Pak. j. sci. ind. res. ,vol. 32, no. 9, September 1989

MANIFESTATION OF HETEROSIS AND COMBINING ABILITY IN UPLAND COTTON

Asif Ali Khan, Mukhtar Muhammad Ali, Abid Mahmood* and M. Amin Khan

University of Agriculture, Faisalabad.

(Received March 11, 1989; revised September 7, 1989)

Estimates of heterosis and combining ability were made using 30 hybrid and 6 parental combination grown under field conditions. The hybrids were produced by crossing in diallel six cotton *(G. hirsutum L.)* varieties having exotic and local backgrounds.

Estimates of gca, sca and reciprocals were highly significant for all the characters under study except the insignificance of sca and reciprocal effects for seed and lint indices respectively. Gca effects were higher than those of sca and reciprocals, for lint percentage, lint index and staple length, indicating a preponderance of additive gene effects. The reverse was true for seed index, where non-additive gene effects were found. Several of the crosses showed considerable heterosis when compared with mid and better parental means.

Key words: Heterosis, Heterobeltiosis, Combining ability.

Introduction

The choice of diverse parents for hybridization must be based upon the knowledge of combining ability of parental lines. Therefore, the studies reported here were undertaken to determine combining ability estimates and the extent of heterosis in a 6 x 6 diallel cross of cotton varieties. The information regarding these parameters will be of great help to cotton breeders in the choice of parental lines and breeding procedure.

The general combining ability (gca) effects were found to be more prominant by Marani [2] , Lee *et. al.* [8], Omran *et. al.* [3], Baker and Verhalen [11], El-Fawal *et. al.* [12] and Shekry *et. al.* [16], while Ahmed *et al.* [1], Kumar *et. al.* [18] Khan *et. al.* [15] and Khan *et. al.* [7] reported the preponderance of specific combining ability (sca) for the traits under investigation. The above mentioned research workers also reported a varying amount of heterosis for lint percentage, seed and lint indices and staple length. The results obtained from the present studies, in strictly statistical sense, apply only for these specific varieties.

Materials and Methods

The parental cotton varieties used in these studies were (1) Acala 63-69, (2) DPL-25, (3) 1038, (4) G-1487-RLEFG (5) PBG-1 and (6) Genetic cotton-181. These lines were crossed in a way to develop a complete diallel set of crosses during 1985-86. The seed of all the genotypes was grown in a Randomized Complete Block Design with four replications, in the experimental area of University of Agriculture, Faisalabad. At maturity, data were taken for lint percentage, seed and lint indices and staple length.

*Ayub Agricultural Research Institute, Faisalabad

The data were analysed for combining ability using Method-1 and Model-II [5]. Heterosis and heterobeltiosis were calculated in terms of percent increase or decrease of a hybrid against its mid and better parental means, respectively. The significance of heterosis and heterobeltiosis was tested according to Wynne *et. al* [10] and Sharma and Singh [6].

Results and Discussion

The estimates for gca, sca and reciprocal effects for lint percentage, seed index lint index and staple length are presented in Table 2, 3 and 4, respectively; while Table 1 shows mean squares and components of variance due to these effects. Gca effects were highly significant for the four quality traits (Table 1).

Sca effects were also highly significant except for seed index, whereas the reciprocal effects were non-significant for lint index and highly significant for the remaining three characters.

Except seed index a higher magnitude of variance due to gca effects indicated the importance of additive type of gene

Table 1. Mean Squares and Components of Variance Due to gca, sca and Reciprocal Effects.

Source of variation	Degrees of freedom	Lint %	Seed index	Lint index	Staple length
General combining ability	5	5.66**	5.67**	1.69**	6.68**
		45.6%	8.7%	50.4%	52.9%
Specific combining ability	15	0.47**	2.26	0.19**	0.36**
		15.5%	10.7%	36.8%	9.7%
Reciprocal	15	0.52**	3.64**	0.03	0.55**
		16.2%	30.2%	1.5%	18.1%
Error	105	0.22	1.66	0.03	0.19
		22.8%	50.5%	10.9%	19.4%

** = Highly significant at 1% level of probability.

TABLE 2. ESTIMATES OF GENERAL COMBINING ABILITY (GCA) EFFECTS.

