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PERFORMANCE OF F1 HYBRIDS FROM VARIOUS PLOIDY LEVELS IN COTTON

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Abstract

Studies were carried out for comparing the magnitude of heterotic expression in F1 hybrids from two ploidy levels i.e., pentaploid x tetraploid and tetraploid x tetraploid. The pentaploid hybrids expressed 22.18% average heterosis over mid parents whereas corresponding value in tetraploid hybrids was 14.17% for plant height. With respect of mid-lobe leaf length, the average increase of pentaploid hybrids against mid and better parents respectively were 22.82 and 6.30% while the corresponding values in tetraploid hybrids were 8.46 and 7.02%. In case of mid- lobe leaf width, pentaploid hybrids on an average, expressed heterosis of 35.74 and 10.33% respectively over mid and better parents as compared to 12.35 and 10.40% respectively in tetraploid hybrids over corresponding parents. On an average pentaploid crosses gave increased seed cotton yield of 136% against mid parents. Regarding ginning outturn percentage, the pentaploid hybrids produced maximum heterosis of 6.09 and 4.39% respectively, against mid and better parents while in tetraploid hybrids, corresponding values of 3.00 and 2.54% were recorded. Concerning staple length, hybrids from two ploidy levels did not show apparent differences.

Introduction

Cotton production in Pakistan although has increased substantially during the last several years, but per acre yield is still low (Khan & Bhatti, 1978). It may be due to less yielder genotypes under cultivation. Thus other approaches such as exploitation of heterosis could be an alternative to boost-up cotton yield. Although tremendous work on this aspect has already been carried out, however, the crosses involved the perents from only lower ploidy levels, such as tetraploids. Plant breeders do know the fact that as the ploidy level in most crop species increases (upto the level that cell can afford the number of chromosomes), gigantism in many attributes such as yield, (Khan & Bhatti, 1978; Khan & Ali, 1980; Aslam & Khan, 1983; Mithaiwala *et al*., 1984), growth and plant height (Sarwar *et al*., 1979; Ahmed *et al*., 1981; Ghulam *et al*., 1987 and Khan & Ghafoor, 1991), staple length (Ahmed & Penhawar, 1987; Baloch *et al*., 1991), ginning outturn (Khan & Ghafoor, 1991; Baloch *et al*., 1991), leaf size, flower shape and size (Ahmed & Memon, 1971) also expresses. Heterosis has already been explored at tetraploid level, involving both intra and interspecific crosses and this so far has not been looked at higher ploidy levels. Therefore the present study was aimed at comparing the level of expression of heterosis between the crosses of tetraploid with tetraploid and pentaploid with tetraploids. This investigation may fulfill one of the recommendations suggested by FAO and ICAR experts at world level meeting held in Nagpur, India, 1990 that heterosis must be explored in various cross-combinations so as to pin-point the best ones for two purposes. One is that, useful hybrid combinations may be used for hybrid cotton development if some day it becomes practical dream in Pakistan and another is that, best combinations may further enhance the opportunities for getting transgressive segregants

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so that new cotton cultivars could be evolved. One must however, realize the fact that hybrid cotton can only be practical when its seed cotton yield exceeds that of pure lines by at least 25% and F_1 seed be produced in a quantity which must pay for the expenses involved.

Materials and Methods

This study was initiated at Cotton Research Institute, Sakrand during the year 1989. The following crosses were attempted in two sets:

Set - 1

1. Pentaploid x B-909
2. Pentaploid x NIAB-78
3. Pentaploid x 108F
4. Pentaploid x Rajhans

Set - 2

1. B-909 x NIAB-78
2. B-909 x 108F
3. B-909 x Rajhans
4. NIAB-78 x 108F
5. NIAB-78 x Rajhans
6. 108F x Rajhans

The seeds obtained from both the sets of crosses were sown as F1s alongwith respective parents in a uniformly fertile soil on 3rd May, 1990 in a randomized complete block design with 4 replications. The rows were 20' long and spaced 2.5' apart. The plants were thinned to maintain 9" space between the plants. For recording the data in both the sets of crosses and their parents 15 interior plants were randomly selected as index plants. In plot arrangement, respective parents flanked their F_1 hybrids on either side. The data on plant height, mid-lobe leaf length and mid-lobe leaf width, yield of seed cotton, ginning outturn % and staple length were recorded.

