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Mini Review Article

COMBINING ABILITY AND HETEROSIS STUDIES IN UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.)

***KHALID MN, AMJAD I**

Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan
**Correspondence author email address: noumankhalidpbg@gmail.com*

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Abstract: *Cotton is Pakistan's most important fiber crop and the country's economic lifeline. It is an important agricultural commodity in Pakistan, providing a source of income for farmers as well as raw materials for the textile industry. Farmers and the textile industry are also looking for ways to improve fiber quality and increase seed cotton production. Given the low yield pattern and growing demand of the textile industry, the breeding programs need to be planned as a breeder to increase cotton production in the region. Knowledge about inheritance mechanisms, heterosis, and the ability of different characters to combine is crucial for this reason. The most challenging task for plant breeders in any hybridization program is finding the best combination of two (or more) parental genotypes to optimize variation within similar breeding populations, and therefore the possibility of detecting superior transgressive segregants in the segregating populations. After its introduction in 1942, the combining capacity has been commonly used in plant breeding to evaluate the performances of lines in hybrid combinations. Heterosis (also known as hybrid vigor) is a natural occurrence in which hybrid offspring of genetically diverse individuals have enhanced physical and functional characteristics compared to their ancestors. For nearly a century, heterosis has been increasingly used in crop development with the aim of producing more vigorous, higher yielding, and better performing cultivars. A short analysis of previous studies on cotton combining ability and heterotic effect estimation has been provided in this paper. This will strengthen our existing understanding of plant breeding's combining ability and heterosis, as well as recent research advances in this field.*

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Introduction

Many crop breeding programs are concerned with selecting the best producing lines (for market release) as well as lines that can be used as parents in potential crosses. Following statistical study, the best performing lines for required characteristics are chosen by conducting multi-environment trials. Genetic and environmental impacts may be distinguished using a well-designed trial and statistical study. Line into tester, North Carolina (NC) designs I, II, and III, and diallel are all examples of mating designs that can be used to pick parental lines. The genetic influences of a line may be partitioned into additive and non-additive components by using those designs. Review of previous literature allows scientists to build up a general thought regarding the conduct of experiments. Similarities and contrasts from prior reviews force analyst to discover the reasons, giving clarification and support about understandings and disagreements. A brief review of previous work on combining ability and heterotic effect estimation of cotton is given below.

Role of combining ability in crop breeding

Crossing a line to many others gives the line's mean performance across all its crosses. Combining ability or productivity in crosses is described as the ability of cultivars or parents to combine during hybridization process to transfer favorable genes or characters to their progenies. In another definition, in any definite mating design, combining ability is an estimate of genotypes' value based on their offspring results (Fasahat et al., 2016). It can scarcely be envisaged dependent solely on parental phenotype, and is therefore calculated by progeny examination. When parental plants produce powerful offspring, good combinability is said to exist. The GCA is a main effect, whereas the SCA is an interaction effect, from a statistical perspective (Pushpam et al., 2015). According to Sprague and Tatum, GCA is caused by the activity of genes with mostly additive effects and additive additive interactions. If epistasis is present, unique combining ability is considered an indicator of loci with dominance variation (non-additive effects) and all three forms of epistatic interaction components. Additive dominance and dominance dominance relationships are examples of these forms of interactions (Hosseini, 2014).Studies on combining ability have been performed in a number of crops, including cereals, fiber, roots, and legumes, suggesting that it is an effective method in plant breeding(Muhammad et al., 2014).

Combining ability of different agronomic traits and yield components and fiber quality traits in cotton