	Lint %	Seed index	Lint index	Staple length
1. Acala 63-69	0.05	1.01	0.32	0.34
2. DPL-25	--0.82	--0.51	--0.37	0.81
3. 1038	0.81	0.41	0.51	0.38
4. G-1487 RLEFG	0.73	0.36	0.11	0.28
5. PBG-1	--0.07	--0.64	--0.16	--1.21
6. Genetic cotton-181	--0.70	--0.63	--0.41	--0.60
CD (gi-gj) 0.05	0.37	1.04	0.13	0.36

TABLE 3. ESTIMATES OF SPECIFIC COMBINING ABILITY (SCA) EFFECTS.

	Lint %age	Seed index	Lint index	Staple length
1 x 20.58	-0.52	0.08	0.46	
1 x 3	0.04	-0.58	-0.05	-0.26
1 x 4	-0.08	3.28	0.34	-0.23
1 x 5	-0.55	-0.18	0.10	0.17
1 x 6	-0.24	-0.09	0.13	0.29
2 x 3	-0.11	0.50	0.16	0.21
2 x 4	0.17	-0.66	-0.08	0.19
2 x 5	0.10	0.04	0.21	-0.41
2 x 6	-0.02	0.05	-0.06	0.02
3 x 4	0.43	-0.23	0.26	0.29
3 x 5	0.51	0.16	-0.01	-0.53
3 x 6	0.37	0.66	0.33	0.53
4 x 5	-0.01	0.03	0.10	0.09
4 x 6	0.41	-0.03	0.14	0.25
5 x 6	-0.64	-0.05	-0.37	-0.29
CD (S_{ij}-S_{ik}) 0.05	0.84	2.33	0.29	0.79
CD (S_{ij}-S_{kl}) 0.05	0.75	2.09	0.27	0.71

TABLE 4. ESTIMATES OF RECIPROCAL EFFECTS.

	Lint %	Seed index	Lint index	Staple length
2 x 1-0.22	0.10	0.01	-0.16	
3 x 1	-0.39	-0.23	-0.23	0.20
3 x 2	-0.26	0.06	-0.04	0.26
4 x 1	0.50	3.65	0.07	-0.18
4 x 2	-0.16	0.20	0.09	0.07
4 x 3	0.03	0.01	0.01	-0.51
5 x 1	0.20	0.02	0.06	0.96
5 x 2	-0.01	0.27	0.14	0.09
5 x 3	0.08	-0.89	-0.10	-0.05
5 x 4	-0.05	0.14	0.08	-0.63
6 x 1	0.23	0.07	0.09	-0.18
6 x 2	-0.18	-0.05	-0.65	0.03
6 x 3	1.13	-0.30	0.10	0.09
6 x 4	-0.16	0.09	0.02	-0.03
6 x 5	-0.02	0.07	0.04	0.53
CD (r_{ij}-r_{kl}) 0.05	0.92	2.56	0.33	0.87

action involved in the manifestation of characters under study. The results suggested that the characters showing a preponderance of additive gene effects would respond to selection. Seed index was found to be controlled by non-addivitive gene action i.e. genes with dominant or epistatic effects, as magnitude of the variance due to reciprocal effects was greater than gca. Additionally it is suggested that the direct and their reciprocal crosses could be composited for lint index which exhibited non-significant reciprocal effects. Almost similar results were reported by most of the earlier workers like Marani [2], Lee *et. al* [8], Omran *et. al* [3], Baker and Verhalen [11], El-Fawal *et. al.* [12] and Shekry *et. al.* [16]. These scientists were of the opinion that quality traits were under the control additive genes. In contrast, Kumar *et. al.* [18], Ahmad *et. al.* [1] and Khan *et. al.* [15] were of different view, they reported non-additive gene effects for the phenotypic manifestation of these traits.

The deviation of findings might be attributed to different breeding material and sight of experimentation. Difference of gene action under different environments have been reported by Thompson and Whitehouse [9] in wheat, Miller and Marani [17] in cotton and Allard [19] in various other crops. It is further emphasized that breeders must not loose sight of the environments for which a variety is to be synthesized.

The estimates of gca of different varieties are presented in Table 2. The variety 1038 was the best general combiner for lint percentage and lint index. While best general combiner for seed index and staple length were Acala 63-69 and DPL-25, respectively.