Heterosis for all the traits in both the sets of crosses was determined as % increase (+) or decrease (-) over their respective mid and better parents. Significance of differences between parents and F1 hybrids was determined by the standard method of analysis of variance (Steel & Torrie, 1980).

Results and Discussion

The analysis of variance for various characters studied in both the sets of crosses (pentaploid x tetraploid called set-1 and tetraploid x tetraploid named set-2) are presented in Tables 1 and 2 and their heterotic effects in Tables 3 and 4 respectively. The results obtained for each character are as follows:

1. Plant height (cms): There existed significant differences amongst mid parents and F1s in both the sets of crosses for plant height (Table 1 and 2). The data presented in Tables 3 and 4 revealed heterotic effects for set-1 and set-2 hybrids, respectively. The data indicated that pentaploid F1s gave increased plant height as compared to tetraploid F1s. The range of heterosis in former hybrids varied from 12.24 to 32.55% and 5.84 to 11.98% against mid parents and better parents, respectively, whereas the corresponding values in the later hybrids ranged from 10.18 to 21.50 % and -1.20 to 13.92 %. In case of

Table 1. Analyses of variance for various traits from pentaploid x tetraploid crosses (set-1).

Source of variation	Degree of freedom	Mean Squares					
		Plant height	Mid-lobe leaf length	Mid-lobe leaf width	Seed cotton yield	Ginning outturn percentage	Staple length
Mid parent and F_1 hybrids	7	545.42*	0.545**	0.2528**	15335.00**	23.65**	6.54**
Replication	3	338.08	0.2345	0.1218	10525.02	4.48	2.32
Error	21	201.23	0.0988	0.0222	2239.87	1.80	0.31
Total	31 Cd (.05)	20.86	0.4623	0.2191	69.61	1.97	0.82
	Cd (.01)	28.39	0.6290	0.2982	94.71	2.68	1.11

** Signficant at 1% probability levels, * Significant at 5% probability levels.

Table 2. Analyses of variance for various traits from tetraploid with tetraploid crosses (set-2).

Source of variation	Degree of freedom	Mean Squares					
		Plant height	Mid-lobe leaf length	Mid-lobe leaf width	Seed cotton yield	Ginning outturn percentage	Staple length
Mid parent and F1 hybrids	11	535.25**	0.5535**	0.2320**	14525.33**	24.48**	8.48**
Replication	3	250.38	0.3341	0.0855	8348.08	8.42	4.99
Error	33	181.28	0.0877	0.0332	2045.65	4.43	2.36
Total	47 Cd (.05)	19.80	0.4230	0.2603	46.60	3.00	2.19
	Cd (.01)	26.47	0.5654	0.3479	86.35	4.02	2.93

** Signficant at 1% probability levels.

pentaploid hybrids, the cross, pentaploid x 108F manifested the highest heterosis of 32.55 and 11.98 % over both mid and better parent respectively whereas in tetraploid hybrids two crosses, 108F x Rajhans and B-909 x 108F expressed the maximum heterosis of 21.50 and 13.92% over mid and better parent, respectively. Thus, the F_1 hybrids derived from set-1 and set-2 crosses indicated that on an average pentaploid hybrids gave increased plant height over tetraploid hybrids. Our results are in conformity with those of Ahmed & Memon (1971) who also supported that pentaploid exhibits gigantism in plant height as compared to tetraploids and diploids. Deodikar (1949) also noted similar results with pentaploid. The manifestation of gigantism probably is due to hybrid vigour, ploidy level or both combined together or genetic diversity between the parents of the crosses. Because pentaploid possess one more but different genome than tetraploids, perhaps this is the reason why it expressed increased heterosis over tetraploid hybrids.

