resulted in a new variety of A. Escullentus called Parbharni kranti.

Plant Breeding for Developing Resistance to Insect Pests

Insect resistance in host crop plants may be due to morphological, biochemical or physiological characteristics. Hairy leaves in several plants are associated with resistance to insect pests. Example: resistance to jassids in cotton and cereal leaf beetle in wheat. In wheat, solid stems lead to non-preference by the stem sawfly and smooth leaves 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.

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

Table 9.2 Pest resistance varieties

9.8 Modern Plant Breeding

In the milestones of plant breeding methods Genetic Engineering, Plant tissue culture, Protoplasmic fusion or somatic hybridisation, Molecular marking and DNA finger printing are some of the modern plant breeding tools used to improve the crop varieties. We have already discussed about the various techniques and application of the above mentioned concepts in Unit VIII.

New Plant Engineering Techniques / New Breeding Techniques (NBT)

NBT are a collection of methods that could increase and accelerate the development of new traits in plant breeding. These techniques

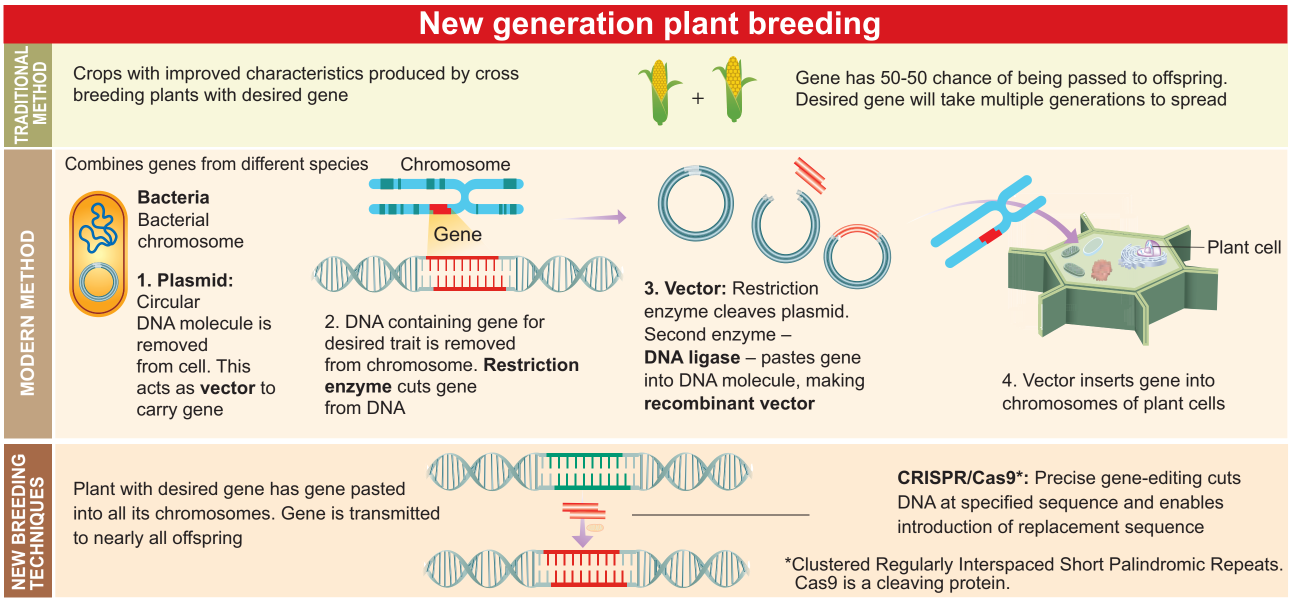


Figure 9.16 Sequential development of plant breeding techniques

often involve genome editing, to modify DNA at specific locations **within the plants** to produce new traits in crop plants. The various methods of achieving these changes in traits include the following.

RE7MVS

- Cutting and modifying the genome during the repair process by tools like CRISPR /Cas.
- Genome editing to introduce changes in few base pairs using a technique called Oligonucleotide-directed mutagenesis (ODM).
- Transferring a gene from an identical or closely related species (cisgenesis)
- Organising processes that alter gene activity without altering the DNA itself (epigenetic methods).

9.9 Seed Protection

Seed is one of the most crucial elements in the livelihoods of agricultural communities. It is the repository of the genetic information of crop species and their varieties resulting from the continuous improvement and selection over the time. The potential benefits of seed to crop productivity and food security can be enormous. Crop protection products can be applied during the growth of the crop or added to the seed. Seed protection play a significant role in improving the establishment of healthy crops. Protection and storage of seeds can be done by traditional and modern methods.

