Plant Breeding

week	Lecture topic	Lab.
1	Introduction to plant breeding, importance of plant breeding, The objectives of plant breeding.	Introduction
2	Reproduction systems in crop plants, Types of reproduction, Sexual reproduction and asexual.	Sexual reproduction
3	Pollination and fertilization, Self-pollinated plants, cross pollinated plants, Self- cross pollinated plants,	Meiosis and mitotic
4	Mutations in plant breeding and The use of mutagens in the field of education and improvement of plants.	Mendelion genetics
5	Hybridization, non- allelic gene interaction, Gene action	Method of plant breeding using mutagens, with experiment.
6	gene frequency	gene frequency
7	sterility and incompatibility	Biological resistance
8	Male sterility and its relationship to plant breeding	Hybridization
9	polyploidy and plant breeding	Testing Qualitative variability
10	Quantitative inheritance	Testing quantitative variability
11	. Methods of crop breeding	Agricultural Extension classes seeds, Seed production problems
12	methods of breeding Self-pollinated crops	Field trials and data recording
13	Genetic basis for breeding cross-pollinated crops, Hardy- Weinberg Law.	Hardy- Weinberg Law.
14	Genotype - environment interference	Genotype - environment interference, How to estimate Genotypes- Environment interference
15	Exam	Exam

Textbook:

1-breeding field crops 5th ed. David allen sleeper and john milton poehlman iowa state university press –ames,ia copyright:2006.isbn10:0_8138-2428-1.

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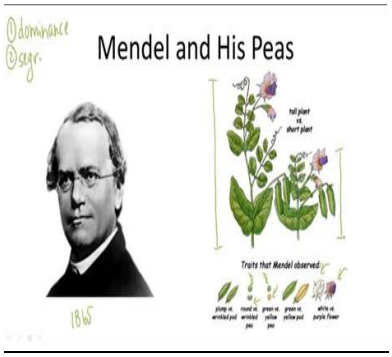
Lecture: 1

Plant Breeding

The population explosion of the last few decades has given rise to a situation causing people, mostly children, to die each day from hunger, malnutrition and related diseases. We need to increase food , bringing more land under cultivation and introduction of modern agricultural technology. Here comes the role of Plant Breeding which aims to evolve improved plant varieties with good qualities in them and also superior to existing varieties in many aspects.The techniques of plant breeding have evolved from simple methods of the remote past to the present in the form of - **1. Selection 2. Hybridisation 3. Introduction 4. Mutation Breeding 5 .Breeding for disease resistance.**

Breeding is hence about manipulating plant attributes, structure, and composition, to make them more useful to humans.

The Scientific approach to plant breeding Two strands:



1. Mendelian: Incorporate information from genes into selection decisions championed by plant breeders
2. Biometric: Incorporate information from relatives into selection decisions championed by animal breeders

Mendel proposed that each genetic character is controlled by a pair of unit factors, now known as alleles or allelomorphic pair..

1. Thus, three combinations are possible: (i) either these are two factors for tall, or (ii) two factors for dwarf stems, or (iii) one of each factor in an individual.This postulate is based on the results obtained in F_1 generation.
2. The one which expresses itself is the dominant unit factor and the other which does not express is the recessive unit factor, and thus, tall stem is said to be dominant over the recessive dwarf stem. The dominant and recessive terms are used to denote a trait, e.g., tall trait or recessive trait.

3. Now the unit factors of Mendel are called genes.
4. After fertilization, F_1 plants will receive one unit factor for tallness and one for dwarfness.
5. With the former (i.e., factor for tallness) being dominant, all F_1 plants will be tall.
6. When F_1 tall plants will form gametes, the principle of segregation will demand that each gamete randomly received either the tall or the dwarf unit factor.
7. (i) tall/tall (ii) tall/dwarf (iii) dwarf/tall (iv) dwar/dwarf.
8. When any individual produces gametes, the alleles segregate; so each gamete receives only one member of the pair of alleles and the paired condition is restored by random fusion of gametes during fertilisation.

This means that the F_2 generation consists of three-fourths tall and one-fourth dwarf or a phenotypic ratio of 3: 1. This is exactly what Mendel observed, and is found in all the monohybrid crosses.

