



# **HETEROISIS AND ESTIMATION OF HYBRID VIGOUR IN HYBRID SEED PRODUCTION**

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# Introduction

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**Heterosis :-** It describes the phenomenon in which hybrids formed between individuals of the same or closely related species are more robust or vigorous than their parents. Thus, the terms Heterosis and hybrid vigor are often used interchangeably.

**Heterosis or Hybrid Vigour Outbreeding:** “ Is the phenomenon that causes crossbred individuals to have an increased level of performance for certain traits over and above the average performance of their straight bred parents. “

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# Heterosis

- ❖ The term heterosis was first used by **Shull in 1914**.
- ❖ It is defined as the superiority of F1 hybrid over both the parents in terms of yield or some other characters.
- ❖ It may be **true heterosis or euheterosis** to distinguish it from luxuriance.
- ❖ Can be occurred in all types of species i.e. self-pollinating, **cross-pollinating** and vegetatively propagated.
- ❖ Koelreuter (1673) in tobacco, Darwin (1876) in several vegetable crops were studied about hybrid vigor.
- ❖ But our present knowledge on heterosis comes from the work on **maize**.

# INBREEDING DEPRESSION

- ❖ Cross pollinated species & 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**.

## Inbreeding

- ❖ It is mating between individuals related by descent or having common ancestry. (Brother- Sister mating or sib mating). The highest degree of inbreeding is obtained by selfing.

# Types of heterosis/ Estimation of heterosis

**1. Average heterosis or Relative heterosis:** It is the heterosis where F1 is superior to mid parent value. In other words superior to average of two parents.

$$\text{Average heterosis} = \frac{\overline{F1} - \overline{MP}}{\overline{MP}} \times 100$$

Where,  $\overline{F1}$  = Mean of hybrid,  $\overline{MP}$  = Mid parental value

This type of heterosis is of no use in agriculture since the superiority is below the better parent value.

**2.Heterobeltiosis:** Superiority of F1 over the better parent.

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$$\text{Heterobeltiosis} = \frac{\overline{F1} - \overline{BP}}{\overline{BP}} \times 100$$

Where,  $\overline{BP}$  = Mean of better parent

**3.Economic or useful heterosis:** Superiority of the F1 compared to the high yielding commercial variety in a particular crop.

$$\text{Economic heterosis} = \frac{\overline{F1} - \overline{CV}}{\overline{CV}} \times 100$$

Where,  $\overline{CV}$  = Mean of commercial variety

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**4. Standard heterosis:** Sometime heterosis worked out over the standard commercial hybrid.

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$$\text{Standard heterosis} = \frac{\overline{F1} - \overline{SH}}{\overline{SH}} \times 100$$

Where,  $\overline{SH}$  = Mean value of standard (local commercial) hybrid

**5. Negative heterosis:** Performance of F1 inferior to better parent / mid parent value. – e.g. Duration (earliness), height in cereals, micronaire value in cotton, and toxic substances like neurotoxin in *Lathyrus sativus*.

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# Luxuriance vs Heterosis

- Luxuriance is the increased vigour and size of interspecific hybrid.
- The principal difference between heterosis and luxuriance lies in the reproductive ability of the hybrid.
- Heterosis is accompanied with an increased fertility, while luxuriance is expressed by interspecific hybrid. That are generally sterile or poorly fertile.

# **Manifestation of heterosis May be in the following form.**

1. Increased yield.
2. Increased reproductive ability.
3. Increase in size and vigour.
4. Better quality
5. Greater adaptability.
6. Earlier flowering and maturity
7. Greater resistant to disease and pest
8. Faster growth rate
9. Increase in the number of a plant part

# Genetic basis of heterosis and inbreeding depression

There are three main theories of heterosis and inbreeding depression.

1. Dominant hypothesis
2. Over dominance hypothesis.
3. Epistasis hypothesis.

# Fixation of heterosis

- 1. Asexual reproduction:** easily conserved in vegetatively propagated crops.
- 2. Apomixis:** Seeds develop without fertilization. Apomictic seeds generally develop from maternal diploid cells and hence are identical to mother plants. Citrus, blackberry, many flowering plants, Hieracium (Hawck weed) are the examples where heterosis can be fixed by apomixis.
- 3. Balance Lethal System:** Homozygotes are lethal and hence die, only heterozygotes survive. E.g. Evening primrose (*Oenothera* spp.), BLS developed due to complex translocation.
- 4. Polyploidy:** By chromosome doubling or polyploidy, especially interspecific and intergeneric hybrid. E.g. wheat-rye cross

# Commercial Exploitation

- ❖ Degree of heterosis is considerably high in production of Hybrid and Synthetic Variety from Cross Pollinated to Often Cross pollinated Crop species.
- ❖ It can also be used in some self pollinated variety but Chief difficulty in commercial Exploitation of Heterosis in production of commercial quantity of Hybrid seed.
- ❖ Cross Pollinated Crops:- Maize, Pearl millet, Sorghum, Cotton, Onion, Sunflower, Alfalfa, etc.
- ❖ Self Pollinated Crops:- Rice, Wheat, etc.
- ❖ Vegetable Crops:- Tomato, Chillies, etc.