9.9.1. Traditional methods of Seed Protection

- In traditional method seeds are coated with fine red soil, Guntur Chilli Powder, Neem leaf Powder, Powder of Bittergourd, Drumstick extract, Pongamia leaf extract and stored for short duration.
- Paddy Seeds are immersed in salt water in the ratio of 1:10 to remove the floating chaffy seed and then dried in shade for one -two years of storage.
- Sorghum seeds were treated with lime water (1 kg of lime in 10 litres of H_20) for 10 days and then the seeds are dried and stored.
- Chickpea were treated with citronella leaf oil, cotton seed oil, soya bean oil, castor seed oil (500 ml of oil for 100 kg of seed).
- Sunflower seeds were kept inside the dried fruit of sponge gourd after removing the seeds. These fruits were kept in an airtight container.

9.9.2. Modern Methods of Seed Protection

The various modern methods of seed protection are as follows:

1. Seed Treatment

In agriculture and horticulture, seed treatment or seed dressing is a chemical, typically antimicrobial or antifungal, with which seeds are treated (or dressed) prior to planting.

Benefits of seed treatment

- Prevents spread of plant disease.
- Protects seed from seedling blights.
- Improves germination.
- Provides protection from storage insects.
- Controls soil insects.

2. Seed Hardening

Seed hardening is a physiological preconditioning of the seed by soaking of seed in water or chemical solution for definite duration in proper ratio (Seed : Solution) and shade drying to bring back the seed to original moisture content.

Benefits:

- It increases the yield, root growth and vigour of seed germination
- The uniformity of seedling emergence.
- Flowering occurs 2-3 days earlier
- Uniform seed set and maturity
- Exposes the seed to drought tolerance.

3. Seed Pelleting

The process of enclosing seed in a filter inert material using an adhesive with bioactive chemicals. Seed pelleting increases the weight, size and shape of seeds by allowing percale maturing and spacing of seed in the field.

4. Seed coating

Seed coating is a thicker form of covering of seed and may contain fertilizer, growth promoters, rhizobium inoculum, nutritional elements and repulsive agents. Chemical, pesticides added to the seed by adhesive agents cause increased seed performance and seed germination.

5. Bio Priming of Seeds

Bio-Priming is a process of biological seed treatment that refers to combination of seed hydration (physiological aspect of disease control) and inoculation (biological aspect of disease control) of seed with beneficial organism to protect seed. It is an ecological approach using selected fungal antagonists against the soil and seed borne pathogens. This seed treatments may provide an alternative to chemical control.

9.10 Seed Storage

Storage starts in the mother plant itself when it attains physiological maturity. Storage may be defined as the preservation of viable seeds from the time of collection until they are required for sowing. After harvesting the seeds are either stored in ware houses or in transit or in retail shop.

9.10.1. Classification of seeds based on storage

SEED STORAGE
Roberts (1973) classified seeds based on physiological behaviour during storing

ORTHODOX SEED	RECALCITRANT SEED
Seeds dried to low moisture of 5% (wet basis) and stored at low or Sub-freezing temperature for long period. Example:Cereals, pulses and oil seeds.	Seeds dried to high moisture of 20 - 50% (wet basis) and which cannot be successfully stored for long period. Example: Mango, Jack fruit, Coconut etc

SEED STORAGE
Ewart (1908) classified seeds into 3 categories based on life span or longitivity

Micro biotic:
Seed life span not exceeding 3 years.
Mesobiotic:
Seed life span not exceeding from 3 to 15 years.
Macrobiotic:
Seed life span not exceeding from 15 years to over 1000 years.

9.10.2. Methods of Seed Storage

i. Conventional Methods of Seed Storage

Conventional storage includes storage in Bamboo structure, mud and earthen structure, wooden structure and underground structure. In village level storage is done in large level in concrete/ cement silos, Metal or plastic drums and metal silos. Improved rural level storage structure includes storage in coal tar drum, udaipur bin, bamboo bin, pusa bin and metal bins.

ii. Modern Methods of Seed Storage

a. Seed storage in cryopreservation: It is the technique of germplasm conservation (storage of cells, tissue, embryo or seeds) by ultra-low temperature in liquid nitrogen at -196oC. It is not practical for commercial seed storage purpose, but is useful to store the valuable germplasm for use in future which cannot be preserved by conventional methods.

b. Seed storage in gene bank: In gene bank, seed storage is the preservation of seed under controlled environmental condition which will prolong the viability of the seeds for long periods. The temperature, relative humidity and seed moisture content. Containers and distribution arrangement vary for each and every type of seed.

c. Svalbard seed bank:

The seeds are stored in four ply sealed envelopes, and then placed into plastic tote containers on metal shelving racks. The storage rooms are kept at $-18^{\circ}C$. The low temperature and limited access to O_2 will ensure low metabolic activity and delayed seed ageing. The permafrost surrounding will help to maintain low temperature of the seed when the electricity supply fails.