Lecture: 2

Reproduction systems in plants

Reproduction: is the process by which plants multiply themselves.The reproduction takes place by means of vegetative, asexual and sexual methods.

Plants are generally classified into two groups based on mode of reproduction as either **sexually reproducin**g or **asexually reproducing.**

Sexual reproduction: Sexual reproduction is the most common method of reproduction in plants and animals. Two parents, one male and other female, are involved in the process of sexual reproduction. It involves the fusion of two types of reproductive cells called gametes to form a single cell called zygote. The zygote multiplies repeatedly and undergoes specific changes to form the new individual.

In order for sexual reproduction to occur, two processes must occur in sexually reproducing species. The first process, meiosis, reduces the chromosome number of the diploid (2n) cell to the haploid (n) number. The second process, fertilization, unites the nuclei of two gametes, each with the haploid number of chromosomes to form a diploid. In most plants, these processes divide the life cycle of the plant into two distinct phases or generations, between which the plant alternates (called alternation of generations) .

The first phase or generation, called the gametophyte generation, begins with a haploid spore produced by meiosis. Cells derived from the gametophyte by mitosis are haploid. The multicellular gametophyte produces gametes by mitosis. The sexual reproductive process unites the gametes to produce a zygote that begins the diploid sporophyte generation phase.

In lower plants (mosses, liverworts), the sporophyte is small and dependent upon the gametophyte. However, in higher plants (ferns, gymnosperms, angiosperms), the male gametophyte generation is reduced to a tiny pollen tube and three haploid nuclei (called the macrogametophyte). The female gametophyte (called the megagametophyte) is a

single multinucleated cell, also called the embryo sac. The genotype of the gametophyte or sporophyte influences sexual reproduction in species with self-incompatibility problems.

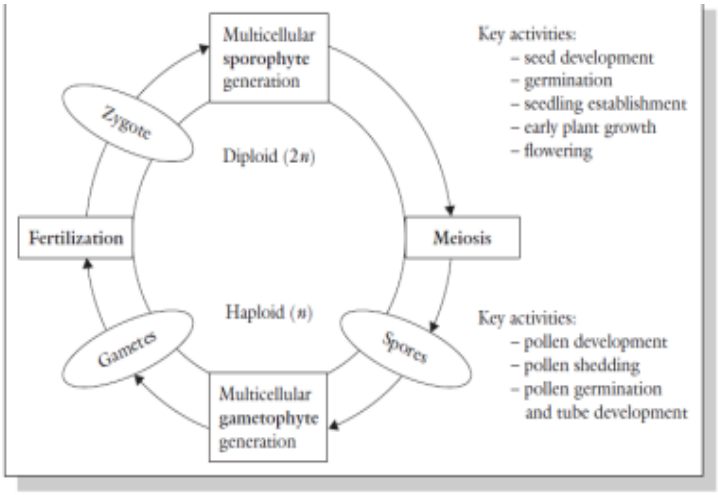


Figure 4.1 Schematic representation of the alternation of generations in flowering plants. The sporophyte generation is diploid, and often the more conspicuous phase of the plant life cycle. The gametophyte is haploid.

Duration of plant growth cycles

The plant may be classified into four categories based on the duration of their growth.

Annuals plants: (or annuals) complete their life cycle in one growing season. Examples of .such plants include corn, wheat.

Biennial plants: completes its life cycle in two growing seasons.

In the first season, it produces basal roots and leaves; then it grows a stem produces flowers and fruits , and dies in the second season ,ex: suger beet.

Perennials : are plants that have the ability to repeat their life cycles indefinitely by circumventing the death .

Monocarp plants: long vegetative cycles that may go on for many years without entering the reproductive phase. Once flowering occurs, the plant dies. Common examples are bromeliads.

Structure of the flower

Flower is the reproductive organ of a flowering plant. A flower has four whorls namely- . petals, sepals, stamens and carpel in order from outside to inside. Of these four parts, carpel and stamen order are the ones that are involved in the process of sexual reproduction. Stamen is the male reproductive organ of the flower while carpel is the female reproductive organ.

