Some important Topics of

Blant Breeding

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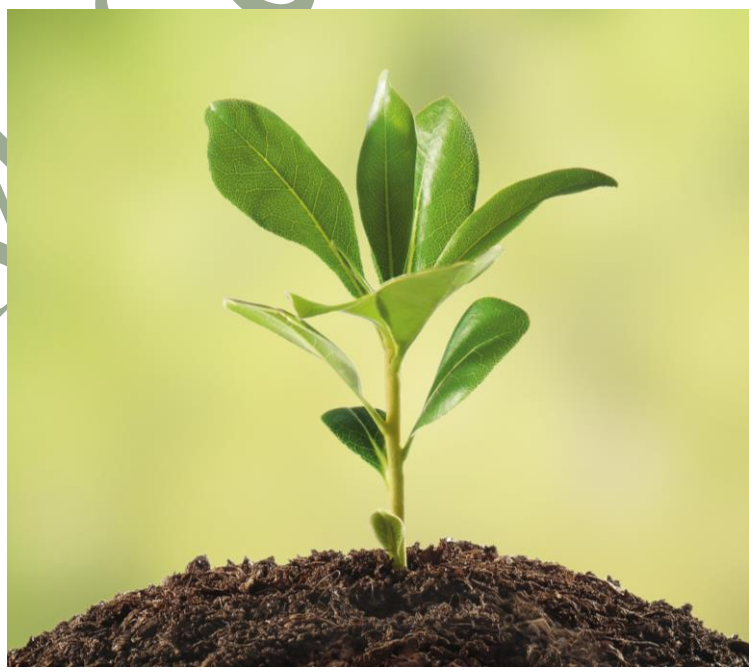

HETEROGENOMIC PLANTS

The term“heterogenomic”refers to organisms that contain heterogeneous genomes. Heterogenomic plants may be two types

(i) Plants in which independent genomes are housed within a single nucleus. E.g., Hybrids.
(ii) Plants in which heterogeneous genomes are housed in separate nuclei. E.g., Chimeras, Graft hybrids etc.

(1) **Chimeras**, which are formed from a conglomeration cells that originated from separate zygotes.

Classification of chimeras

Chimeras and genetic mosaics can be classified by the **arrangement of their genetically distinct cell types as well as the nature of their origin.** Most seed plants have tunica-corpus SAMs that are organized into clonally distinct cell layers with outer “tunica” layers dividing anticlinally and an inner “corpus” layer that divides both an ticlinally and periclinally. Gymnosperms typically have a single tunica layer, while most angiosperms have two layer.

1. Periclinal. This type of chimera consists of two thin layers of different genetic makeup, one over the other.
2. Mericlinal. When an outer layer of different genetic tissue does no completely extend over the layer below, the chimera is mericlinal.
3. Sectorial. This chimera is observed in a growing shoot as two different tissues located side-by-side. The effect of this modification is that the stem develops with two distinct tissues on each half.

