Combining Ability define by Gene Action

- Combining ability is a very important concept in plant breeding and it can be used to compare and investigate how two inbred lines can be combined together to produce a productive hybrid or to breed new inbred lines.

- Selection and development of parental lines or inbred with strong combining ability is one of the most important breeding objectives.

- In maize breeding, Sprague and Tatum (1942)
- Two categories of combining ability,
  General combining ability (GCA)
  Special combining ability (SCA).

- The GCA for an inbred line or a cultivar can be evaluated by the average performance of yield or other economic traits in a set of hybrid combinations.

- The SCA for a cross combination can be evaluated by the deviation in its performance from the value expected from the GCA of its two parental lines.

- The total variation among crosses can be partitioned into two components ascribable to GCA and SCA.

- The mean performance of a cross (X_{AB}) between two inbred lines A and B can be represented as
  $X_{AB} = GCA_A + GCA_B + SCA_{AB}$

  The GCA_A and GCA_B are the GCA of the parents A and B, respectively.

- The cross of A X B is expected to have a performance equal to the sum ($GCA_A + GCA_B$) of the GCA of their parents.

- The actual performance of the cross, however, may be different from the expectation by an amount equivalent to the SCA.

- Sprague and Tatum (1942) interpreted these combining abilities in terms of type of gene action.

The differences due to GCA of lines are the results of additive genetic variance and additive by additive interaction
SCA is a reflection of non-additive genetic variances.

Combining ability analysis:
- Diallel
- Partial diallel
- Line X Tester

Concept of Gene Action with effect on combining ability

- In plant breeding, gene action is usually measured in terms. of components of genetic variance or combing ability variances and effects.

- Use of combining ability as a measure of gene action was suggested by Sprague and Tatum (1942) in maize.

- Combining ability analysis is a very systematic and efficient method to understand the type of gene action involved in the inheritance of a quantitative character.

- Analysis of combining ability estimates require half-sib and full-sib progenies.

- Plants of a cross between two known parents are known as full-sibs and plants of two or more crosses in which one parent is common parent known as half-sibs

- The variation among the half-sib families in a diallel cross is an estimate of gca or additive genetic variance.

- The full-sib families provide an estimate of sca or non-additive gene action.
- Covariance between relatives is also used to estimate genetic variances especially additive genetic variance. Three types of relative, viz., parent offspring, full-sibs and half-sibs are commonly used for this purpose.

- Additive genetic variance can be estimated from any of the following covariance's (Falconer, 1989).
  Covariance between parent and offspring = 1/2 VA
  Covariance among full-sibs = 1/2 VA + 1/4 VD
  Covariance among half-sibs = 1/4 VA

  where, VA = additive variance and VD = dominance variance

- This method is more common in animal breeding than in plant breeding.

- Regression coefficient of parent on offspring can be worked out from the covariance between parent and offspring. Heritability can also be worked out which is expressed as twice the regression coefficient of parent on offspring

- The study of gene action involves four important steps, viz., (1) selection of genotypes, (2) making crosses, (3) evaluation of material, and (4) analysis of data.

- Non-additive gene action is a prerequisite for launching a heterosis breeding programmes. If there is preponderance of non-additive gene action, the breeding .objective should be towards development of hybrids for commercial purpose.

- If both additive and non-additive gene actions are of equal magnitude, population improvement programme should be taken up for the development of superior lines with several desirable genes

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- In cross-pollinated species, various types of selections are used depending upon the relative importance of gene action.

- Recurrent selection for General combining ability is effective with additive gene effects; and reciprocal recurrent selection utilizes both additive and non-additive gene effects.

- Additive genetic is required for the estimation of heritability in narrow sense and response to selection is directly proportional to narrow sense heritability.
- ***TABLE: Breeding Procedures in Relation to Gene Action***

Type of Gene Action	***Breeding Procedure to be adopted***	***Possible outcome***
(a) Self-pollinated Species		
1. Additive	Pure line selection	Pure line variety
	Mass selection	Mass selected variety
	Progeny selection	New variety
	Hybridization and selection	Superior segregant or new variety
2. Non-Additive	Heterosis breeding	Hybrid variety
(b) Cross-pollinated species		
1. Additive	Recurrent selection for gca	Population improvement
	Synthetic breeding	Synthetic variety
	Composite breeding	Composite variety
2. Non-Additive	Heterosis breeding	Hybrid variety
	Recurrent selection for sca	Population improvement
3. Both additive and Non-additive	Reciprocal Recurrent	Population improvement selection

- Additive genetic is required for the estimation of heritability in narrow sense and response to selection is directly proportional to narrow sense heritability.

- The additive and dominance variances are also required for the estimation of degree of dominance and various genetic ratios.

ACTION IN BREEDING POPULATIONS

- In intermating populations, additive genetic variance is never exhausted due to self conversion of non-additive genetic variance into additive one.

- This type of conversion takes place due to fixation of heterozygotes into homozygotes

- In self-pollinated species, additive genetic variances is in abundance in segregating generation and mixtures of several different pure lines.

- Thus, additive genetic variance is of universal occurrence in plant breeding populations.

- Non-additive variance also exists, but generally smaller in magnitude than additive one.

- In natural plant populations,

  Additive genetic variance > dominance variance > Epistatic variance

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