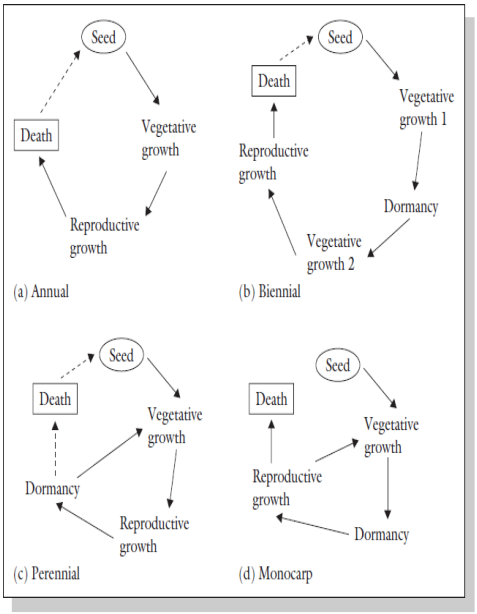


Figure 4.2 Flowering plants have one of four life cycles – annual, biennial, perennial, and monocarp.

-: **Flower parts**: The basic parts of a flower, from the base to the apex are

1- Pedicel : Is the flower stalk (if a pedicel is absent, the flower is sessile).

2- Bract : A modified, generally reduced leaf borne on the side of a pedicel.

3-Bracteole or bractlet : A smaller or secondary bract on the sideof a pedicel, where present typically paired

1- Epicalyx : A series of bracts, immediately subtends the calyx as in Hibiscus and other members of Malvaceae.

2- Receptacle or torus : A region of flower to which other floral parts are attached.

3- Perianth : The outer most non reproductive group of modified leaves of flower, if the perianth is undifferentiated, its components called tepals.

4- -Calyx : It's the outer most series or whorl of modified leaves in the perianth, individual units of the calyx are sepals

5- -Corolla : It's the inner most series or whorl of modified leaves in the perianth, individual units of corolla are petals.

6- -Androcium : It refers to all the male organs of a flower, collectively all the stamens.

7- -Gynocium : It refers to all of the female organs of flower, collectively all the carpels.

Flower sex refers to the presence or absence of male and female parts with a flower.

1. Perfect(Bisexual) : Having both stamens and carpels

2.Imperfect (Unisexual) : In this case flowers are either staminate or pistillate.

A/ Staminate: In which only stamens develop as in Oak.

B/ Pistillate : In which only carpels develop as in Salix , Arum .

- Plant sex refers to the presence and distribution of perfect or imperfect flowers on individuals of a species:

A/ Hermaphrodite : A plant with only bisexual flowers.

B/ Monoecious : Plant with only unisexual flower, both staminate and pistillate on the same individual plant as in Quercus.

C/ Dioecious : A plant with unisexual flowers but with staminate and pistillate on the separate individual plants as in Salix.

D/ Polygamous : plant with both bisexual and unisexual flowers.

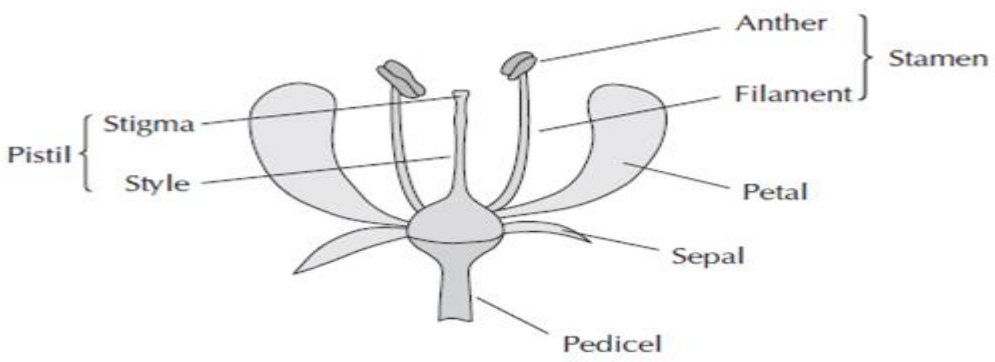


Figure 4.3 The typical flower has four basic parts – the petals, sepals, pistil, and stamen. The shape, size, color, and other aspects of these floral parts differ widely among species.