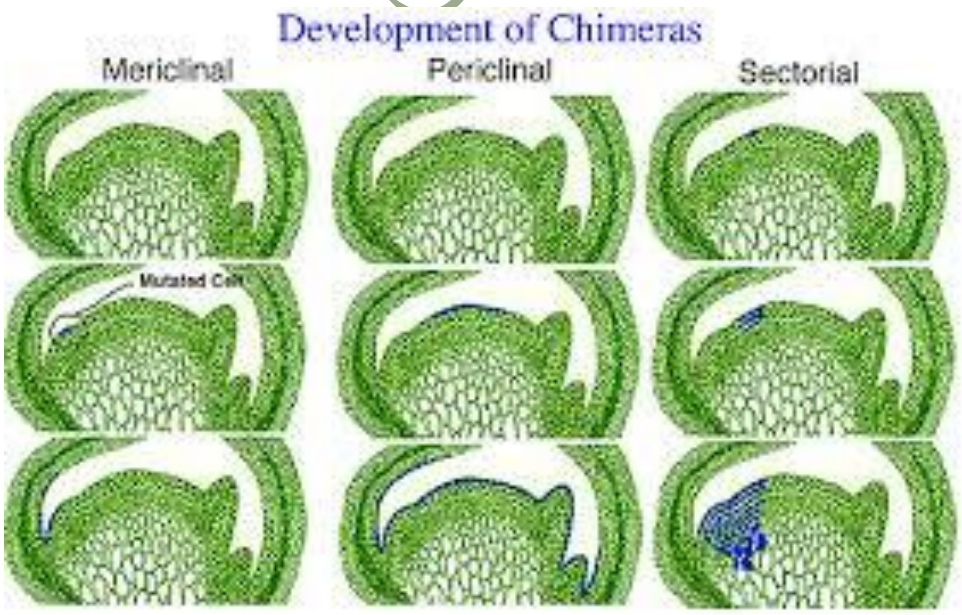

Fig. 1, Showing development of various types of chimeras.

(2) **Grafted plants or Graft hybrid,** which are formed through the physical joining of separate plant parts (between scion and stock). It is some time also known as **graft-chimera**.

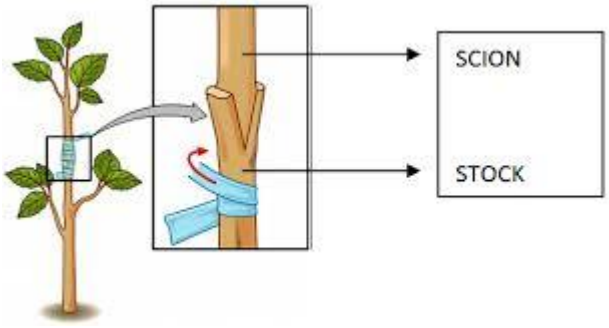

Figure 2. Showing graft hybrid.

METHODS OF CROP IMPROVEMENT

SELECTION METHOD FOR CROP IMPROVEMENT:

- It is the simplest and oldest breeding method. It is also called as German method or German method of broad breeding because once it was used nicely in Germany for improving the sugar beets and small grains such as rye and wheat.
- It can be defined as preservation of certain individual plants of desirable characters. In simplest form selection means choosing plants of one's choice. It is the basis of all crop improvement. Even today it is most common method of crop improvement among the cultivators.

Types of Selection Method:

1. Natural Selection:

This is a natural process. It operates in the nature without human interference. According to the Darwin's principle "Survival of the fittest" plants which survive through the adversities of nature are preferred and the weaker ones are wiped out. Thus, nature itself selects the fittest organisms. So, natural selection favours these characters which are essential for survival of a species. The selection pressure ultimately resulted in the appearance of many differences between species and subspecies. Natural selection has given the cultivated crops and 'ecotypes' in plants.

2. Artificial Selection:

It can be defined as to choose certain individual plants for the purpose of having better crop from a mixed population where the individuals differ in characters. Here the selecting agent is man. Man exploits the variations existing among the species. He picks of a few plants of better qualities from mixed populations and tries to propagate them

There are 4 methods of artificial selection:

(i) Mass selection

(ii) Progeny selection

(iii) Pure line selection and

(iv) Clonal selection,

(i) Mass selection

- The choosing of the individuals (Plants or Animals) for reproduction from the entire population on the basis of the individual's phenotypes rather than the phenotypes of their relatives.
- The Danish biologist, **W. Johansen**, is credited with developing the basis for mass selection in 1903.
- This method of selection is applicable to both self- and cross-pollinated species, provided there is genetic variation.

1. **Negative mass selection:** The general procedure in mass selection is to rogue out off-types or plants with undesirable traits. This is called by some researchers negative mass selection.
2. **Positive mass selection:** Whereas rouging out and bulking appears to be the basic strategy of mass selection, some breeders may rather select and advance a large number of plants that are desirable and uniform for the trait(s) of interest (positive mass selection).

