Heterosis and Inbreeding Depression

***Kana Ram Kumawat, Ravi Kumawat and Madhu Choudhary**
Department of Plant Breeding and Genetics, S.K.N. Agriculture University
Jobner-303329, Jaipur, Rajasthan, India
*Email: kanaramkumawat8@gmail.com

Heterosis

Heterosis is defined as the superiority of F_1 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 F_1 is superior to mid parent value. In other words superior to average of two parents. It may be estimated using following formula:

$$\text{Average Heterosis} = \frac{(\overline{F1} - \overline{MP})}{\overline{MP}} \times 100$$

Where,

$\overline{F1}$= Mean of hybrid

$\overline{MP}$= Mid parent value = $\frac{(P1+P2)}{2}$

Where,

P1= Parent 1

P2= Parent 2

2. Heterobeltiosis

It is the superiority of F_1 over the better parent. It may be estimated using following formula:

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

Where,

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

3. Economic heterosis

It is the superiority of the F_1 compared to the high yielding commercial variety in a particular crop. It may be estimated using following formula:

$$\text{Economic Heterosis} = \frac{(\overline{F1} - \overline{CV})}{\overline{CV}} \times 100$$

Where,

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

4. Negative heterosis

It is the performance of F_1 inferior to better parent / mid parent value. e.g. Duration

Manifestation of heterosis may be in the following form:

- Increased yield.
- Increased reproductive ability.
- Increase in size and vigour.
- Better quality

- Greater adaptability.

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.

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.

Effects of inbreeding

1. Appearance of lethal and sub lethal alleles: Chlorophyll deficiency, rootless seedlings and other malformations.
2. Reduction in vigour: Appearance of dwarf plants.
3. Reduction in reproductive ability: Less seed set, sterility
4. Segregation of population in distinct lines.
5. Increase in homozygosity
6. Reduction in yield.

Degrees of inbreeding depression

Various plant species exhibit different degrees of inbreeding depression. The depression may be from very high to nil. Based on degree of depression, the plant species can be grouped into four broad categories.

1. High inbreeding depression

Inbreeding leads to severe depression and exhibit lethal effects. After 3 or 4 generations of selfing it is hard to maintain lines. E.g. Lucerne, Carrot.

2. Moderate inbreeding depression

Though lethal effects are there, lines can be separated and maintained. E.g. Maize, Jowar, Bajra.

3. Low inbreeding depression

Only a small degree of inbreeding depression is observed. E.g. Cucurbits, Sunflower.

4. No inbreeding depression

The self-pollinated crops do not show inbreeding depression.

References (if any)

1. Singh, B.D. (2015) Plant Breeding Principles and Methods. 10th Revised Edition, Kalyani Publishers, New Delhi.
2. Internet (IASRI)

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