Figure 9.17 Svalbard seed bank

DO YOU KNOW?

Nanotechnology in Agriculture:

Currently nanotechnology provides different nano devices and nano material that have a unique role in agriculture. For example Nano biosensors to detect moisture content and nutrient status in the soil. Nanotechnology can offer Nano-fertilizers for efficient nutrient management, Nano-herbicides for selective weed control in crop field, Nanonutrient particles to increase seed vigor, Nano-pesticides for efficient pest management. Hence, nanotechnology have greater role in crop production with environmental safety, ecological sustainability and economic stability.

9.10.3. Seed Certification

Seed certification is a legally sanctioned system for quality control of seed multiplication and production. The purpose of this certification is to maintain the seeds and make them available to the public. Through certification, high quality seeds and propagating materials of notified kind and variety are grown and distributed to ensure genetic identity and purity.

Summary

Economic Botany deals with the relationship between people and economically important plants to fulfill the three basic needs of life such as food, clothing and shelter. Domestication, a term often used for a more intricate process, involves the genetic alteration of plants which did not appear at once, but rather over a substantial period of time, perhaps hundreds of years for some species. In the history of agriculture Vavilov has given the eight main centres of origin of plants were now divided into 12 centres of origin. In Organic agriculture biofertilizers are microbial inoculants which is ecofriendly, more effective even though cost effective than chemical fertilizers. Rhizobium, Azolla, VAM and sea weeds are used as fertilizers which increase the crop yield many fold.

Plant breeding is a purposeful manipulation of plant species in order to create desirable genotype and phenotype for the benefit of mankind. Plant introduction, selection, hybridization, heterosis, mutation breeding, polyploidy breeding and green revolution are the different methods of conventional breeding.

Seed is an important part of the plant as it gives the food for future generation, so it should be carefully protected and stored. Seed hardening, seed treatment, seed pelleting, seed coating and bio priming of seeds are the modern methods of seed protection. Seeds are stored in bamboo structure, mud or earthen structure in conventional method of storage. In villages, the farmers store the entire seeds in concrete / cement silos or metal or plastic drums. In modern methods of storage we have cryo preservation, gene bank and Svalbard seed bank for long time seed storage.

Evaluation

S8ZGWS

1. **Assertion:** Genetic variation provides the raw material for selection

   Reason: Genetic variations are differences in genotypes of the individuals.

   a) Assertion is right and reason is wrong.
   b) Assertion is wrong and reason is right.
   c) Both reason and assertion is right.
   d) Both reason and assertion is wrong.

2. While studying the history of domestication of various cultivated plants ________ were recognized earlier

   a) Centres of origin
   b) Centres of domestication
   c) Centres of hybrid
   d) Centres of variation

3. Pick out the odd pair.

   a) Mass selection - Morphological characters
   b) Purline selection - Repeated self pollination
   c) Clonal selection - Sexually propagated
   d) Natural selection - Involves nature

4. Match Column I with Column II

Column I	Column II
i) William S. Gaud	I) Heterosis
ii) Shull	II) Mutation breeding
iii) Cotton Mather	III) Green revolution
iv) Muller and Stadler	IV) Natural hybridization

   a) i – I, ii – II, iii – III, iv – IV
   b) i – III, ii – I, iii – IV, iv – II
   c) i – IV, ii – II, iii – I, iv – IV
   d) i – II, ii – IV, iii – III, iv – I

5. The quickest method of plant breeding is

   a) Introduction b) Selection
   c) Hybridization d) Mutation breeding

6. Desired improved variety of economically useful crops are raised by

   a) Natural Selection b) hybridization
   c) mutation d) biofertilisers

7. Plants having similar genotypes produced by plant breeding are called

   a) clone b) haploid
   c) autopolyploid d) genome

8. Importing better varieties and plants from outside and acclimatising them to local environment is called

   a) cloning b) heterosis
   c) selection d) introduction

9. Dwarfing gene of wheat is

   a) pal 1 b) Atomita 1
   c) Norin 10 d) pelita 2

10. Crosses between the plants of the same variety are called

   a) interspecific b) inter varietal
   c) intra varietal d) inter generic

11. Progeny obtained as a result of repeat self pollination a cross pollinated crop to called
    a) pure line b) pedigree line
    c) inbreed line d) heterosis
12. Jaya and Ratna are the semi dwarf varieties of
    a) wheat b) rice
    c) cowpea d) mustard
13. Which one of the following are the species that are crossed to give sugarcane varieties with high sugar, high yield, thick stems and ability to grow in the sugarcane belt of North India?
    a) *Saccharum robustum* and *Saccharum officinarum*
    b) *Saccharum barberi* and *Saccharum officinarum*
    c) *Saccharum sinense* and *Saccharum officinarum*
    d) *Saccharum barberi* and *Saccharum robustum*
14. Match column I (crop) with column II (Corresponding disease resistant variety) and select the correct option from the given codes.

