Research Article

Yield and Fiber Quality Traits Study in Upland Cotton (*Gossypium hirsutum* L.) Using Line × Tester Analysis

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Abstract | Cotton provides a living for 25 million Pakistanis and a major raw material for textile sector which accounts for 75 % of the fiber mix in textile industry products. Fiber yield and quality are very crucial parameters for a cotton breeding program. Five varieties namely FH-414, FH-415, FH-490, FH-492, and FH-ANMOL were used as lines and crossed with three testers namely NIAB- SANAM, CIM-602, and EYE-111 during the year 2019-20. Data was recorded for plant height (PH), number of monopodial branches (MB), number of sympodial branches (SB), number of bolls/plant (BP), boll weight (BW), ginning out turn (GOT), fiber fineness (FF), fiber length (FL), fiber strength (FS) and seed cotton yield (SCY). FH-414 proved to have very good GCA for BW and FL. FH-415 showed good GCA for FL and monopodial branches. Similarly, FH-490 for GOT and FF, FH-492 for SB, BW, BP and SCY. FH-ANMOL proved best combiner for, SB, BP, and SCY. CIM-602 was good combiner for BP, SB, BW, GOT, FS and SCY. EYE-111 found to be a good combiner for BP, GOT, and FF. The hybrid FH-415 × CIM-602 showed good SCA for MB and FH-ANMOL × EYE-111 for SB. For bolls/plant (BP) FH-492 × EYE-111, for boll weight (BW) FH-ANMOL × EYE-111, for GOT FH-415 × EYE-111, for fiber fineness (FF) FH-414 × EYE-111, for fiber length (FL) FH-92 × NIAB-SANAM, for fiber strength (FS) FH-414 × CIM-602 and for seed cotton yield (SCY) FH-492 × EYE-111 proved to be very good hybrid. These results indicated that these lines and testers have desired variability to exploit in the traits which were investigated.

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Introduction

Dealing with the cotton needs of Pakistan's textile industry the demand for good quality fiber has increased (Felker *et al.*, 2001; Chen *et al.*, 2009). According to an estimate by 2020, 20 million bales of cotton would be needed only for the textile industry in Pakistan. There is a need to focus on different fiber quality traits like length, strength, uniformity,and fiber fineness. It is very difficult to improve the fiber

quality trait, as it is controlled by multiple genes (Lacape *et al*., 2005; Meredith Jr, 2005; Zhang *et al*., 2013).

A major portion of cotton is grown by these four countries: India, China, USA, and Pakistan. 2/3 part of the world's cotton land is utilized by these countries (Dahab *et al*., 2013). Pakistan is the third major consumer of cotton while fourth-largest producer and the 7th largest cloth manufacturer in the World. 15% of Pakistan's agricultural area is under cotton cultivation. Mostly, it is grown in the Punjab and Sindh provinces of Pakistan having 79% and 20% share, respectively (Ali *et al*., 2019). Tremendous efforts and progress have been made to increase cotton production, currently estimating around 685 kg/ha (Anonymous, 2019-20). This is better than the world average yield which is 581 kg/ha, but it is much lower than its potential (Mansoor *et al*., 2020).

Accomplishment of breeding program is majorly dependent on selection of parents (Liu *et al*., 2020; Solongi *et al*., 2019; Vavdiya *et al*., 2019; Isong et al., 2019). Choice of competent parents leads to a successful breeding program and, thereafter, To improve the fiber quality, it is necessary to focus on different characters such as: staple length, fineness, FS uniformity and maturity also (Ali *et al*., 2008). (Bowman *et al*., 1996), decrease in the yield and other parameters like fiber quality is due to less genetic variations. Introduction of new cultivars with modified genetic base is very important step in plant breeding. The lower genetic base creates problem for researchers (Qin *et al*., 2008). Therefore, it is very important for a breeder to have knowledge about variations and inheritance of different traits. Different methods are used to create variation, out of which, one is line × tester analysis. Line × tester analysis provides a way to investigate different characters by detecting suitable parents and crosses (Kempthorne, 1957). Line × Tester analysis is also helpful to provide knowledge about GCA and SCA for the parents and crosses. The main objective of this research work is to asses the GCA and SCA effects of fiber quality and yield related traits among eightcotton genotypes of upland cotton (*Gossypium hirsutum* L.).

Materials and Methods

The experiment was conducted at the Cotton Research Station AARI, Faisalabad during 2020-21 in the field condtions. Sowing was done on the 2nd week of May. This material had diverse genetic back ground. The eight parents were crossed following the Line × Tester crssoing scheme for the estimation of heterosisand combining abilities for yield related and fiber quality traits. Five parents were used as female lines and other three parents were used as male testers. All the genotypes belonged to *Gossypium hirsutum* L. These eight genotypes were sown at optimum temperature 28°C in green house for suitable cotton germination. All genotypes were sown in pots, each containing 4 kg soil. 5 lines were crossed with three testers at the time of flowering. Eight parents along with fifteen crosses were field planted following three replications by using the randomized complete block design. Bed planting method was used in such a way that Plant × Plant and Row × Row distance followed 45 and 75cm, respectively. In each hole three seeds were sown and later on thinned after emergence.

Data recording

Data was recorded for different traits (PH, MB, SB, BP, BW, GOT, FF, FL, FS, SCY) by randomly selecting ten different cotton plants in a row for each trait and the average was estimated for statistical analysis. Plant height was recorded from first node to ceased apical bud in cm at the stage of ceased Plant growth. At every picking no. of bolls/plant were counted. After final picking no. of bolls at each picking were summed up and the average of no. of bolls/plant were estimated for each cultivar in one replication. Ten bolls were selected at random and weighed them separately. After that average weight of boll was estimated for each plant in a row in each replication. Clean sample of lint were collected from randomly selected bolls and fiber related traits were estimation with the help of high volume instrument (HVI) at Cotton Research Station AARI, Faisalabad.