For lint percentage the crosses 1 x 2 (Acala 63-69 x DPL) and 6 x 3 (Gene. cotton 181 x 1038) showed highest sca and reciprocal effects, respectively. These combinations involved parents with highest and lowest gca. The cross of 1 x 4 (Acala 63-69 x G-1487 RLEFG) proved to be the best specific combiner for seed index and lint index. Higher reciprocal effects has been shown by 4 x 1 (G 1487 x Acala 63-69) for seed index and 5 x 2 (PBG-1 x DPL-25) for lint index. These crosses included parents with high and medium gca. As far as staple length is concerned 3 x 6 (1038 x Gene. cotton 181) had high sca estimate and 5 x 1 (PBG-1 x Acala 63-69) showed highest reciprocal value. These combinations involved medium x low gca in the parents.

It is concluded from the above results that gca is not a suitable criterion to predict specific combining ability; a recommendation that has also been made by Chang and Baluch [13], Khan and Bhatti [14], Soomro and Soomro [4] and Khan *et. al.* [7].

Heterosis and heterobeltiosis. For lint percentage the crosses 3 x 6 (1038 x Genetic cotton 181) and 3 x 4 (1038 x

TABLE 5. HETEROSIS (HT.) AND HETEROBELTIOSIS (HBT) IN VARIOUS CROSSES OF *G. hirsutum* L.

Combination	Lint percentage		Seed index		Lint index		Staple length	
	Ht.%	Hbt.%	Ht.%	Hbt.%	Ht.%	Hbt.%	Ht.%	Hbt.%
1 x 2	1.68	-2.07	-0.11	-4.62	4.51	-3.69	6.51**	1.09
1 x 3	0.35	0.30	2.18	0.82	4.95	3.99	1.03	0.50
1 x 4	2.03	1.73	12.12**	1.54	19.84**	11.09**	3.11	2.65
1 x 5	-3.09	-3.21	5.72*	-3.38	4.65	-2.22	3.18	0.07
1 x 6	-0.61	-2.78	9.49**	-1.85	10.65**	-2.03	3.74*	-0.44
2 x 1	2.90	-0.89	0.05	-2.36	4.31	-3.88	3.82	2.18
2 x 3	1.71	-2.09	5.34*	1.90	7.85*	-1.45	2.93	1.83
2 x 4	2.34	-1.71	3.34	-2.25	7.19	6.49	4.69*	4.40
2 x 5	0.45	-3.37	-2.01	-6.42*	-1.29	-2.77	-2.13	-6.53**
2 x 6	0.25	-1.34	-2.65	-8.91**	-2.18	-6.36	2.56	-3.05
3 x 1	2.48	2.42	9.09**	8.11**	13.37**	12.34**	-0.41	-0.93
3 x 2	3.18*	-0.68	4.14	0.74	9.43*	0.00	1.08	0.00
3 x 4	4.14**	3.90*	12.07**	2.74	19.64**	9.98*	0.72	-0.25
3 x 5	2.33	2.26	1.94	-5.69	5.97	-1.81	-3.51	-6.89**
3 x 6	5.57**	3.21	8.59**	1.48	17.08**	3.63	4.26*	-0.43
4 x 1	0.69	-0.98	18.45**	9.43**	17.05**	8.50*	1.69	1.23
4 x 2	3.25*	-0.84	-2.26	-7.55	3.05	2.38	3.17	1.09
4 x 3	4.01*	3.77*	11.83**	2.52	19.05**	9.44*	4.38*	3.37
4 x 5	0.38	0.22	13.27**	12.14**	13.73**	12.76**	1.97	-0.66
4 x 6	1.76	-0.73	12.29**	10.99**	14.22**	8.66*	3.44	-0.29
5 x 1	-3.20	-3.32	7.88**	0.64	2.27	-4.44	-3.96	-6.85**
5 x 2	0.51	-3.32	-8.26**	-12.40**	-7.56*	-8.94*	-2.80	-7.16**
5 x 3	2.00	1.93	6.26*	-1.69	9.89**	1.81	-3.18	-6.66**
5 x 4	0.46	0.29	7.64**	8.55**	10.30**	9.36*	-2.30	-5.31*
5 x 6	1.90	-0.51	0.63	-1.49	-3.72	-9.15*	-3.55	-4.60*
6 x 1	-1.87	-4.01*	10.49**	11.07**	6.89	-5.36	4.12*	-7.25**
6 x 2	1.29	-0.31	-1.45	7.78	0.80	-3.51	2.30	-3.30
6 x 3	-0.69	-2.91	15.56**	4.84	13.84**	0.00	3.55	-1.11
6 x 4	2.65	0.14	8.82**	7.58*	13.54**	8.01	3.66*	-7.32**
6 x 5	-2.77	-5.00**	-1.01	-3.09	-5.30	-10.64*	0.59	-0.50

** Significant at 1% level; * at 5% level.

G-1487 RLEFG) proved to be the best hybrids as they scored the maximum i.e. 5.57 and 4.14% heterosis while 3.21 and 3.90% heterobeltiosis, respectively. The crosses having 1038 as one of the parent performed better in this regard (Table 5). This situation conforms the superiority of 1038 for its gca effects as was observed before (Table 2). Since lint percentage is an important quality and yield character, 1038 could be given due consideration when selecting the parents to be used in a crossing programme.