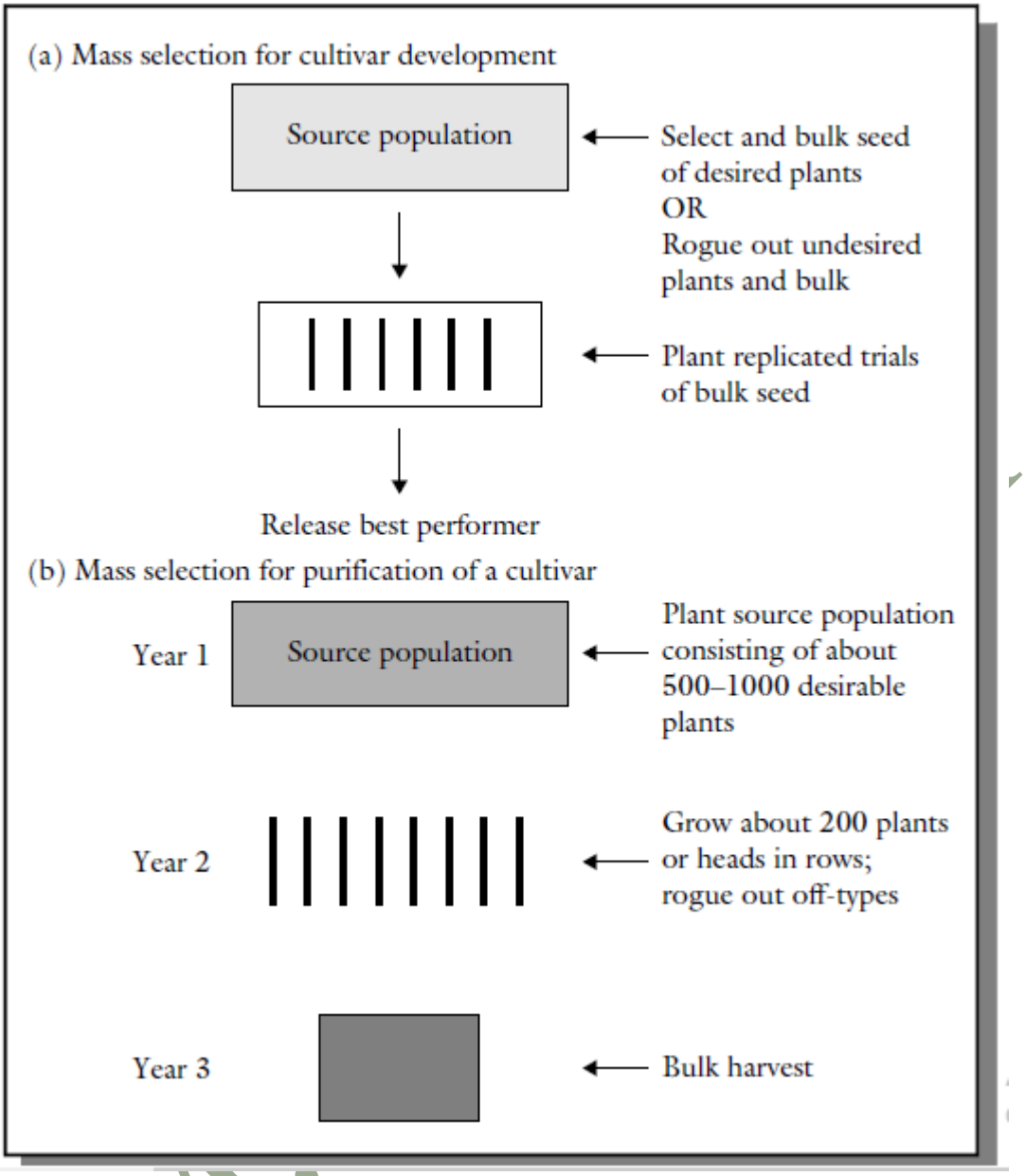

Figure 1 Generalized steps in breeding by mass selection: (a) for cultivar development and (b) for purification of an existing cultivar.

ADVANTAGES

1. It is rapid, simple, and straightforward. Large populations can be handled and one generation per cycle can be used.
2. It is inexpensive to conduct.
3. The cultivar is phenotypically fairly uniform even though it is a mixture of pure lines.

DISADVANTAGES

1. To be most effective, the traits of interest should have high heritability.

2. Because selection is based on phenotypic values, optimal selection is achieved if it is conducted in a uniform environment.
3. Phenotypic uniformity is less than in cultivars produced by pure line selection.
4. With dominance, heterozygotes are indistinguishable from homozygous dominant genotypes. Without progeny testing, the selected heterozygotes will segregate in the next generation.