2. ***Mid-lobe leaf length:*** Significant differences among mid parents and F_1 hybrids in both the sets of crosses were observed (Tables 1 and 2). The heterotic responses of pentaploid and tetraploid hybrids are presented in Tables 3 and 4, respectively. All the F1s which received pentaploid genome gave longer leaf mid-lobes than the F1s that involved tetraploid parents only. The range of heterotic effects in pentaploid hybrid varied from 18.91 to 26.40% against mid parents and from 2.96 to 8.98% against better parents. The heterosis in tetraploid hybrids ranged from 6.99 to 11.33% and 5.41 to 10.76%. On an average, pentaploid hybrids gave 22.82 and 6.30% heterosis against mid and better parents, respectively whereas corresponding values in tetraploids were 8.46 and 7.02%. The maximum heterosis i.e., 26.40% and 8.89% for mid-lobe leaf length in pentaploid hybrids i.e., Pentaploid x NIAB-78 was recorded against mid-parent and better parent, respectively. Their findings revealed that pentaploid F1s expressed more heterosis against tetraploids for mid-lobe leaf length could be by virtue of bigger cell size due to higher ploidy level and or hybrid vigour. At this stage we are not certain whether F1s obtained from pentaploid parents were also pentaploid which of course is difficult to get but not impossible for which cytological investigations are intended in the future. Our present results, however, agree with those of Ahmed & Memon (1971) who also noted vigour in leaf length of pentaploids. Ahmed *et al.*, (1981) also reported vigour in mid-lobe leaf length in intra-hirsutum crosses.

3. ***Mid-lobe leaf width:*** Results in Tables 1 and 2 revealed highly significant differences among mid parents and hybrids from both the sets of crosses. Both pentaploid and tetraploid hybrids expressed positive heterosis for mid-lobe leaf width (Tables 3 and 4). The heterotic ranges in pentaploid hybrids varied from 31.01 to 44.01% and 4.00 to 18.67% over mid and better parents, respectively. The corresponding ranges in tetraploid hybrids were 10.44 to 13.36% and 9.07 to 12.17%. Pentaploid hybrids gave average mid-parent and better parent heterosis of 35.74 and 10.33% respectively, whereas these averages in tetraploids hybrids were 12.00 and 10.40%. Thus pentaploid hybrids on an average gave 189.39% more vigour in this trait than tetraploid hybrids against mid parent. In pentaploid hybrids, the highest heterosis of 44.01 and 18.67% were exhibited by the cross pentaploid x B-909 over mid and better parents, respectively, while in tetraploid hybrids, the maximum heterosis of 14.26% was manifested by the cross B-909 x Rajhans against better parent. The high % of heterosis regarding midlobe leaf width in pentaploid hybrids over tetraploids probably is due to bigger cell size due to higher ploidy level or hybrid vigour. The wider leaf-lobes of pentaploid in this study are

Table 3. Heterosis of various characters from Pentaploid x Tetraploid Crosses.

Character Studied	Crosses	Mother parent	Pollen parent	Mid parent	F_1 hybrid	Percentage increase (+) or decrease (-) of F_1 over	
						Mid Parent	Better Parent
	Pentaploid x B-909	130.2	87.50	108.86	137.80	26.60	5.84
Plant	Pentaploid x NIAB-78	130.2	110.00	120.10	140.90	17.32	8.22
height	Pentaploid x 108F	130.2	89.80	110.00	145.80	32.55	11.98
(cms)	Pentaploid x Rajhans	130.2	125.50	127.85	143.50	12.24	10.22
	Mean:					22.18	9.07
	Pentaploid x B-909	13.5	10.17	11.84	14.50	22.47	7.41
Mid-lobe	Pentaploid x NIAB-78	13.5	9.76	11.63	14.70	26.40	8.89
leaf	Pentaploid x 108F	13.5	9.87	11.69	13.90	18.91	2.96
length	Pentaploid x Rajhans	13.5	9.66	11.58	14.30	23.49	5.93
(cms)	Mean:					22.82	6.30
Mid-lobe	Pentaploid x B-909	7.5	4.85	6.18	8.90	44.01	18.67
leaf	Pentaploid x NIAB-78	7.5	4.60	6.05	8.50	40.50	13.33
Width	Pentaploid x 108F	7.5	4.73	6.12	7.80	27.45	4.00
(cms)	Pentaploid x Rajhans	7.5	4.55	6.03	7.90	31.01	5.33
	Mean:					35.74	10.33
Seed-	Pentaploid x B-909	94.5	105.80	100.15	163.75	63.50	54.77
cotton	Pentaploid x NIAB-78	35.4	80.00	57.70	88.56	53.48	10.70
yield	Pentaploid x 108F	96.6	108.00	102.30	203.30	98.73	88.24
(gms)	Pentaploid x Rajhans	57.5	57.50	58.25	82.60	41.80	40.00
	Mean					64.38	48.45

Table 3 (Cont'd)