The maximum heterosis for seed index (18.45%) was exhibited by the cross of G-1487 RLEFG x Acala 63-69 (4 x 1) followed by G-1487 RLEFG x PBG-1 (13.27%). These two crosses proved to be the best in performance when compared with their better parents; they showed 9.43 and 12.14% heterobeltiosis respectively (Table 5).

Regarding lint index, the maximum heterosis (19.84%) was shown by the corss 1 x 4 (Acala 63-69 x G-1487 RLEFG), followed by 1038 x G-1487 RLEFG (19.64%). While the cross 3 x 1(1038 x Acala) was at the top (12.34%) as far as heterobeltiosis is concerned. The best general combiner 1038 in this regard also produced comparatively better hybrids (Table 5). With respect to staple length 1 x 2 (Acala 63-69 x DPL-25) and 2 x 4(DPL-25 x G-1487 RLEFG) achieved the highest values of heterosis i.e. 6.51 and 4.69%, respectively. The DPL-25 x G-1487 combination also exhibited the largest heterobeltiosis value (4.40%). Those crosses where DPL-25 was used as a parent generally produced better hybrids for staple length (Table 5). This parent has already been proved its superiority for gca effects (Table 2). Therefore, this variety may be given due consideration while selection of the parents is to be made for further improvement of the cotton plant with respect to staple length. It is concluded from the foregoing discussions that the varieties having high gca generally produced better hybrids. These results also suggested that the three characters, viz. lint % age, lint index and staple length, showing a preponderance of additive gene effects would respond to selection. Individual plant selection could be practised and also biparental crossing could be implemented.

References

1. A.A. Ahmed, K.M.Al -Rawi and S.R.Hassan, Iraqi J. Agric.Sci., **1**,133 (1983).
2. A. Marani, Crop Sci., **7**, 519 (1967).
3. A.O. Omran, A.E. El-Gonayni and H. Jalal, Cotton Grow. Rev., **51**, 192 (1974).
4. B.A. Soomro and A.R. Soomro, The Pak. Cottons, **22**, 269 (1978).
5. B. Griffing, Austa. J. Biol., **9**, 463 (1956).
6. G.S. Sharma and R.B. Singh, Indian J. Agric. Sci., **48**, 510 (1978).
7. I.A. Khan, M.A. Khan and M. Iqbal, The Pak. Cottons, **29** 77 (1985).
8. J.A. Lee, P.A. Miller and J.O. Rewlings, Crops Sci., **7**, 477 (1967).
9. J.B. Thompson and R.N.H. Whitehouse, Euphytica, **11**, 181 (1962).
10. J.C. Wynne, D.A. Emery and P.M. Rice, Crop Sci., **10**, 713 (1970).
11. J.L. Baker and I.M. Verhalen, Cotton Grow. Rev., **52**, 209 (1975).
12. M.A. El-Fawal, F.A. Bedair, M.A. Bishr and E.K. Hassoub, Egy. J. Gent. Cyto., **7**, 15 (1978).
13. M.A.K. Chang and M.A. Baluch, The Pak. Cottons, **12**, 55 (1968).
14. M.A. Khan and A.D. Bhatti, The Pak. Cottons, **22**, 117 (1978).
15. M.A. Khan, F.M. Azhar and H.U. Rana, J. Agric. Res., **22**, 187 (1984).
16. M.A.H. Shekry, M. El-Maghazy and H.Y. Awad, Res. Bull., Fact. Agric. Ainshams Univ., **1620**, 11 (1981).
17. P.A. Miller and A. Marani, Crop Sci., **3**, 646 (1963).
18. P. Kumar, R.S. Pathak and R.K. Singh, Indian . J. Agric. Sci., **44**, 145 (1974).
19. R.W. Allard, Genetics, **41**, 305 (1956).