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EXPLORING HETEROSIS FOR SEED COTTON YIELD IN UPLAND COTTON UNDER DIFFERENT IRRIGATION REGIMES

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Abstract

An experiment during the years 2003 and 2004 was conducted to explore the Heterosis in 15 F_1 hybrids along with the performance of 6 parents regarding seed cotton yield per plant under 3 irrigation treatments (2, 4 and 7 irrigations). Results revealed that statistically all the parents and hybrids exhibited significant variation among them. Parents Marvi, CRIS-134 and CRIS-52 showed better performance regarding seed cotton yield per plant under all the three irrigation treatments. Hybrids Marvi x CRIS-134, Marvi x CRIS191 and CRIS-52 x CRIS-191 showed positive and constantly higher heterosis estimates over mid and better parent values under all the three irrigation treatments. Thus these parents viz., Marvi, CRIS-134 and CRIS-52 are recommended for sowing in the areas where there is shortage of water. Further these parents may be utilized extensively to develop above three specific hybrids for sowing in drought conditions and also for development of commercial varieties resistant to drought for Sindh province.

Introduction

In Pakistan, cotton accounts for 60% of total foreign exchange earnings through the export of raw cotton and cotton products. It also provides raw material to local domestic cotton industry. It has 85% shares in the total vegetable oil produced in the country. Cottonseed cake, an important by-product, is a valuable source of protein for ruminant cattle. About 40% labour force of the country is employed in cotton fields and cotton processing mills (Cotistics, 2008). It accounts for 8.2% of the value added in agriculture and about 2% to GDP. Pakistan ranks fourth in area and production of cotton in the world. Pakistan has 9.36% of total world cotton area, 10.18% of production, 8.06% of consumption and 4.55% of total world export of raw cotton (Cotistics, 2008).

World crop production is largely limited by abiotic stresses such as drought temperature, salinity, water logging and flooding etc., (Boyer 1982). Among these, drought is the major abiotic stress causing not only significant yield reduction but also erratic variation from year to year in various cultivation zones. Economically, quite a number of species experience variable soil-water contents depending on irrigation, rainfall, leaf area, transpiration and evaporation index. Thus, during their life cycle, all crops experience drought of various intensities at one time or the other, causing yield reduction (Boyer 1982).

Plant breeders and plant physiologists are of the opinion that genotypes well adapted and higher yielding in drought areas can be bred and managed more effectively and efficiently, if their attributes that confer drought resistance could properly be identified and used as selection criteria in objectively defined breeding programs (Blum, 1983; Rosenow *et al*., 1983; Bidinger *et al*., 1982; Garrity *et al*., 1982).

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The most important development in plant breeding programs in recent decades has been the use of heterosis or hybrid vigour. Heterosis is the superiority of a hybrid over its mid parent value (relative heterosis) or over its better parent (heterobeltiosis). It is now well established fact that heterosis does occur in the hybrids when the most appropriate and compatible combinations of parents are involved. Development of hybrids as a commercial variety is getting importance. In many cases, F_1 hybrids have been found out-yielding their parents or prevalent local best varieties used as check. This encourages studying the heterosis from wide array of parental combinations and identification of best combinations.

Heterosis has substantially remained as one of the significant developments in cotton breeding programs. The glaring examples include: Soomro and Kalhoro, (2000); Soomro *et al*., (2000); Ansari *et al*., (2000); Saira *et al*., (2001); Solangi *et al*., (2001); Tunio *et al*., (2001); Lakho *et al*., (2001); Chang *et al*., (2001); Baloch *et al*., (2001); Dayo *et al*., (2002); Panhwar *et al*., (2002); Rehana *et al*., (2002); Soomro *et al*., (2002); Baloch *et al*., (2002); Baloch *et al*., (2003); Ansari *et al*., (2004); Ansari *et al*., (2005); Memon *et al*., (2005); Ansari *et al*., (2006).

Soomro, *et al*., (2005) investigated economic heterosis in 12 F_1 hybrids and 2 commercial checks. They recorded maximum increase of 61.3% over CIM-499 by hybrid H-448 for number of bolls/plant and 105.1% over CIM-499 by hybrid H-458 for yield/plant. They concluded that 6 hybrids out of 12, were high yielding, therefore, may extensively be exploited for development of commercial hybrid cotton and as well as commercial varieties for getting maximum seed cotton yield.