PURE-LINE SELECTION

Pure-line or true breeding line: A true breeding line is one that have undergone continuous self-pollination, shows the stable trait inheritance and expression for several generations.

As a result of true breeding genetically identical (homozygous) organisms are produced for each trait. This is called true breed or pure breed.

The theory of the pure line was developed in 1903 by the Danish botanist **Johannsen**.

Steps

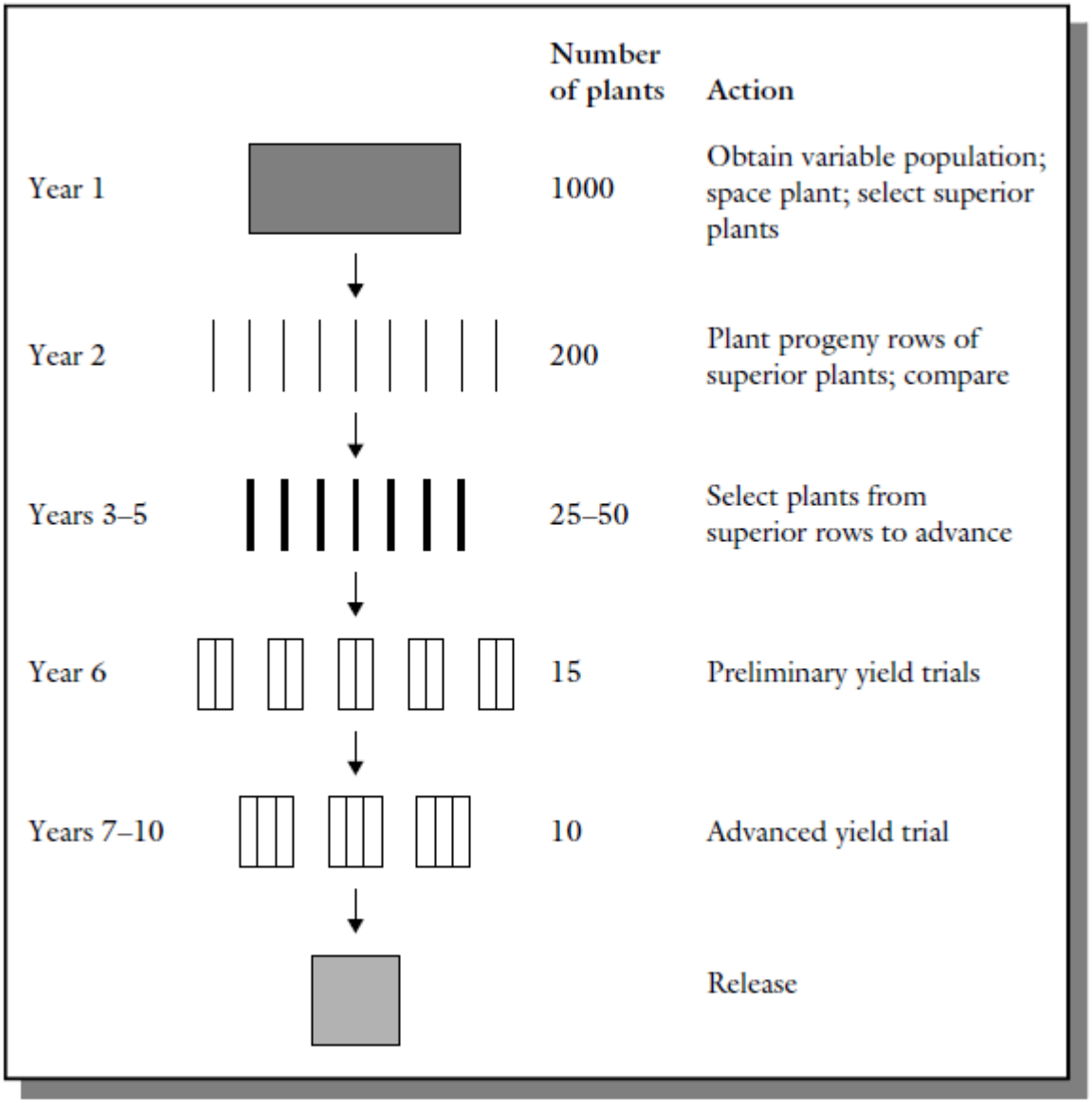

Figure 2. Generalized steps in breeding by pure-line selection.