Column I	Column II
I) Cowpea	i) Himgiri
II) Wheat	ii) Pusa komal
III) Chilli	iii) Pusa Sadabahar
IV) Brassica	iv) Pusa Swarnim

	I	II	III	IV
a)	iv	iii	ii	i
b)	ii	i	iii	iv
c)	ii	iv	i	iii
d)	i	iii	iv	ii

15. A wheat variety, Atlas 66 which has been used as a donor for improving cultivated wheat, which is rich in
    a) iron b) carbohydrates
    c) proteins d) vitamins
16. Which one of the following crop varieties correct matches with its resistance to a disease?

Variety	Resistance to disease
a) Pusa Komal	Bacterial blight
b) Pusa Sadabahar	White rust
c) Pusa Shubhra	Chilli mosaic virus
d) Brassica	Pusa swarnim

17. Which of the following is incorrectly paired?
    a) Wheat - Himgiri
    b) Milch breed - Sahiwal
    c) Rice - Ratna
    d) Pusa Komal - Brassica
18. Match list I with list II

List I	List II
Biofertilizer	**Organisms**
i) Free living N2	a) *Aspergillus*
ii) Symbiotic N2	b) *Amanita*
iii) P Solubilizing	c) *Anabaena azollae*
iv) P Mobilizing	d) *Azotobacter*

    a. ic, iia, iiib, ivd b. id, iic, iiia, ivb.
    c. ia, iic, iiib, ivd c. ib, iia, iiid, ivc.
19. List the ways by which seeds can be stored for longer duration.
20. Differentiate primary introduction from secondary introduction.
21. How are microbial innoculants used to increase the soil fertility?
22. Discuss the importance of neem in seed storage?
23. What are the different types of hybridization?
24. Explain the best suited type followed by plant breeders at present?
25. Write a note on heterosis.
26. List out the new breeding techniques involved in developing new traits in plant breeding.

Glossary

Acclimatization : The adaptation of an individual to a changed climate or the adjustment of a species or a population to a changed environment over a number of generations.

Agronomy : Science of farming

Anthesis : Period of opening of flower.

Certified seed : Seed produced from the foundation or certified seed under the regulation of a legally constituted agency.

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

Non recurrent parent : The parent of a hybrid that is not again used as a parent in backcrossing

Pure-Line: Progeny of a single self-fertilised homozygous individual.

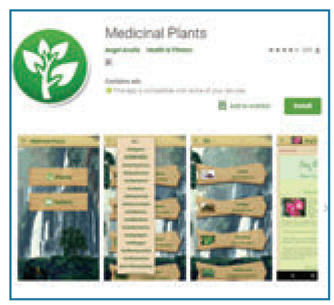
Quarantine : Strict isolation imposed to prevent the spread of disease

Strain : A group of similar individuals from a common origin.

ICT Corner

Plant Breeding

Let us know about the details of Medicinal Plants in detail.



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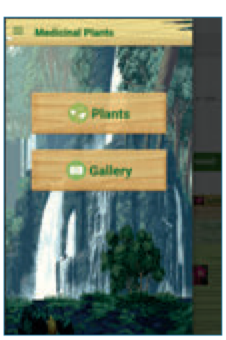
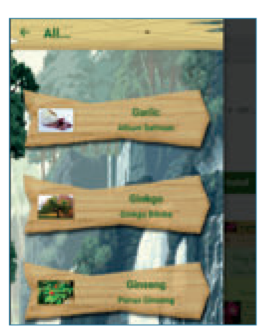
Steps

- Type the URL or scan the QR code to open the activity page then Introduction page will open.
- Click on 'Plants' it will display list of Medicinal Plants.
- Click on each plants individually on the next screen it displays the description, harvesting and properties of the plants.
- Click the option on the top left side of the front page to see the preparation of oils, Powder etc.,



Step 1

Step 2



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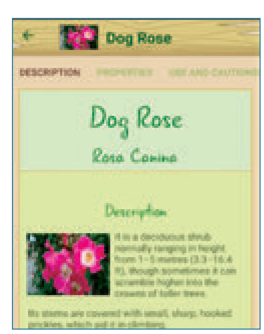

Step 4

* Pictures are indicative only

URL:
https://play.google.com/store/apps/details?id=com.dssoft.plantasmedicinales