Leghari, *et al*., (2005) evaluated 12 F_1 intraspecific crosses belonging to *Gossypium hirsutum* L., for combining ability effects (general and specific) for three economic traits viz., ginning outturn percentage, staple length and seed cotton yield per plant. Mean squares revealed that GOT% and seed cotton yield/plant were significant except staple length, which reflected non-significant differences. Variances for combining ability showed additive and dominant gene effects in all the characters. The parental variety Rehmani displayed maximum positive GCA effects in respect of seed cotton yield. The SCA effects were highly significant in hybrid Stoneville-213 x NIAB-78 for all the characters.

Soomro & Baloch (2005) made intrahirsutum crosses to study heterosis in F_1 hybrids over commercial variety Rehmani for number of bolls per plant, boll weight, seed cotton yield/plant, ginning outturn % and staple length mm. Results revealed that out of 12 F_1 hybrids, 10 showed positive heterosis for number of bolls, 9 for boll weight and 10 for seed cotton yield per plant in the range of 4.35 to 86.69%, 0.83 to 31.08% and 12.83 to 52.63% respectively. The most successful cross was TS-31/89 x Shahbaz-95 showing 86.96%, 26.04%, 52.63% and 8.64% increase in number of bolls per plant, boll weight, seed cotton yield per plant and staple length over Rehmani standard.

Gamal, *et al*., (2009) conducted study on heterosis estimation under drought conditions. They established crosses among 6 local cotton varieties viz., Giza-88, Giza 90, Giza 87, Giza 89, Giza 91 and Giza 83 in order to estimate the genetic parameters of seed-cotton yield and its components under two divergent environments of clay-fertile and sandy-calcareous infertile soils.

The average reduction in seed-cotton yield/plant under drought stress was 42 and 37.4% and in lint yield/plant was 46.2 and 40.5% for the parent and their F_1 hybrids, respectively.

The objective of the present investigation was to identify those hybrids which possess superior hybrid vigour for seed cotton yield under different irrigation stresses.

Material and Methods

Exploration of hybrid vigour in some cotton hybrids under different irrigation regimes was made, in this regard, an experiment was laid out on the experimental field of Shah Abdul Latif University, Khairpur during cotton seasons 2003 and 2004. Six varieties were planted during the year 2003 to make hybridization in all possible combinations excluding reciprocals. At least 30 pollination attempts were made to get enough seed for sowing as F_1 during next season. In this way 15 cross combinations were made and in the end of season successful crossed bolls were picked, ginned and seed was preserved for sowing as F_1. In the year 2004, six parents along with 15 F_1 hybrids were sown for exploration of hybrid vigour for seed cotton yield in a split plot design replicated thrice keeping genotypes in main blocks and three irrigation treatment in sub plots.

The irrigation treatments and genotype details are as under:

Genotypes (main plots)

Parents

1. CRIS-9	**3.** MARVI	**5.** CRIS-110
2. CRIS-134	**4.** CRIS-52	**6.** CRIS 191

Hybrids

1. CRIS-9 x CRIS-134	**6.** CRIS-134 x MARVI	**11.** MARVI x CRIS-110
2. CRIS-9 x MARVI	**7.** CRIS-134 x CRIS-52	**12.** MARVI x CRIS-191
3. CRIS-9 x CRIS-52	**8.** CRIS-134 x CRIS-110	**13.** CRIS-52 x CRIS-110
4. CRIS-9 x CRIS-110	**9.** CRIS-134 x CRIS-191	**14.** CRIS-52 x CRIS-191
5. CRIS-9 x CRIS-191	**10.** MARVI x CRIS 52	**15.** CRIS-110 x CRIS-191

Irrigations (sub plots):

I1 = Two Irrigation = 60 + 100 dap (dap= days after planting)
I2 = Four Irrigations = 50 + 70 + 90 + 110 dap
I3 = Seven Irrigations = 35 + 50 + 65 + 80 + 95 + 110 + 125 dap

Three seeds were dibbled per hill spaced at one foot; the rows were distanced at 2.5 feet from each other. Later, one healthy plant was left per dibble. Three rows of 10 feet were provided to each entry in each replication. Total of 21 entries (15 one way crosses + 6 parents) were sown as F_1 during 2004. Ten plants were randomly selected per entry per replication and treated as index plants for recording observations on seed cotton yield per plant. The mean performance of parents and hybrids regarding seed cotton yield was worked out. The data obtained from F_1 population and their parents was also computed for heterotic performance as per formula developed by Fonesca (1965) as follows:

$$\text{Mid parent value (MP)} = \frac{P1 + P2}{2}$$

High parent value was counted as Better Parent (BP)

$$\text{Mid parent heterosis (Relative heterosis)} = \frac{F_1\text{-MP} \times 100}{MP}$$

$$\text{Better Parent heterosis (Heterobeltiosis)} = \frac{F_1\text{-BP} \times 100}{BP}$$

Table 1. Mean performance of six parents and 15 hybrids for seed cotton yield per plant (gm) under different irrigation treatments during 2004 in experimental plot at SALU, Khairpur.