Asexual reproduction: may be categorized into two– vegetative propagation and apomixis.

A-Vegetative propagation:. Pieces of vegetative materials called cuttings are obtained from parts of the plant (e.g., root, stem, leaf) for planting. Potato, cassava, sugarcane, rose, grape, and some perennial grasses are frequently propagated by stem cuttings.

B- Apomixis : Seed production in higher plants that are sexually propagated species normally occurs after a sexual union in which male and female gametes fuse to form a zygote, which then develops into an embryo. However, some species have the natural ability to develop seed without fertilization, a phenomenon called apomixis.

Lecture:3

mechanisms and processes of sexual and asexual reproduction in plants.

Sexual reproduction in seeded plants: There are two major processes in sexual reproduction of seeded plants:

A/Pollination :- It is the transfer of pollen grains from microsporangia to the ovule or stigma. There are two types of pollination

1 -Self-pollination: It is the transfer of pollen from the stamens to the stigma in the same flower. This type of pollination happened in the following:

A- Hermaphrodite flowers

B- Cleistogamus flowers as in Avena

2 -Cross-pollination: It is the transfer of pollen from the stamens of one flower to the stigma of a different flower. This type has the most distinct advantage of providing more

genetic variation .

Mechanisms favouring cross-pollination:

1 -Being dioecious (that is having separate male and female plants as in Salix.(

2 -Being monoecious (that is having separate male and female flowers as in hazel.(

3 -The maturation of anthers and stigmas in different times. If the anthers mature first is called protandry as in Bunium, if the stigmas mature first called protogyny.

4 -In heterostyled flowers.

5 -In self-incompatible flowers.

B/Fertilization :- It is the union of sperm and egg. Pollination usually followed by fertilization. There are different types of F.

1- **Inbreeding** (also called selfing): Is the union of gametes derived from a single individual. In flowering plants, inbreeding may occur either within a single flower or between flowers derived from one individual.

2- **Outbreeding**(also called outcrossing or allogamy:(

Is the transfer of gametes from one individual to another, genetically different individual. The general advantage of outbreeding is to promote an increase in phenotypic variability within a pollination. This generally enables plants to adapt to a wider range of environmental conditions.

2- **Allautogamy**(means have both outcrossing and selfing flowers): As in Viola, have two types of flowers, flowers are typical ones in which the perianth opens and expose the sexual organs, with subsequent cross-pollination common. Other flowers the perianth remains closed (so the pollination is selfing).

*** in plants:** Four broad contrasting pairs of reproductive mechanisms or options occur in plants:

1-**Hermaphrodity versus unisexuality**. Hermaphrodites have both male and female sexual organs and hence may be capable of self-fertilization. On the other hand, unisexuals, having one kind of sexual organ, are compelled to cross-fertilize.

2-**Self-pollination versus cross-pollination**. Hermaphrodites

that are self-fertile may be self-pollinated or cross-pollinated. In terms of pollen donation, a species may be autogamous (pollen comes from the same flower – selfing), or allogamous (pollen comes from a different flower).

3-**Self-fertilization versus cross-fertilization**. Just because a flower is successfully pollinated does not necessarily mean fertilization will occur.

4-**Sexuality versus asexuality**. Sexually reproducing species are capable of providing seed through sexual means. Asexuality manifests in one of two ways – vegetative reproduction (in which no seed is produced)or agamospermy (in which seed is produced).

Lec:**4** Plant Mutation Breeding

Mutation is defined as any sudden and drastic heritable change in gene which is not traceable or ascribable to segregation or recombination. According to Darwin sudden appearance of new hereditary character in the offspring of plants.

Mutations may be natural or induced and may be occur at chromosome level or at gene or molecular level or may takes place involving the cytoplasm or cytoplasmic organelles like plastids.