Character Studied	Crosses	Mother parent	Pollen parent	Mid parent	F_1 hybrid	Percentage increase (+) or decrease (-) of F_1 over	
						Mid Parent	Better Parent
Ginning	Pentaploid x B-909	33.4	33.20	33.32	33.12	-0.60	-0.96
outturn	Pentaploid x NIAB-78	32.4	33.50	32.97	34.97	6.07	4.39
percentage	Pentaploid x 108F	33.4	33.80	33.58	34.42	2.50	1.83
	Pentaploid x Rajhans	32.8	32.90	32.84	32.77	-0.21	-0.40
Staple	Pentaploid x B-909	27.2	27.00	27.10	27.70	2.21	1.84
length	Pentaploid x NIAB-78	26.5	26.50	26.50	26.06	-1.66	-1.66
(mms)	Pentaploid x 108F	26.7	26.50	26.60	27.17	2.14	1.76
	Pentaploid x Rajhans	26.7	26.80	26.75	27.00	0.93	0.75

in close agreement with those of Ahmed & Memon (1971) and Ahmed *et al.*, (1981) who reported similar findings.

*4. **Seed cotton yield:*** It appears from the Tables 1 and 2 that mid parents and F_1 hybrids from both the sets of crosses expressed significant differences in producing seed cotton yield. A review of hybrids performance (Table 3 and 4) demonstrated that all pentaploid hybrids manifested positive mid-parent and better parent heterosis that varied from 41.80 to 98.73% and 10.70 to 88.24%, respectively. Heterotic responses in tetraploid hybrids although were positive over mid-parents, nevertheless gave negative heterosis against better parents. On an average, tetraploid hybrids did not exceed to that of pentaploids against either mid or better parents. The average heterosis of pentaploid hybrids over mid parent was 64.38% and the corresponding value in tetraploid hybrids was 27.24%, thus excelled tetraploids by 136.34% in seed cotton yield. In pentaploid hybrids, the maximum heterosis of 98.73 and 88.24% were expressed respectively by the cross pentaploid x 108F against mid and better parents. While in tetraploid hybrids, the highest heterosis of 43.62 and 25.00% over mid and better parents were given respectively by the cross, NIAB-78 x 108F. Our results for seed cotton yield indicated that when crosses were made between pentaploid with tetraploids, the F1s produced were probably the pentaploids. The higher ploidy level coupled with different genomes from barbadense and anomalum probably were responsible for higher yields in pentaploid hybrids as compared to tetraploids. However, one can still argue that pentaploid hybrids can only be obtained when pentaploid parents may have transmitted 3x39 chromosomal gametes and 2x26 gametes must have come from tetraploid parents. Ahmed & Memon (1971) have carried out cytological studies in pentaploid and found that pentaploid produced 60.0% viable gametes. They further supported that pentaploid also produces some multivalents, specially trivalents, however, at very small %. Further cytological studies are needed to confirm their genomes and ploid levels so as to determine the factor involved in expressing more heterosis in pentaploids as compared with tetraploid hybrids. Baloch *et al.*, (1991) observed heterosis at tetraploid level in this trait.

*5. **Ginning outturn percentage:*** The differences among mid parents and F1s from pentaploid and tetraploids were highly significant for ginning outturn % (Tables 1 and 2). The heterosis in pentaploid hybrids varied from -0.21 to 6.07% and -0.40 to 4.39% against mid and better parents, respectively, whereas corresponding ranges in tetraploids varied from -0.60 to 3.00% and -1.49 to 2.54%. These ranges in hybrids demonstrated that pentaploid hybrids expressed more heterosis for ginning outturn % than tetraploid hybrids. The cross pentaploid x NIAB-78 however, ginned the maximum lint of 6.07 and 4.39% respectively against mid and better parents. Similarly, in tetraploids, the cross B-909 x NIAB-78 produced 3.00 and 2.54% respectively more lint over mid and better parents. These results suggested that the best pentaploid hybrid i.e., pentaploid x NIAB-78 exceeded the best tetraploid hybrid (B-909 x NIAB-78) by 102.33 and 72.83% against respective mid and better parents. Heterosis in ginning outturn was also noted by Ghulam *et al.*, (1987) and Baloch *et al.*, (1991) in intra-hirsutum crosses.