Statistical analysis

Data from experiment were analyzed forn ANOVA given by (Steel *et al*., 1997). Traits that showed significant differences were further analyzed through for estimation of combining ability effects by Kempthorne (1957) and heterosis by Mather and Jinks (1982).

Results and Discussion

For hybrid development combining ability studies is a useful tool for parent lines selection. Eight parents

evaluated for their general combining abilities for different characters in cotton. The results indicated that parent line FH-414 was thebest general combiner for PH, BW and FL. FH-415 showed good general combining ability for MB and FL. FH-490 found to be a good combiner for BP, GOT, and FF. The parental line FH-492 found to be good combiner for PH, SB, BP, BW and SCY. FH-ANMOL proved to be a very good general combiner for PH, SB, and SCY. These results indicated that these five lines FH-414, FH-415, FH-490, FH-492 and FH-ANMOL have desired traits for a breeder to exploit variability in the traits which are investigated here.

Among testers the NIAB-SANAM proved a good general combiner for PH and BP. CIM-602 found to be good combiner for SB, BP, BW, GOT, FS and SCY. EYE-111 found to be a good combiner for PH, GOT, BP, and FF.

Parents which have good GCA for a specific trait are expected to be give good yield in cross combinations (Khan *et al*., 1991; Ayub *et al*., 1991) and this trend is found in present studies for example FH-414 and CIM-602 indicated good general combining ability for PH and produced desired hybrids i.e. FH-414 × CIM-602 etc.

For PH FH-414 from lines and CIM-602 from testers was good general combiner for PH so these parents are supposed to be used in future breeding programs. The crosses FH-492 × CIM-602, FH-414 × CIM-602 (-15.956), FH-490 × EYE-111, FH-ANMOL × EYE-111 and FH-415 × NIAB-SANAM proved to be very good hybrids for PH. Both type of gene actions i.e. additive and non-additive found to be important for plant height (Khan, 2013; Neelima *et al*., 2004; Iqbal *et al*., 2003).

For MB the non-additive gene action is more important than additive type. These findings were reported by (Iqbal *et al*., 2003; Neelima *et al*., 2004; Kansik and Kapoor, 2006). These branches give bushy look to the plants which result in slow boll formation.

For SB, thenon-additive gene action is important than additive. Ahmad *et al*. (2000) and Subhan *et al*. (2000), described that the gene action of non-additive type is more imperative for SB. Greater the SB, the greater will be the fruiting, because plant enters into the fruiting stage earlier.

The testers EYE-111 and CIM-602 indicated positive GCA values which shown that these testers are the best general combiner for BP. For this trait non-additive genes are more important than additive genes. The findings of present study relate to the previous findings of (Neelima *et al*., 2004; Khan *et al*., 1991; Iqbal *et al*., 2005; Hassan *et al*., 1999; Murtaza *et al*., 1995; Rauf *et al*., 2005).

For FF the gene action of non-additive types were more important which relate to the findings of Khan *et al*. (1991). FL was also controlled by non-additive gene actions which confirm the findings of Sarwar *et al*. (2011). FS is mostly reported to be controlled by gene action of non-additive type which was also confirmed in the previous studies, Karademir and Gencer (2010) and Ilyas *et al*. (2007). Fiber properties are very important in outcome of spinning process.

Parental lines were good general combiners for a specific trait expected to produce good cross combinations (Khan *et al*., 1991). In the present study critical comparison of cross combinations give some interesting information. Some crosses with one parent have good GCA value and other parent have low GCA value for a particular trait showed best combinations for that trait. For example, FH-492 and CIM-602 showed poor combining ability for PH but they produced best combination with high PH. FH-415 and NIAB-SANAM cross combination was very good combination but this cross produced from parents with poor combining ability. FH-490 showed good general combining ability for GOT and NIAB-SANAM showed poor combining ability for this trait but their cross combination proved good for GOT. So it is cleared from these results that parents with poor combining abilities can produce desired hybrids for a specific trait which confirms the findings of Azhar and Rana (1993).

Parental lines play an important role towards variation in MB, number of sympodial branches, number of bolls/plant, boll weight, GOT, FL, FF and SCY which revealed maternal effects for these characters. Testers play an important role towards variation in PH, and FS. The contribution of both parents was found to be greater for variation in PH, MB, number of bolls/plant, boll weight, GOT, FF, FL and FS which relate to the results of Kannababu and Kavrkaratharaju (2000).

Conclusions and Recommendations

The dominant gene action is prevailing in all the genetypes and non-additive gene action is dominant over additive gene action therefore, heterosis breeding will be more fruitful than varietal development. Moreover, delayed selection must be favourable in breeding populations because non-additive genes have low heritability. The parents which have good general combining ability for specific traits and the cross combinations with good specific combining ability are supposed to be utilized in future breeding programs for the improvement of these traits in cotton.

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Novelty Statement

The parents with good GCA for specific traits and the cross combinations with good SCA are important source to be utilized in future Cotton breeding programs for the improvement of yield and quality traits in cotton. These parents are yet not been reported for this kind of study before.

Author's Contribution

YA and GM: Performed the experiment and collected data under the supervison of KK and GS.
MA: Managed overall crop and gave technical input.
KK and ZAZ: Helped in paper write up.
GM: performed the statistical analysis.
YA: Collected the literature.
GS and ZAZ: Supervised the study.

Conflict of interest

The authors have declared no conflict of interest.

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