From Mendel's experiment on hybridization it is understand that genes are hereditary units transmitted from one generation to other generation through the germ cells and associated with carrying the characters. Mendel used the term factor for these

hereditary units.The term gene was first used by johansen 1909. After him several workers experimentally proved that genes are the fractions or part of DNA molecule which regarded as the genetic material. Suton and boveri independently suggested that chromosome is the container of hereditary units. T.M Morgan proposed the gene theory which state that:

i) Chromosomes are bearers of hereditary units and each chromosome carries hundreds or thousands of genes.

ii) The genes are arranged on the chromosomes in the linear order and on the special regions or locus.

Classical concept of gene: was introduced by sutton (1902) and was elaborated by morgan (1913). Bidge (1923), Muller (1927) and others which outlined as follows.

i) Genes are descrete particles inherited in mendelian fashion that occupies a definite locus in the chromosome and responsible for expression of specific phenotypic character.

ii) Number of genes in each organism is more than the number of chromosomes; hence several genes are located on each chromosome.

iii) The genes are arranged in a single linear order like beads on a string.

iv) Each gene occupies specific position called locus.

v) If the position of gene changes, character changes.

vi) Genes can be transmitted from parent to off springs.

vii) Genes may exist in several alternate formed called alleles.

viii) Genes are capable of combined together or can be replicated once during a cell division.

ix) Genes may under for sudden changes in position and composition called mutation.

x) Genes are capable of self duplication producing their own exact copies.

Gene types:On the basis of their behavior the genes may be categorized into the following types.

i) Basic genes: These are the fundamental genes that bring about expression of particular character.

ii) Lethal genes: These bring about the death their possessor.

iii) Multiple gene: When two or more pairs of independent genes act together to produce a single phenotypic trait.

iv) Cumulative gene: Some genes have additive effects on the action of other genes. These are called cumulative genes.

v) Pleiotropic genes: The genes which produce changes in more than one character is called pleiotropic fene.

vi) Modifying gene: The gene which cannot produce a character by itself but interacts with other to produce a modified effect is called modifier gene.

vii) Inhibitory gene: The gene which suppresses or inhibits the expression of another gene is called inhibitory gene.

Chromosomal mutation: refers to any change in the structure or gross morphology of chromosome and change in chromosome number. The former case involve loss or gain or any alteration in chromosome which called chromosomal aberrations and the later is the change in basic chromosomal aberrations and the later is the change is basic chromosome number of a species and called polyploidy or numerical mutation.

i) Chromosomal aberrations: These include structural changes which takes place during meiosis. These are following types:

a. Deletion or deficiency: In this case if a chromosome broken in to pieces and reunion takes place without taking one or more pieces with loss of a segment. It has great cytological and genetic effect on organism and may be lethal.

b. Duplication: If an extra chromosomal part is added to normal character, it is called duplication. Duplication takes place when delated part of a chromosome added to another chromosome.

c. Translocation: When a part of chromosome is broken into two or more pieces and some fragment is transferred from the broken chromatid and rejoin with the other chromatid then it is called translocation. It may be simple or reciprocal causing disturbance in position of genes. It may cause sterility in plants.

d. Inversion: In this process a piece of chromosome is removed and reinserted in reverse order changing the gene sequences. It may be paracentric or pericentric type. It causes position effect resulting alteration in geneaction.

ii) Poly ploidy : (Numerical mutation): In this type of mutation basic genomic set changed due to disjunction or defective meiosis or nuclear division. Thus changed into 3n or 4n or 6n etc. these polyploidy can be classified into Autopolyploidy and allopolyploidy.

a) Autopolyploidy: When the basic chromosome set of an individual is multiplied due to union of two diploid gametes or somatic doubling of chromosomes or union of one haploid and one diploid gamets. It may be autotriploid, autotetraploid etc. these are found in avaena, coffee, apple, banana, sugarcane, chili etc.

(b) Allopolyloids: formed by multiplication of chromosome sets of a hybrid of two diploid species. Suppose in a cross between a species – X (AA) and species Y(BB) is made it will give rise to F1 hybrid with chromosome doubling and a alloteraploid having (A,A,B,B)genomic set will be obtained.