*6. **Staple length (mm):*** The differences among mid parents and F_1 hybrids from both the sets of crosses for staple length were highly significant (Tables 1 and 2). The pentaploid and tetraploid hybrids showed mixed trends of positive and negative heterosis for staple length against mid and better parents (Tables 3 and 4). Moreover, there was no conspicuous differences in the ranges of pentaploid and tetraploid hybrids. However,

Table 4. Heterosis in various characters from tetraploid x tetraploid Crosses.

Character Studied	Crosses	Mother parent	Pollen parent	Mid parent	F_1 hybrid	Percentage increase (+) or decrease (-) of F_1 over	
						Mid Parent	Better Parent
	B-909 x NIAB-78	87.50	110.00	98.75	108.80	10.18	-1.20
Plant	B-909 x 108F	87.50	89.80	88.65	102.30	15.40	13.92
height	B-909 x Rahans	87.50	125.50	106.50	122.60	15.17	-2.31
(cms)	NIAB-78 x 108F	110.80	89.80	100.30	112.70	12.36	1.71
	NIAB-78 x Rajhans	110.80	125.50	118.15	130.90	10.50	4.30
	108F x Rajhans	89.80	125.50	107.65	130.80	21.50	4.22
	Mean:					14.17	3.44
	B-909 x NIAB-78	10.17	9.76	9.97	10.77	8.02	5.90
Mid-lobe	B-909 x 108F	10.17	9.87	10.07	10.72	6.99	5.41
leaf	B-909 x Rajhans	10.17	9.66	9.92	10.82	9.07	6.39
length	NIAB-78 x 108F	9.76	9.87	9.82	10.52	7.13	6.59
(cms)	NIAB-78 x Rajhans	9.76	9.66	9.71	10.81	11.33	10.76
	108F x Rajhans	9.87	9.66	9.77	10.57	8.19	7.09
	Mean:					8.46	7.02
	B-909 x NIAB-78	4.85	4.60	4.73	5.33	12.68	9.90
Mid-lobe	B-909 x 108F	4.85	4.73	4.79	5.29	10.44	9.07
leaf	B-909 x Rajhans	4.85	4.55	4.70	5.37	14.26	10.72
Width	NIAB-78 x 108F	4.60	4.73	4.67	5.17	10.71	9.30
(cms)	NIAB-78 x Rajhans	4.60	4.55	4.58	5.16	12.66	12.17
	108F x Rajhans	4.73	4.55	4.64	5.26	13.36	11.21
	Mean:					12.35	10.40

Table 4 (Cont'd)

Character Studied	Crosses		Mother parent	Pollen parent	Mid parent	F_1 hybrid	Percentage increase (+) or decrease (-) of F_1 over	
							Mid Parent	Better Parent
	B-909	x NIAB-78	105.80	80.00	92.90	131.90	41.98	24.67
Yield of	B-909	x B-108F	105.80	108.00	106.00	129.75	21.38	20.14
seed-	B-909	x Rajhans	105.80	59.00	82.40	97.40	18.20	-7.94
cotton	NIAB-78	108F	80.00	108.00	94.00	135.00	43.62	25.00
(gms)	NIAB-78	x Rajhans	80.00	59.00	69.50	83.60	20.29	4.00
	108F	x Rajhans	108.00	59.00	83.50	98.50	17.96	-8.80
		Mean					27.24	9.51
	B-909	x NIAB-78	33.2	33.5	33.35	34.35	3.00	2.54
Ginning	B-909	x 108F	33.2	33.8	33.50	34.30	2.39	1.48
outturn	B-909	x Rajhans	33.2	32.9	33.05	33.65	1.82	1.36
percentage	NIAB-78	x 108F	33.5	33.80	33.65	34.55	2.67	2.22
	NIAB-78	x Rajhans	33.5	32.9	33.20	33.00	-0.60	-1.49
	108F	x Rajhans	33.8	32.9	33.35	34.05	2.10	0.74
		Mean:					1.99	1.14
	B-909	x NIAB-78	27.0	26.5	26.75	26.20	-2.06	-2.96
Staple	B-909	x 108F	27.0	26.5	26.75	27.50	2.80	1.85
length	B-909	x Rajhans	27.0	26.8	26.90	27.60	2.60	2.22
(mms)	NIAB-78	x 108F	26.5	26.5	26.50	26.40	-0.38	-0.38
	NIAB-78	x Rajhans	26.5	26.8	26.65	26.70	0.19	-0.37
	108F	x Rajhans	26.5	26.8	26.65	27.00	1.31	0.75
		Mean:					0.74	0.19

the hybrid pentaploid x B-909 manifested maximum heterosis of 2.21 and 1.84% respectively against mid and better parents, whereas two out of six tetraploid hybrids exhibited maximum heterosis of 2.80 and 2.22% against their respective mid and better parents. Our present findings are in accordance with those of Vallejo *et al.*, (1974), Khan *et al.*, (1978), Choudhry *et al.*, (1978), Ahmed & Panhwar (1987), Ghulam *et al.*, (1987) and Baloch *et al.*, (1991) who have already reported heterosis for this character in cotton.

