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Development of superior f1 hybrids: design-ii analysis for estimating combining ability of fibre and earliness in upland cotton

[1]Abdul Wahid Baloch; [1]Muhammad Ejaz; [3]Imran Ahmad; [5]Humaira wasila; [2]Muhammad Jurial Baloch; [1]Ghulam Asghar Baloch; [1]Tauqeer Ahmad Yasir; [4]Siddiq ur Rahman; [1]Sikandar Hayat; [1]Syed Noor Muhammad Shah and [6]Muhammad Ali Khan

[1]College of Agronomy, North West Agricultural and Forestry University, Shaanxi, P.R. China.
[2]Professor and Chairman Department of Plant Breeding and Genetics Sindh Agriculture University Tando Jam Sindh, Pakistan.
[3]College of Horticulture, North West Agricultural and Forestry University, Shaanxi, P.R. China.
[4]College of Life sciences, North West Agricultural and Forestry University, Shaanxi, P.R. China.
[5]College of Food science and Engineering Northwest A & F University, Yangling, Shaanxi, 712100, P R China.
[6]College of Agronomy and Biotechnology, China Agricultural University, Beijing 100193, P.R. China

ABSTRACT

Combining ability analysis is an important tool for the selection of desirable parents together with the information regarding nature and magnitude of gene effects controlling quantitative traits. So this study was carried out in term to estimate the combining ability of eight upland cotton genotypes using F1 hybrid production and also to select desirable progenies from segregating populations. The genotypes comprised four parents as females (BH-160, NB-999, NIBGE-2 and FH-901) and four parents as males (CIM-56, CIM-497, CIM-707 and RH-501). The mean squares due to general combining ability (GCA) and specific combining ability (SCA) were significant for all the traits studied. The significance of GCA and SCA variances suggested that both additive and non-additive genes were controlling the characters. Among the four females, parent NB-999 manifested maximum GCA estimates for plant height (1.96) and micronaire value (0.17). While among the male parents, the maximum GCA effects of 10.04 and 0.89 were exhibited by RH-510 for plant height and ginning outturn percentage respectively. The GCA effects of female and male inbreds therefore suggested that NB-999 from among the female parents and RH-510 from male parents may be preferred for hybridization and selection program so as to improve majority of the characters. The SCA estimates however suggested that hybrids FH-901 x CIM-506 expressed maximum effects for ginning outturn percentage (4.00) and micronaire value (0.33); NB-999 x CIM-497 for earliness (5.29) and staple length (1.69) and FH-901 x CIM-497 (16.17) for plant height. These results indicated that in order to improve various traits, different hybrids may be exploited for hybrid crop development.

Key words:

Introduction

Developments of superior hybrids have been in practiced very successfully since long time throughout the world. This is one of the best ways to capitalize the hybrid vigour of cotton varieties. Though, hybrid vigor has often been obtained in cotton but to be of potential value of hybrid should be more profitable than the best available commercial variety. This means that hybrids should be higher yielding and probably possess superior fibre properties as well. Recently, a summary was put forwarded by Meredith *et al.* (1990) that F_1 and F_2 generations could increase yield heterosis value averaged of 21.4 and 10.7 respectively. Hybrid cotton is an optimistic approach for significant important in genetic potential for yield and fibre quality traits. All the cotton producing countries are conscious to increase yield through commercial cultivation of hybrid generations but till now India and China are the leading countries having significant acreage under hybrid cotton. According to the Dongre and Parkhi (2005), in India hybrid cotton is grown approximately 45 percent of total production area and accounts for about 55 percent of India's total production. While in China since 2000, not huge but a reasonable percentage of total acreage of hybrid cotton production is reported by Dong et al that covers approximately 20 percent.

Combining ability analysis is an important tool for the selection of desirable parents together with the information regarding nature and magnitude of gene effects controlling quantitative traits. The success of the hybridization program depends on the ability of the parents entering into hybridization to yield desirable segregants (Halluaer and Miranda 1981). Combining ability helps to define the pattern of gene effects in the expression of quantitative traits by identifying potentially superior parents and hybrids (Goyal and Kumar;

Corresponding Author: Imran Ahmad, College of Horticulture, North West Agricultural and Forestry University, Shaanxi, P.R. China.
E-mail: imran73aup@yahoo.com

Ahuja and Dhayal 2007). Good general combining ability is mandatory of parents, while specific combining ability is the final measure in choice of parents. Sprague and Tatum (1942) used the term general combining ability (GCA) to designate the average performance of a line in hybrid combination and specific combining ability (GCA) as deviation in performance of a cross from that predicted on the basis of general combining ability of parents involved in the cross.