Sathya & Jebaraj, (2015) conducted an experiment with four genotypes NIAB-KIRN, PB-76 FH-942 and PB-896 to understand the processes of genetic control which contributes to raw cotton yield. They found that the genotype NIAB-KIRN was a good general combiner since it showed additive genetic effects for seeds per boll. PB-896xPB-76 recorded significant specific combining ability (SCA) for number of seed/boll and seed cotton yield (SCY). PB-896 × FH-942 showed substantially good heterosis for fiber characteristics together with the seed cotton yield (SCY). Ali et al., (2017) measured combining ability besides heterosis of parental genotypes in two cotton diallel crosses. Their analysis showed the substantial positive values of the general combing ability (GCA) for the varieties “Beli Iskar” (1st diallel cross) and “Natalia” (2nd diallel cross) which led to high yield/plant. SCA effects were found to be significant and positive in both diallel crosses. Heterosis was also observed in both the crosses which reached 20% and 17.7% respectively. Variance of the GCA and SCA presented the predominance of dominant gene prevalence that was vital in relation to productivity Geng et al., (2016) evaluated fifty hybrids for the assessment of GCA, SCA and heterotic effects. They identified three parental genotype GSHV-177, BGDS-1055 and TSH-321 having high GCA variance for fiber quality and yield related parameters. The hybrid cross CCH-15-1 × GSHV-177 and TSH-321 x African 1-2 were identified as good specific combiner as they demonstrated high SCA values for SCY/plant. Their results indicated that the hybrid combination showing high specific combining ability should be exploited in heterosis breeding for enhancement of cotton genotypes. Sekmen et al., (2014) studied GCA and SCA effects of parents and crosses, respectively. RCB design with two replications was used. Height of plant, vegetative branches, boll number per plant, boll weight, lint percentage, lint index and seed index mean square were found to be highly significant. The parental genotypes MNH 998, FH-114, NS-131 were proved to be best general combiner. The appropriate progeny selection method should be adopted for these cultivars. The hybrid combination such as FH 2015 x MS 71, CRS 2007 x NS- 131, MNH-998 x IUB-65, FH-2015 x FH-114 and CRS-200 x FH-114 showed higher SCA effects. Hence, these crosses should be exploited in the heterosis breeding for the crop improvement.

Heterotic studies of different agronomic traits and yield components and fiber quality traits in cotton

Heterosis, also known as hybrid vigor, refers to the phenomenon that the heterozygous hybrids show superior performance over their parents. This phenomenon is quite beneficial for plants on reproduction and adaptation to environmental changes (Saleem et al., 2014). It is also of great importance on agriculture production, as hybrid breeding has been proved to be one of the most efficient ways to increase grain yield of various crops. Since heterosis was found in plants more than a century ago, it has attracted many scientific researchers’ attention, resulting in many classical experiments, hypotheses and discussions (Thi & Lee, 2017). Ranganatha et al., (2013) undertaken an investigation to find heterosis, general and specific combining ability in diallel fashion. Hybrid TCH1819 x TCB37 was found to be highest in yield. The hybrid cross TCH1819 x TCB37 showed highest commercial and heterobeltiosis of 90.6% and 193.69%, respectively. An equivalent significance of additive and dominant genetic factors for fiber quality traits was found in all the crosses. Solanki et al., (2014) estimated the type and magnitude of heterosis for different yield attributes in cotton. Hetrobeltiosis and relative heterosis significance was witnessed for seed cotton yield (SCY) per plant. Since it logged desirable heterobeltiosis for GJHV 500 x GTHV 7/70, G. Cot 18 x GSHV 173, G. Cot 12 x GSHV 173 and GJHV 536 x GTHV 7/70. These crosses also showed positive and maximum heterosis for height of plant, fruiting branches /plant along with boll weight.(Wu et al., 2004)found the combining ability and hybrid vigor of different lines using a diallel analysis. General combining ability (GCA) for weight of ball was non-significant. Good general combing ability was found significant in Chandi-95, IR-1524 and Shahbaz for seed cotton yield. These parental varieties can be utilized for selection of desirable plants. The hybrid combination Sindh-1 x Shahbaz, Sadori x Shahbaz, and Hardost x NIA ufaq exhibited significant SCA effects. IR-1524 x NIA-ufaq and Sadori x Shahbaz expressed higher heterotic valuse for seed cotton yield (SCY). Their conclusion emphasized the manipulation of heterosis in cotton. Ganapathy & Nadarajan, (2008) investigated different crosses having higher combining ability for yield affiliated traits. BBGH-77 x BBGH-1 cross displayed maximum heterotic effects for all the quality characters under evaluation as compared to the commercial variety. Analysis of variance indicated significant mean sum of squares for general combining ability and specific combining ability. Most of the traits revealed the preponderance of non-additive gene action.

Conclusion and future prospects

Despite the fact that plant breeding has made significant progress in crop development, it is critical that it proceed. Present breeding programs continue to develop through widely implemented breeding techniques. The combining ability analysis and heterosis may contribute greatly to this object. Combining abilities as a major analytical tool not only helps choosing desirable parents but also offers knowledge on the nature and significance of genetic background that affect quantitative characteristics. Despite the hope that the results of traditional breeding will continue to improve, new methods, such as QTL mapping, will be required to boost the chance of success. Additional improvements in marker technologies will minimize QTL mapping costs and make them more applicable for combining ability programs.

Conflict of interest

The authors declared absence of conflict of interest.

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