Advantages

1. It is a rapid breeding method.
2. The method is inexpensive to conduct. The base population can be a landrace. The population size selected is variable and can be small or large, depending on the objective.
3. The cultivar developed by this method has great "eye appeal" (because of the high uniformity of, e.g., harvesting time, height, etc.).
4. It is applicable to improving traits of low heritability, because selection is based on progeny performance.
5. Mass selection may include some inferior pure lines. In pure line selection, only the best pure line is selected for maximum genetic advance.

Disadvantage

1. The purity of the cultivar may be altered through admixture, natural crossing with other cultivars, and mutations. Such off-type plants should be rogued out to maintain cultivar purity.
2. The cultivar has a narrow genetic base and, hence, is susceptible to devastation from adverse environmental factors because of uniform response.
3. A new genotype is not created. Rather, improvement is limited to the isolation of the most desirable or best genotype from a mixed population.
4. The method promotes genetic erosion because most superior pure lines are identified and multiplied to the exclusion of other genetic variants.
5. Progeny rows takes up more resources (time, space, funds).

CLONAL SELECTION

- Clone is the progeny of a single plant, produced by asexual reproduction
- Clonal selection is the selection of the most desirable members of a clone for continued vegetative propagation rather than for sexual reproduction.
- The members of a clone keep up genetic constancy.
- So by clonal selection and continued vegetative propagation, the desirable qualities of plants can be maintained for long.

- All the members of a clone has identical genetic constitution.
- Clones may have hybrid vigour, and it is conserved through asexual reproduction.
- variations can occur in a clone by mutations, and occasional sexual reproduction.

Clonal selection has two primary goals – to maintain disease-free and genetically pure clones, and the development of new cultivars.

Purifying an infected cultivar

Clonal cultivars may become infected by pathogens, some of which may be systemic (e.g., viruses). Two general approaches may be used to purify a cultivar to restore it to its disease-free original genetic purity.

1 **Screening for disease-free material.** Plant materials may be visually inspected for the presence of pathogens. However, because some pathogens may be latent, a variety of serological and histological techniques are used to detect the presence of specific pathogens. Called indexing, these techniques can detect latent viruses (viral indexing) as well as other pathogens. A negative test may not always be proof of the absence of pathogens. It could be t the particular assay is not effective. The clean clonal material is then used as starting material for multiplication for propagation.

2 **Elimination of pathogen**. A positive test from indexing indicates the presence of a pathogen. Should this be the only source of planting material, the breeder has no choice but to eliminate the pathogen from the plant tissue by one of several methods.

(a) Tissue culture. Even when the pathogen is systemic, it is known that tissue from the terminal growing points is often pathogen-free. Tissue from these points may be ascetically removed and cultured under tissue culture conditions to produce disease-free plantlets. Through micropropagation, numerous disease- free plants can be obtained.

(b) Heat treatment. This may be short- or long duration. Short-duration heat treatment is administered to the plant material for about 30 minutes to 4 hours at 43–57 ^{o}C. This could be in the form of hot air treatment or by soaking the material in hot water. This works well for fungal, bacterial, and nematode infection. For viruses, a longer treatment of about several weeks (2–4 weeks) is used. Potted plants are held at 37 ^{o}C in a controlled environment for the duration of the treatment. Cuttings from the treated plants may be used as scions in grafts, or rooted into a seedling.

(c) Chemical treatment. This surface sterilization treatment is suitable for elimination of pathogens that are external to the plant material (e.g., in tubers).

(d) Use of apomictic seed. Viral infections are generally not transmitted through seed in cultivars that are capable of apomixis (e.g., citrus).

Clonal selection for cultivar development: This procedure is effective if variability exists in the natural clonal population.