In recent years, better fibre quality has become a slogan for businessmen because globalization and technological changes in textiles industries have demanded higher quality of fibre for maximum efficiency, quality and market competitiveness. Previous studies resulted that fibre traits have been affected by both additive and non-additive gene actions. Myers and Lu (1998) reported that GCA effects were more than SCA effects for micronaire and fibre elongation suggesting that additive gene action is important for fibre traits. While Lukange *et al*. (2007) revealed additive gene effects for fibre strength and micronaire value and non-additive gene action for fibre length. Recently, Karadmir and Geucer (2010) reported that significant additive genetic effects were observed for ginning percentage, fibre length, micronaire and fibre elongation.

Besides breeding for fibre traits, earliness is also an efficient quantitative trait and it is affected by genetic-physiological composition of plants and environmental conditions (Kassianko *et a.*, 2003). When growing the crop early maturity increases the possible that harvest can be completed before cold and rainy weather. However, early maturing of cotton is to prefer because of decreasing inputs of fertilizer, irrigation, crop protection and providing proper time for rotation of the other crops. According to Ji *et al*. (1996), that non-additive gene action is responsible for early maturing. In contrary Malek and Shamsuddin (1999), reported that additive gene action is also responsible for days to flowering and boll forming period.

In early plant breeding era, large number of crosses was attempted and potential parents based on their progeny performance were recognized. These approaches of identifying potential parents and genes functioning for various plant characters require lot of resources in terms of manpower, space and time (Baloch 2003). Additive and dominant genetic variances are also important for breeders. They arbitrate as how far a particular trait is amenable to selection in segregating generation or useful for hybrid cotton development. Various mating designs in this regard have been very valuable. The diallel analysis has been used more than any other mating design to designate GCA and SCA of the parents, thereby, obtaining the information on the types of gene actions controlling different traits in cotton. However, diallel mating design has its own limitations i.e. it uses less number of parents and requires more resources. Cross Classification Design-II analysis as compared to diallel, involves more number of parents with same resources. So Design-II analysis provides information for large number of parents with more reliable estimates of genetic parameters (Baloch and Bhutto 2003).

The objective of present study was to determine the general and specific combining ability of cotton inbred parents using North Carolina Design-II genetic analysis.

Materials and Methods

Experiment was conducted during Kharif season 2007 at Botanical Garden, Department of Plant Breeding and Genetics, Faculty of Crop Production, Sindh Agriculture University, Tando Jam. The plant materials used in the present study were obtained by using North Carolina Design-II crossing method. Eight upland cotton genotypes, namely, BH-160, NB-999, NIBGE-2, FH-901, CIM-506, CIM-497, CIM-707 and RH-510 were used in crossing programme. According to this method, equal numbers of female and male parents were to be used in crossing block. Four female parents BH-160, NB-999, NIBGE-2, FH-901 and four males CIM-506, CIM-497, CIM-707 and RH-510 were crossed under the field conditions.

During 2008, 16 F_1 hybrids were grown in the field of the Department of Plant Breeding and Genetics, Faculty of Crop Production, Sindh Agriculture University, Tando Jam in Randomized Complete Block Design with three replications. Recommended agronomic practices were carried out for the whole experimental material. The plant traits studied are; plant height (cm), earliness (bolls formed after 80 days of planting), staple length (mm), ginning outturn percentage and micronaire value (µm/inch). Ten index plants were tagged at random from each replication per genotype and for recording various observations.

The cross classification Design-II analysis was carried out for determining the genetic variability and the effects due to combining ability as described by Comstock and Robinson (1948) and adopted by Hallauer and Miranda (1986).

Results And Discussion

The mean squares due to crosses, female inbreds, male inbreds and males x female's interactions were significant for all characters studied (Table 1). The significance of mean squares due to male and female inbreds both designate GCA variances while female x male interaction signify SCA variances employed that additive as

well as non-additive genes were important in the expression of characters studied. However, the general combining ability (GCA) effects were higher than specific combining ability (SCA) effects for all characters which indicated that additive gene action is prevailing with dominant or epistatic for the expression of these traits.