	Two Irrigations	Four Irrigations	Seven Irrigations
Parents			
CRIS-9	29.83CD	77.32AB	87.48A
CRIS-134	29.32CD	69.83AB	76.95AB
MARVI	34.04CD	57.14B	74.95AB
CRIS 52	30.04CD	56.76B	73.34AB
CRIS-110	23.09E	50.78B	62.52B
CRIS 191	19.72E	38.12C	45.29C
Hybrids			
CRIS-9 x CRIS-134	35.79CD	37.76C	44.69C
CRIS-9 x MARVI	53.38BC	56.76B	58.67BC
CRIS-9 x CRIS-52	29.28CD	37.54C	43.30C
CRIS-9 x CRIS-110	36.35CD	37.73C	43.80C
CRIS-9 x CRIS-191	44.09BC	48.81B	49.93BC
CRIS-134 x MARVI	79.11A	81.18A	92.49A
CRIS-134 x CRIS-52	36.28CD	44.26BC	50.38BC
CRIS-134 x CRIS-110	46.88BC	49.91B	55.85BC
CRIS-134 x CRIS-191	48.49BC	51.06B	61.71B
MARVI x CRIS 52	51.72BC	58.91B	61.36B
MARVI x CRIS-110	42.32BC	45.20BC	47.91C
MARVI x CRIS-191	64.29AB	60.99AB	68.81B
CRIS-52 x CRIS-110	66.29AB	69.85AB	77.19AB
CRIS-52 x CRIS-191	52.52BC	55.73B	59.68BC
CRIS-110 x CRIS-191	45.46BC	49.10B	62.72B

Means followed by similar letter do not differ significantly according to DMR test

Results and Discussion

An experiment was laid out to explore the heterosis for seed cotton yield per plant under three irrigation regimes (two, four and seven irrigations) in 6 parents and 15 hybrids (total 21 entries). The mean performance of parents and 15 F_1 hybrids for seed cotton yield per plant under three irrigation treatments is presented in Table 1. Statistically, all the parents and F_1 hybrids showed significant variation under all the irrigation treatments for seed cotton yield per plant. Numerically, among the parents, Marvi produced highest seed cotton yield per plant of 34.04gm when it was irrigated two times but it was statistically at par with other three parents (CRIS-9, CRIS-134 and CRIS-152).

When these parents were irrigated four times, CRIS-9 yielded highest (77.32gm) and was statistically at par with CRIS-134. Again CRIS-9, when irrigated with normal dose (7 irrigations), yielded highest (87.48gm) followed by CRIS-134, Marvi and CRIS-52.

Among the parents, it was observed that Marvi can resist the water stress shock and may perform better than other varieties followed by CRIS-9 and CRIS-134.

As regards to 15 hybrids, the data presented in Table 1 revealed that highest yield per plant of 79.11gm was produced by hybrid CRIS-134 x Marvi when irrigated two times only. Both the parents involved in this hybrid had individually performed higher also under 2 irrigations. Other two hybrids CRIS-52 x CRIS-110 (66.29gm) and Marvi x CRIS-191 (64.29gm) also performed better under two irrigations, this might be due to the presence of Marvi as one of the two parents in this hybrid because Marvi has already performed better under tow irrigations. Under 4 irrigations, hybrid CRIS-134 x Marvi excelled all other hybrids by producing 81.18gm seed cotton yield per plant followed by CRIS-52 x CRIS-110 (69.85gm) and Marvi x CRIS-9 (60.99gm). Thus it is clear that when ever parents Marvi, CRIS-134 and CRIS-52 are involved, the hybrids performed best under water stress conditions.

Again CRIS-134 x Marvi produced highest seed cotton yield per plant of 92.49gm when it was irrigated normally (7 irrigations) followed by same two hybrids (CRIS-52 x CRIS-110 and Marvi x CRIS-191) which yielded better than other hybrids under water stress conditions. It is obvious from the data in Table 1 that parents Marvi, CRIS-134 and CRIS-52 individually as well as in hybrid combinations can perform better under water stress and as well as in normal irrigated environment. It is suggested that the above three parents may extensively be used in hybridization for development of hybrids and commercial varieties which may be planted where there is shortage of irrigation water.

