Experiment: Estimation of heterosis, inbreeding depression and heritability

Aim: To provide knowledge for estimating heterosis, inbreeding depression and heritability and about their utilization in crop improvement.

Heterosis

The term heterosis was first used by Shull in 1914. Heterosis may be defined as the superiority of an F, hybrid over both its parents in terms of yield or some other character. Generally, heterosis is manifested as an increase in vigour, size, growth rate, yield or some other characteristic. But in some cases, the hybrid may be inferior to the weaker parent. This is also regarded as heterosis.

Estimation of heterosis

Heterosis is estimated in three ways,viz (1) over mid parent (2)over better parent (3) over commercial cultivar or hybrid.Thus on the basis of estimation,heterosis is of three types as given below

1) Average Heterosis; when the heterosis is estimated over mid parent, i.e., mean value or average value of the two parents, it is known as average heterosis, which is estimated as follows;

Average heterosis= [(F1-MP)/MP] X 100

Where F1 is the mean value of F1 and MP is the mean value of two parents involved in the cross.

2) Heterobeltosis; when the heterosis is estimated over superior or better parent. it is referred to as heterobeltiosis.It is worked out as follows:

Heterobeltiosis= [(F1-BP)/BP] X 100

Where BP is the mean value(over replications) of the better parents of the particular cross.

3) Useful Heterosis; The term useful heterosis was used by Meredith and Bridge in 1972.It refers to the superiority of F1 over the standard commercial check variety ,it is also called as economic heterosis.This type of heterosis is of direct practical value in plant breeding.It is estimated as follows.

Useful heterosis= [(F1-CC)/CC] X 100

Where CC is the mean value(over replications) of the local commercial cultivar.

Sometimes heterosis is worked out over the standard commercial hybrid .it is estimated in those crops where hybrids are already available for comparison.This type of heterosis is known as standard heterosis.This is also of direct practical importance in plant breeding. It is estimated as follows.

Standard heterosis= [(F1-SH)/SH] X 100

Where SH is the mean value(over replications) of the standard(local commercial) hybrid.

Inbreeding Depression

Inbreeding Depression Inbreeding or consanguineous mating is mating between individuals related by descent or ancestry. When the individuals are closely related, e.g., in brother-sister mating or sib mating, the degree of inbreeding is high. The highest degree of inbreeding is achieved by selfing. The chief effect of inbreeding is an increase in homozygosity in the progeny, which is proportionate to the degree of inbreeding. The degree of inbreeding of an individual is expressed as inbreeding coefficient (F). The degree inbreeding is proportional to degree of homozygosity.

Inbreeding depression may be defined as the reduction or loss in vigour and fertility as a result of inbreeding.

Inbreeding depression = F1-F2 / F1 x 100

Effects of inbreeding

Inbreeding is accompanied with a reduction in vigour and reproductive capacity i.e. fertility. There is a general reduction in the size of various plant parts and in yield. In many species, harmful recessive alleles appear after selfing; plants or lines carrying them usually do not survive. The different effects of inbreeding are :

- Appearance of Lethal and SublethalAlleles : IB results in appearance of lethal; sublethal and subvital characters. Eg : Chlorophyll deficiencies, rootless seedlings, flower deformities – They do not survive, they lost in population.
- Reduction in vigour : General reduction in vigour size of various plant parts.
- Reduction in Reproductive ability : Reproductive ability of population decreases rapidly. Many lines reproduce purely that they can’t be maintained.
- Separation of the population into distinct lines : population rapidly separates into distinct lines i.e. due to increase in homozygosity. This leads to random fixation of alleles in different lines. Therefore lines differ in genotype and phenotype. It leads to increase in the variance of the population.
- Increase in homozygosity: Each line becomes homozygous. Therefore, variation within a line decreases rapidly. After 7-8 generations of selfing the line becomes more than 99% homozygous. These are the inbreds. These have to be maintained by selfing.
- Reduction in yield : IB leads to loss in yield. The inbreds that survive and maintained have much less yield than the open pollinated variety from which they have been developed.

Heritability

The ratio of genetic variance to the total variance i.e phenotypic variance is known as heritability. The extent of contribution of genotype to the phenotypic variation for a trait in a population is ordinarily expressed as the ratio of genetic variance to the total variance. i.e Phenotypic variance. Thus heritability denotes the proportion of phenotypic variance that is due to genotype. Heritability may be represented as follows:

Heritability (H) = VG/VP or VG/VG+VE

Where VG, VP and VE are the genotypic phenotypic and environmental component of variance respectively.

Types of heritability:

There are two types of heritability viz
1) Broad sense heritability and 2) Narrow sense heritability.

1) Broad sense heritability:

It is the ratio of genotypic variance VG to the total phenotypic variance (VP)

$$h^2 \text{ (bs)} = VG/VP \text{ or } VG/VG+VE$$

Broad sense heritability estimates are valid for homozygous lines, or populations. However, when we are dealing with segregating generation. The genetic variance consists of additive and dominance component. Since in self-pollinated crop we develop homozygous lines, the dominance component will not contribute to the phenotype of homozygous lines derived from a population.

Consequently in such cases only the additive component of variation is important. Therefore, for segregating generation broad sense heritability is less important but narrow sense heritability is more important because it cannot realize fully in the offspring.

2) Narrow sense heritability:

It is the ratio of additive genetic variance VA to the total phenotypic variance VP (smith, 1952)

$$h^2 \text{ (ns)} = VA/VP = VA/VG + VE$$

Narrow sense heritability is reliable measures, as it is based on breeding value. The magnitude of narrow sense heritability is always less than or equal to broad sense heritability. Variation in the quantitative traits occurs due to their degree of heritability. **Robinson (1966)** grouped the heritability estimates in crop plants into three categories:

- Low heritability – 5 to 10 percent.
- Moderate heritability – 10 to 30 percent.
- Higher heritability – 30 to 60 percent.

This classification represents average of heritability estimates over various crop plants, types of population, procedures of determination and environments encountered in different locations and years. If heritability is 100% the phenotypic performance would be a perfect indication of genotypic value. However, in this hypothetical situation, the heritability values in it provide no indication of the amount of genetic progress that would result from selecting the best individuals.

Uses of heritability:

- It is useful in predicting the effectiveness of selection.
- It is also helpful for deciding breeding methods to be followed for effective selection. It gives us an idea about the response of various characters to selection pressure.
- It is useful in predicting the performance under different degree of intensity of selection.
- It helps for construction of selection index.

Estimates of heritability serve as a useful guide to the breeder, to appreciate the proportion of variation that is due to genotypic or additive effects.