Recently, Karademir and Gencer (2010) used 4 Multi Adversity Resistance (MAR) and three commercial cotton varieties in half diallel fashion in order to estimate the GCA and SCA effects of parents and observed significant GCA and SCA effects for all fibre traits. For earliness, Malek and Shamsuddin (1999) reported that additive gene action play vital role for initiation of early flowering and boll forming period. Generally, it is assumed that *per se* performance of hybrid is reflected in GCA and for sure in SCA. However, Ashokkumar *et al.* (2010) noted that cross combination MCU-15 x TEH-1646 revealed high performance for micronaire value but showed negative SCA effects. Moreover, Cetin Karademir *et al.* (2007) reported that hybrid Sicala- 33 x Stoneville-453 expressed high hybrid performance for staple length and showed SCA effects close to negative (0.00). Though, such assumption did not always hold true because in our study hybrid FH-901 x CIM-506 manifested higher hybrid performance for ginning outturn percentage and micronaire value and simultaneously exhibited better specific combining ability for both parameters.

With respect to GCA effects of female inbreds, NB-999 displayed maximum positive GCA effects (1.96) for plant height and of 0.17 for micronaire. While the highest positive GCA effects of 2.05, 0.48 and 0.18 for earliness, ginning outtern percentage and staple length were produced by BH-160, NIBGE-2 AND FH-901 respectively. Among male inbreds, the parent RH-510 showed maximum positive GCA effects for plant height (10.04) and ginning outtern percentage (0.89) where as other male parents such as CIM-497, CIM-506 and CIM-707 demonstrated the highest GCA effects of 9.71, 0.49 and 0.29 for earliness, staple length and micronaire value respectively (Table 2). GCA effects are showing that NB-999 from female inbreds and RH-510 from male inbreds may be preferred for hybridization and selection programs to isolate desirable plants from segregating population to improve majority of the characters studied.

Table 1: Mean squares from North Carolina Design-II analysis for various characters in intra-hirsutum F_1 hybrids.

Source of variation	Degrees of freedom	Mean squares				
		Plant height	Earliness (No. of bolls formed at 80 days)	Ginning outturn percentage	Staple length	Micronaire value
Replication	2	1.313	61.25	0.089	0.791	0.065
F_1 hybrids	15	404.644**	148.613**	19.560**	2.740**	0.249**
Males (GCA)	3	794.167**	507.472**	20.705**	1.536**	0.564**
Females (GCA)	3	60.222**	61.25**	2.816**	0.844**	0.175**
Males x females (SCA)	9	389.611**	58.120**	24.761**	3.773**	0.169**
Error	30	6.757	7.263	0.217	0.104	0.011

** Significant at 1% probability levels

Table 2: General combining ability estimates of male and female inbreds for various characters in intrahirsutum F_1 hybrids

Inbred parents	Plant height	Earliness (No. of bolls formed at 80 days)	Ginning outturn percentage	Staple length	Micronaire value
Male inbreds:					
CIM-506	-6.04	-2.70	0.87	0.49	-0.05
CIM-497	3.04	9.71	-1.89	0.02	0.00
CIM-707	-7.20	-2.86	0.14	-0.33	0.29
RH-510	10.04	-4.11	0.89	-0.24	-0.23
S.E. (gi)	0.750	0.777	0.134	0.093	0.30
Female inbreds:					
BH-160	1.79	2.05	0.28	0.09	-0.11
NB-999	1.96	1.80	-0.60	-0.39	0.17
NIBGE-2	-1.54	-1.36	0.48	0.12	-0.06
FH-901	-2.37	-2.45	-0.14	0.18	0.00
S.E. (gi)	0.750	0.777	0.134	0.093	0.30

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In cross combinations almost half of the total hybrids having significant SCA effects showed better mean performance as reflected by positive association between them indicating that cross combination may be selected either on the basis of SCA or mean performance or in combination (Table 3). In agreement of our results, Saeed *et al.* (2006) noted that cross CIM-473 x ACALA 1517/C which manifested that the highest SCA effects was also associated with high performance for ginning outtern percentage and micronair value while cross CIM-473 x CIM-420 for staple length.

Table 3: *Per se* performance of intrahirsutum F_1 hybrids for various characters.