Regarding the exploration of heterosis (hybrid vigour), 15 hybrids were also sown under three irrigation regimes. Heterosis was calculated as percent increase or decrease of F_1 hybrids over their respective mid and better parent values under each of three irrigation treatments {(Table 2 (2 irrigations); Table 3 (4 irrigations) and Table 4 (7 irrigations)}.

Table 2. Heterosis estimates of seed cotton yield per plant under 2 irrigations during the year 2004 in experimental plot at SALU, Khairpur.

Entry/Treatment	Female parent	Male parent	F_1 hybrid	Mid parent	Better parent	% Increase (+) or Decrease (-) over	
						Mid parent	Better parent
Hybrids							
CRIS-9 x CRIS-134	29.83	29.32	35.79	29.575	29.83	17.37	16.65
CRIS-9 x MARVI	29.83	34.04	53.38	31.935	34.04	40.17	36.23
CRIS-9 x CRIS-52	29.83	30.04	29.28	29.935	30.04	-2.24	-2.60
CRIS-9 x CRIS-110	29.83	23.09	36.35	26.46	29.83	27.21	17.94
CRIS-9 x CRIS-191	29.83	19.72	44.09	24.775	29.83	43.81	32.34
CRIS-134 x MARVI	29.32	34.04	79.11	31.68	34.04	59.95	56.97
CRIS-134 x CRIS-52	29.32	30.04	36.28	29.68	30.04	18.19	17.20
CRIS-134 x CRIS-110	29.32	23.09	46.88	26.205	29.32	44.10	37.46
CRIS-134 x CRIS-191	29.32	19.72	48.49	24.52	29.32	49.43	39.53
MARVI x CRIS 52	34.04	30.04	51.72	32.04	34.04	38.05	34.18
MARVI x CRIS-110	34.04	23.09	42.32	28.565	34.04	32.50	19.57
MARVI x CRIS-191	34.04	19.72	64.29	26.88	34.04	58.19	47.05
CRIS-52 x CRIS-110	30.04	23.09	66.29	26.565	30.04	59.93	54.68
CRIS-52 x CRIS-191	30.04	19.72	52.52	24.88	30.04	52.63	42.80
CRIS-110 x CRIS-191	23.09	19.72	45.46	21.405	23.09	52.91	49.21

Table 3. Heterosis estimates of seed cotton yield per plant under 4 irrigations during the year 2004 in experimental plot at SALU, Khairpur.

Entry/Treatment	Female parent	Male parent	F_1 hybrid	Mid parent	Better parent	% Increase (+) or Decrease (-) over	
						Mid parent	Better parent
Hybrids							
CRIS-9 x CRIS-134	77.32	69.83	37.76	73.575	77.32	-94.85	-104.77
CRIS-9 x MARVI	77.32	57.14	56.76	67.23	77.32	-18.45	-36.22
CRIS-9 x CRIS-52	77.32	56.76	37.54	67.04	77.32	-78.58	-105.97
CRIS-9 x CRIS-110	77.32	50.78	37.73	64.05	77.32	-69.76	-104.93
CRIS-9 x CRIS-191	77.32	38.12	48.81	57.72	77.32	-18.25	-58.41
CRIS-134 x MARVI	69.83	57.14	81.18	63.485	69.83	21.80	13.98
CRIS-134 x CRIS-52	69.83	56.76	44.26	63.295	69.83	-43.01	-57.77
CRIS-134 x CRIS-110	69.83	50.78	49.91	60.305	69.83	-20.83	-39.91
CRIS-134 x CRIS-191	69.83	38.12	51.06	53.975	69.83	-5.71	-36.76
MARVI x CRIS 52	57.14	56.76	58.91	56.95	57.14	3.33	3.00
MARVI x CRIS-110	57.14	50.78	45.20	53.96	57.14	-19.38	-26.42
MARVI x CRIS-191	57.14	38.12	60.99	47.63	57.14	21.91	6.31
CRIS-52 x CRIS-110	56.76	50.78	69.85	53.77	56.76	23.02	18.74
CRIS-52 x CRIS-191	56.76	38.12	55.73	47.44	56.76	14.88	-1.85
CRIS-110 x CRIS-191	50.78	38.12	49.10	44.45	50.78	9.47	-3.42

Table 4. Heterosis estimates of seed cotton yield per plant under 7 irrigations during the year 2004 in experimental plot at SALU, Khairpur.