# Types of crosses


- ❖ Hybrid : First generation from a cross between two pure lines, inbreds, open-pollinated varieties, clones or other population that are genetically dissimilar
- ❖ Single cross :  $(A \times B)$
- ❖ Double cross :  $(A \times B) \times (C \times D)$
- ❖ Three way cross :  $(A \times B) \times Z$
- ❖ Top cross : Inbred  $\times$  open pollinated variety
- ❖ Polycross : Open pollination in isolation

# **Procedure for development of inbred lines and their evaluation:**

- ❖ Development of inbred lines: Inbred lines are developed by continuous self fertilization of a cross-pollinated species. Inbreeding of an OPV leads to many deficiencies like loss of vigour, reduction plant height, plants become susceptible to lodging, insects and pests and many other undesirable characters appear.

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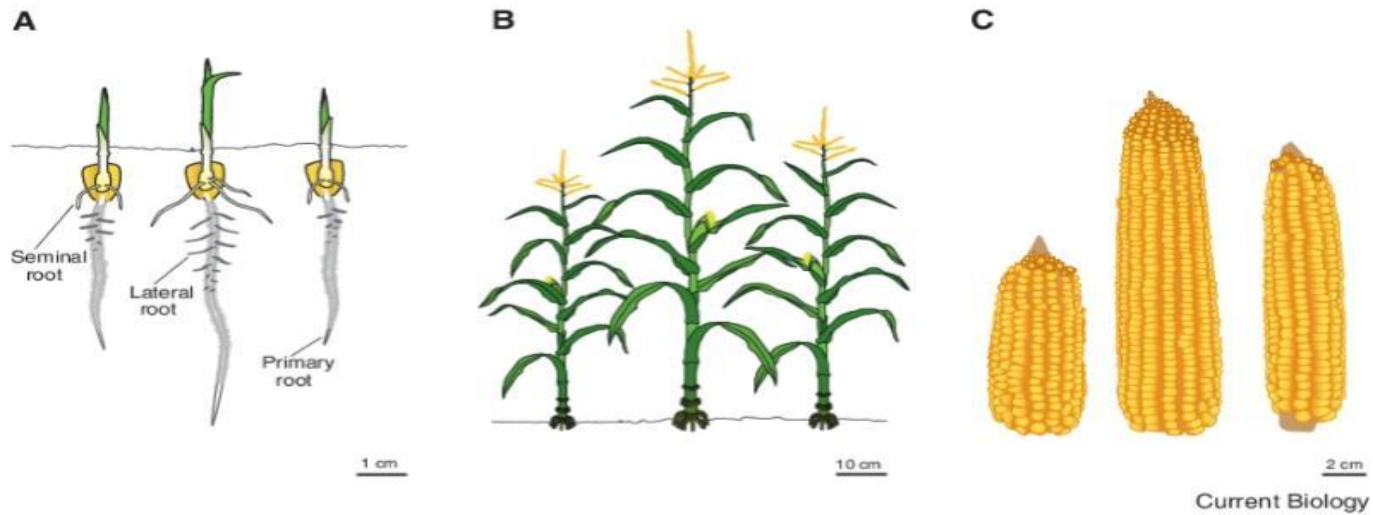
## Cont....

- ❖ After each selfing desirable plants are selected and self pollinated or sib pollinated. Usually it takes 6-7 generations to attain near homozygosity. An inbred line can be maintained by selfing or sibbing. The purpose of inbreeding is to fix the desirable characters in homozygous condition in order to maintain them without any genetic change.
  - ❖ The original selfed plants is generally referred as  $S_0$  plant and the first selfed progeny as  $S_1$  second selfed progeny as  $S_2$  as so on. The technique of inbreeding requires careful attention to prevent natural crossing.
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# Evaluation of inbred lines:

- ❖ After an inbred line is developed, it is crossed with other inbreds and its productiveness in single and double cross combination is evaluated. The ability of an inbred to transmit desirable performance to its hybrid progenies is referred as its combining ability.
- ❖ GCA : The average performance of an inbred line in a series of crosses with other inbred lines is known as GCA.
- ❖ SCA : The excessive performance of a cross over and above the expected performance based on GCA of the parents is known as specific combining ability
- ❖ Thus GCA is the characteristic of parents and SCA is characteristic of crosses or hybrids. The inbreds are evaluated in following way.



**Figure 1. The manifestation of heterosis with respect to different phenotypic traits of maize.**

# Phenotypic Evaluation

- ❖ It is based on phenotypic performance of inbreds themselves. It is effective for characters, which are highly heritable i.e. high GCA. Poorly performing inbreds are rejected. The performance of inbreds is tested in replicated yield trials and the inbreds showing poor performance are discarded.

# Top Cross Test

- ❖ The inbreds, which are selected on phenotypic evaluation, are crossed to a tester with wide genetic population, eg. an OPV, a synthetic variety or a double cross.
- ❖ A simple way of producing top cross seed in maize is to plant alternate rows of the tester and the inbred line and the inbred line has to be detasselled.
- ❖ The seed from the inbreds is harvested and it represents the top cross seed. The performance of top cross progeny is evaluated in replicated yield trials preferably over locations and years.
- ❖ Based on the top cross test about 50% of the inbred are eliminated. This reduces the number of inbreds to manageable size for next step. Top cross performance provides the reliable estimate of GCA.

# Single Cross Evaluation

- ▶ Outstanding single cross combinations can be identified only by testing the performance of single cross. The remaining inbred lines after top cross test are generally crossed in diallel or line x tester mating design to test for SCA.
- ❖ Number of single crosses with reciprocals =  $n(n-1)$ ,
- ❖ Number of single crosses without reciprocals =  $n(n-1)/2$