References

Ahmed, M. and A.M. Memon. 1971. Morphological, cytological and fertility studies in Pentaploid. *The Pakistan Cottons*, 15: 157-168.

Ahmed M., M.H. Channa and B.A. Soomro. 1981. Hybrid vigour in some morphological characters of *Gossypium hirsutum* cottons. *The Pak. Cottons*, 28: 77-87.

Ahmed, M. and G.N. Panhwar. 1987. Assesment of *Gossypium hirsutum Gossypium barbadense* F1 hybrids against commercial variety Qalandari. *The Pak. Cottons*, 31: 25-30.

Aslam, M. and M.A. Khan. 1983. Heterosis, heterobeltiosis and inbreeding depression estimates of yield and yield components in some intraspecific crosses of cotton *Gossypium hirsutum* L. *The Pak. Cottons*, 27: 187-197.

Baloch, M.J., G.H. Tunio and A.R. Lakho. 1991. Expression of heterosis in F_1 and its deterioration in intrahirsutum F_2 hybrids *Pakphyton*, 3: 95-106.

Choudhary M.A., M.A. Khan and M. Khan. 1978. Heterosis for quality characters in intraspecific crosses of *Gossypium hirsutum L. The Pak. Cottons*, 23: 49-58.

Deodikar, G.B. 1949. Cytogenetic studies on crosses of *Gossypium anomalum* with cultivated cottons. I. (*G. hirsutum* x *G. anomalum* doubled x *G. hirsutum*). *Indian J.S. Agric. Sci.*, 19: 389-399.

Ghulam, M., S. Hassan, N.H. Shah and G. Hassan 1987. Manifestation of heterosis in diallel crosses of *Gossypium hirsutum* L. *The Pak. Cottons*, 31: 177-185.

Khan, M.A. and A.D. Bhatti. 1978. Heterosis and combining ability for yield in intraspecific diallel crosses of cotton (*Gossypicum hirsutum* L.). *The Pak. Cottons*, 22: 117-29.

Khan, W.S., A. Latif and H. Ali. 1978. Heterosis in some intraspecific crosses of cotton (*Gossypium hirsutum* L.) and their performance in F_2 generation. *The Pak. Cottons*, 22: 139-145.

Khan, W.S. and H. Ali 1980. Hybrid vigour for seed cotton yield and its components in *Gossypium hirsutum* L., crosses. *The Pak. Cottons*, 24: 225-239.

Khan, M.A. and A. Ghafoor. 1991. Combining ability for yield and its components in up-land cotton. *Pak. J. Agric. Res.*, 12: 18-23.

Mirza, S.H. 1986. Heterosis and heterobeltiosis estimates for plant height, yield and its components in intraspecific diallel crosses of *Gossypium hirsutum* L. *The Pak. Cottons*, 30: 13-22.

Mithaiwala, I.K., M.J, Mirbahar, A.A. Channa and G.H. Kalwar. 1984. Estimation of heterosis in F1 crosses of *Gossypium hirsutum* L. The Pak. Cottons, 28: 77-87.

Sarwar, G., A. Hussain, M. Salam and M.A. Choudhary. 1979. Hybrid vigour for seed cotton yield and its components in some intraspecific crosses of *Gossypium hirsutum* L. *The Pak. Cottons*, 23: 127-132.

Steel, R.G.D. and J.H. Torrie. 1980. *Principles and procedures of statistics. Abiometrical approach.* McGraw-Hill Book Company, USA.

Vallejo, R.E., V.O. Marin and A.R. Bravo. 1974. Study on heterosis and gene action governing eleven characteristics in five crosses of Upland cotton (*Gossypium hirsutum* L.). *Insitute Colombiano Agropecuario*, Palmira, Colombia, 9: 271-296.

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