F_1 hybrids	Plant height (cm)	Earliness (No. of bolls formed at 80 days)	Ginning outturn percentage	Staple length (mm)	Micronaire value (µg/inch)
BH-160 x CIM-506	132.33	18.00	36.99	30.33	4.05
BH-160 x CIM-497	130.33	36.00	39.73	29.83	4.33
BH-160 x CIM-707	126.00	16.67	43.38	29.87	4.70
BH-160 X RH-510	141.67	18.33	42.60	30.97	3.83
NB-999 x CIM-506	135.00	17.33	40.95	29.30	4.53
NB-999 x CIM-497	130.00	37.00	35.33	31.57	4.32
NB-999 x CIM-707	136.00	15.33	39.75	29.77	4.65
NB-999 x RH-510	129.00	18.33	43.12	28.43	4.50
NIBGE-2 x CIM-506	122.67	16.67	42.03	31.83	3.90
NIBGE-2 x CIM-497	127.33	27.00	40.55	29.70	4.32
NIBGE-2 x CIM-707	117.00	19.33	39.40	28.83	4.63
NIBGE-2 x RH-510	150.00	12.33	41.53	30.77	4.20
FH-901 x CIM-506	108.00	18.00	45.11	31.13	4.70
FH-901 x CIM-497	147.67	19.67	38.37	29.63	4.36
FH-901 x CIM-707	115.33	18.00	39.61	30.83	4.50
FH-901 x RH-510	142.67	15.33	37.89	29.77	3.87
Grand mean	130.75	20.21	40.40	30.16	4.33
LSD (5%)	4.33	4.49	0.78	0.54	0.17

Table 4: Specific combining ability estimates of intrahirstum F_1 hybrids for various characters.

F_1 hybrids	Plant height	Earliness (No. of bolls formed at 80 days)	Ginning outturn percentage	Staple length	Micronaire value
BH-160 x CIM-506	5.75	-1.54	-4.55	-0.41	-0.11
BH-160 x CIM-497	-5.33	4.04	0.96	-0.44	0.11
BH-160 x CIM-707	0.59	-2.72	2.56	-0.05	0.19
BH-160 X RH-510	-1.0	0.2	1.04	0.89	-0.15
NB-999 x CIM-506	9.25	-1.97	2.29	-0.95	0.09
NB-999 x CIM-497	-5.83	5.29	-2.55	1.69	-0.19
NB-999 x CIM-707	10.42	-3.79	-0.17	0.34	-0.14
NB-999 x RH-510	-13.83	0.45	2.45	-2.14	0.23
NIBGE-2 x CIM-506	-0.59	0.53	0.29	1.06	-0.30
NIBGE-2 x CIM-497	-4.99	-1.54	1.58	-0.06	0.06
NIBGE-2 x CIM-707	-5.08	3.37	-1.62	-1.10	0.08
NIBGE-2 x RH-510	10.67	-2.37	-0.23	0.82	0.17
FH-901 x CIM-506	-14.41	2.95	4.00	0.30	0.33
FH-901 x CIM-497	16.17	-7.80	0.03	-0.73	0.03
FH-901 x CIM-707	-5.70	3.12	-0.76	0.67	-0.12
FH-901 x RH-510	4.17	1.70	-3.24	-0.23	-0.24
S.E. (si.)	1.50	1.555	0.268	0.186	0.060

As regards to SCA effects, the maximum positive SCA effects were revealed by the hybrid FH-901 x CIM-497 for plant height (16.17), NB-999 x CIM-497 for earliness (5.29) and staple length (1.69), FH-901 x RH-510 for ginning outtern percentage and micronaire value (0.33) (Table-4). These results suggested that

different hybrid may be considered for improving various traits. Regarding to GCA and SCA effects, the parent CIM-497 showed positive GCA effects for all traits except for ginning outtern percentage and in addition contributed positive SCA effects for various traits except ginning outtern percentage and micronaire value, therefore the parent CIM-497 proved its worthiness in future breeding program.

Conclusion:

The parents and their hybrids manifested significant differences in mean performance for all characters studied. The significance of GCA and SCA mean squares expressed the importance of both additive and dominant variances for all characters. Higher GCA effects of female parents and male parents were, however, demonstrated by CIM-497, NB-999 and FH-901 for majority of the characters as good general combiners. It suggested that these parents may be preferred for hybridization and selection programmes. SCA effects indicated that for hybrids crop development, cross NB-999 x CIM-497 may be utilized for improving earliness and staple length and FH-901 x CIM-506 for ginning outturn percentage and micronaire value.

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