Allopolyploidy can be induced and have played important role in evolution of new species. Example: Raphanobrassica, Gossipium hissutum etc.

ii) Germinal Mutation: Those mutations occur in the germplasm of an organism and may occur at any time during life cycle are called germinal mutation. The effect of these mutations expressed in the progenies. This mutation is found in wheat as dwarfism. Expression of germinal Mutation depends upon whether it is of dominant or recessive form. The progeny produced will be mutant if the gamete posses mutant gene.

iii) Somatic mutation: are the mutation occurs in the somatic cells of an individual, which cannot be passed to the offspring through the gamets. This mutated genes lost with the death of the individual. In somatic mutations, the extent of phenotypic effect depends on various factors, like the stage of life cycle. It can not be pass on to the germ cells and only inherited to the next generation of progeny which produced from the mutated somatic cell. This mutation cause cancerous growth and defected metabolism of cells and tissues produced by the mutated cell. It is found in vegitatively and asexulally reproducing plants and animals. Such mutations used in production of delicious apples, navel orange and many other fruits and flower production.

Now it is commercially used in horticultural practices.

iv) Gene mutation or point mutation: These gene mutations are intragenic in which alteration in the structure of DNA molecule within a gene occurs. These occurs change in the normal base sequence of DNA molecule which leads to modification of structural characteristic or enzymatic activity of an individual. The unit of gene mutation, i.e. a specific nucleotide or nucleotides called muton.In this type of mutation tautomerism occur in the structure of base molecule, which enable it for unusual pairing. “Adenine instead of bonding with “Thymine” binds with guanine or other bases or other tautomeric forms of bases.Gene mutations may be spontaneous or may be induced by application of mutagenic agents.)

v) Plastid mutation: Mutations in the genetic materials in plastids are called plastid mutation and it is governed by the self duplicating non-med3elian genetic material called plastogenes. Plastogenic mutation cause defective plastid characters which traced in maize, barley and rice.

vi) Cytoplasmic mutation: Mutation which takes place in the nucleus free or extra chromosomal genetic material is called cytoplasmic mutation. These mutations effect cytoplasmic inheritance chlorophyl deficiency in algae, like chlamydomonas, enzmatic alteration in yeast and antibiotic resistant in bacteria are the consequences of cytoplasmic mutation. These mutations occure at plasmogenes or cytogenes or plasmones or plasmid.

Role of Mutation in Plant Breeding. Plant breeding aims at improving the crop quality but improving the heredity through the cross hybridization technique. In plants mutations can be artificially incused by mutagenic agents and there utilization for production of new superior varieties of species from traditional variety. This process is called mutation breeding.The history of mutation breeding in India started in 1935 at Bose research institute, Calcutta and established at IARI, New Delhi in 1959. **Mutation breeding in wheat (Triticum species), rice (Oryzaesativa), cotton (Gossypium), sugarcane, potato.**

Lac:5

Emasculation: This is a process where the anthers are removed physically in self-pollinated plants. In cases where physical removal is not possible, other methods are adopted. These are dipping the panicle in hot water (50°c) for 10 minutes as practiced in Sorghum, or through chemical treatments like dichlorophenoxy acetic acid maleic hydrazide, as practiced for plants like wheat. These methods ensure male sterility. Bagging: After emasculation flower buds are enclosed in bags to avoid getting pollers from undesired sources. Bagging is done with special paper or polythere but there should be complete protection to the flowers. After bagging, the emasculated flowers are labelled properly.

Artificial Pollination: Pollens from the selected male plants are collected in suitable containers (paper bags, tubes or dishes) and then dusted with a fine brush, on to the receptive stigma of the female parent. After this, the female flower is securely sealed in a bag till the time of seed setting.

Rising of hybrids: Seeds are collected from the fertilized plants and the F_i plants are raised. The F_i offspring's are allowed to self-pollinate and seeds are again collected to raise F_2 generation. From the F_2 plants, the best plant is selected for its seeds to raise F_3 generation. The process is repeated till about Fi generation, because by that time the plants have become nearly homozygous for certain dominant genes so that the plants shall breed true for the desired traits.

***Commercial hybridizing is done to get some type of valued attribute of each initial variety into the offspring. Hybrids might be developed for disease resistance, size of plant, flower, or fruit, increased flowering, color, taste or any reason a plant might be considered special. Most modern plants currently on sale are hybrids.**