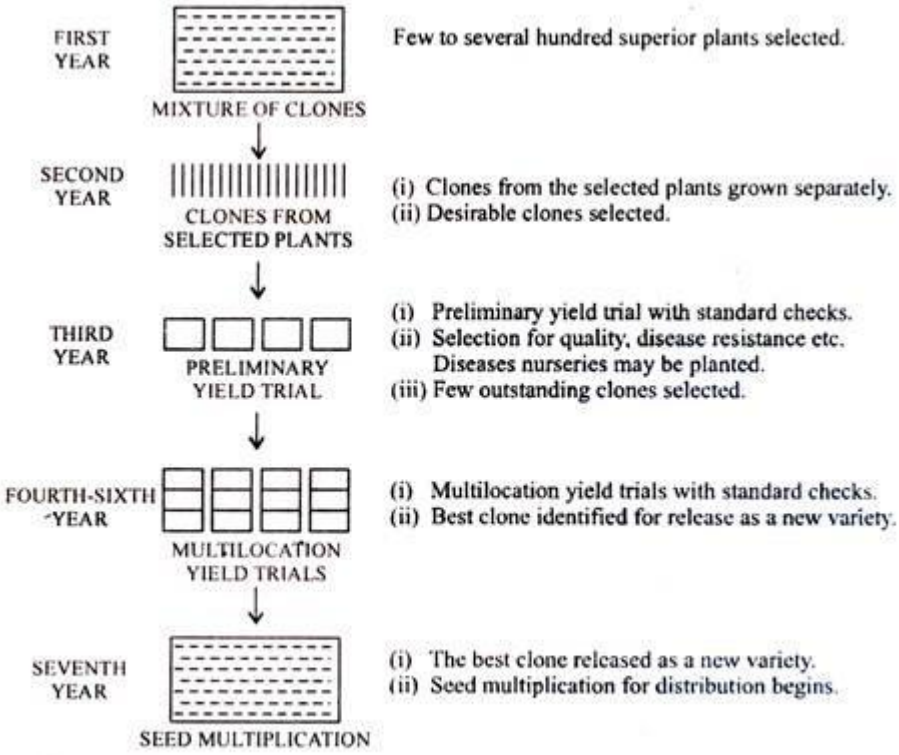

Fig. 5. Procedure of clonal selection in asexually propagated crops. This method of selection applies to a crop in which one generation does not take more than one year.

ADVANTAGES

1. Sterility is not a factor in clonal propagation because seed is not involved.
2. Because clonal plants are homogeneous, the commercial product is uniform.
3. Micropropagation can be used to rapidly multiply planting material.
4. Heterozygosity and heterosis are fixed in clonal populations.

DISADVANTAGES

1. Clonal propagules are often bulky to handle (e.g., stems, bulbs).
2. Clones are susceptible to devastation by an epidemic. Because all plants in the clonal population are identical, they are susceptible to the same strain of pathogen.
3. Clonal propagules are difficult to store for a long time because they are generally fresh and succulent materials.

INBREEDING DEPRESSION & HETEROSIS

Heterosis is defined as the superiority of F1 hybrid over both the parents in terms of yield and/or

some other characters. The term heterosis was first used by Shull in1914.

Types of heterosis

1. Average heterosis: It is the heterosis where F1 is superior to mid parent value. In other words superior to

average of two parents.

3. Heterobeltiosis: It is the superiority of F1 over the better parent.
4. Economic heterosis: It is the superiority of the F1 compared to the high yielding commercial variety in a particular crop.
5. Negative heterosis: It is the performance of F1 inferior to better parent / mid parent value. e.g. Duration

Genetic basis of heterosis

1. Dominant hypothesis

It is firstly proposed by **Davenport** in 1908. It was later on expanded by Bruce, Keeble and Pellow. According to this hypothesis at each locus the dominant allele has favourable effect, while the recessive allele has unfavourable effect. In heterozygous state, the deleterious effects of recessive alleles are masked by their dominant alleles. Inbreeding depression is produced by the harmful effects of recessive alleles, which become homozygous due to inbreeding.

2. Over dominance hypothesis

This hypothesis was independently proposed by **East and Shull in 1908**. It is also known as single gene heterosis or super dominance theory. According to this hypothesis, heterozygotes or at least some of the loci are superior to both the homozygotes. Thus heterozygote Aa would be superior to AA and aa.

Inbreeding Depression: Cross pollinated species and species reproducing asexually are highly heterozygous. When these species are subjected to selfing or inbreeding they show severe reduction in vigour and fertility. This phenomenon is known as inbreeding depression.