Entry/Treatment	Female parent	Male parent	F_1 hybrid	Mid parent	Better parent	% Increase (+) or Decrease (-) over	
						Mid parent	Better parent
Hybrids							
CRIS-9 x CRIS-134	87.48	76.95	44.69	82.22	87.48	-83.97	-95.75
CRIS-9 x MARVI	87.48	74.95	58.67	81.22	87.48	-38.43	-49.11
CRIS-9 x CRIS-52	87.48	73.34	43.30	80.41	87.48	-85.70	-102.03
CRIS-9 x CRIS-110	87.48	62.52	43.80	75.00	87.48	-71.23	-99.73
CRIS-9 x CRIS-191	87.48	45.29	49.93	66.39	87.48	-32.96	-75.21
CRIS-134 x MARVI	76.95	74.95	92.49	75.95	76.95	17.88	16.80
CRIS-134 x CRIS-52	76.95	73.34	50.38	75.15	76.95	-49.16	-52.74
CRIS-134 x CRIS-110	76.95	62.52	55.85	69.74	76.95	-24.86	-37.78
CRIS-134 x CRIS-191	76.95	45.29	61.71	61.12	76.95	0.96	-24.70
MARVI x CRIS 52	74.95	73.34	61.36	74.15	74.95	-20.84	-22.15
MARVI x CRIS-110	74.95	62.52	47.91	68.74	74.95	-43.47	-56.44
MARVI x CRIS-191	74.95	45.29	68.81	60.12	74.95	12.63	-8.92
CRIS-52 x CRIS-110	73.34	62.52	77.19	67.93	73.34	12.00	4.99
CRIS-52 x CRIS-191	73.34	45.29	59.68	59.32	73.34	0.61	-22.89
CRIS-110 x CRIS-191	62.52	45.29	62.72	53.91	62.52	14.05	0.32

The heterosis estimates data for seed cotton yield per plant under two irrigations are presented in Table 2 which shows that highest percent increase over mid parent (59.95%) and over better parent (56.97%) was given by the hybrid CRIS-134 x Marvi followed by the hybrids CRIS-52 x CRIS-110 (59.3% over mid parent and 54.68% over better parent) and Marvi x CRIS-191 (58.19% over mid parent and 47.05% over better parent) under two irrigations. Out of 15, only one hybrid (CRIS-9 x CRIS-52) showed negative heterosis against mid as well as better parent values.

The similar trend of heterosis over mid and better parent values as observed in 2 irrigation regimes was recorded when the hybrids were irrigated 4 and 7 times (Table 3 and 4). The same hybrids CRIS-134 x Marvi, Marvi x CRIS-191 and CRIS-52 x CRIS-191 showed positive and higher increase over their mid and better parent values under 4 and 7 irrigation treatments but almost all other remaining hybrids showed negative heterosis in both the treatments, this is some what confusing and might be due to an error in the experimentation or changed behaviour of genotypes in the two irrigation regimes i.e., four and seven irrigations. However, considering the continuous better performance of parents CRIS-134, Marvi, CRIS-52 and the hybrids CRIS-134 x Marvi, Marvi x CRIS-191 and CRIS-52 x CRIS-191 in all the three irrigation regimes (water stress and normal irrigation), it is recommended that these parents and their specific hybrids may extensively be utilized in hybridization program for development of drought resistant hybrids and commercial varieties for the province of Sindh.

The present results are in accordance with the results of Gamal *et al*., (2009) who noticed the average reduction of 42 and 37.4% in seed cotton yield/plant and in lint yield/plant it was 46.2 and 40.5% for the parents and their F_1 hybrids under drought stress. In present study parents and hybrids showed considerable reduction in seed cotton yield when irrigated two and four times as against the normal irrigation of seven times. Soomro and Baloch (2005) made intrahirsutum crosses to study heterosis in F_1 hybrids over commercial variety Rehmani for number of bolls per plant, boll weight, seed cotton yield/plant, ginning outturn% and staple length mm and reported that out of twelve F_1 hybrids, 10 showed positive heterosis for number of bolls, 9 for boll weight and 10 for seed cotton yield per plant in the range of 4.35 to 86.69%, 0.83 to 31.08% and 12.83 to 52.63% respectively. The most successful cross was TS-31/89 x Shahbaz-95 showing 86.96%, 26.04%, 52.63% and 8.64% increase in number of bolls per plant, boll weight, seed cotton yield per plant and staple length over Rehmani standard.

While comparing the present study with that of Soomro and Baloch (2005), it is observed that the present results are more or less in similarity as maximum heterosis of 59.59% and 59.93% in respect of seed cotton yield per plant was exhibited by the two hybrids CRIS-134 x Marvi and CRIS-52 x CRIS-110 respectively. The maximum heterosis in seed cotton yield per plant of 59.5% obtained in present study also coincide the heterosis obtained by Soomro, *et al*. (2005) who recorded maximum increase of 61.3% over CIM-499 by hybrid H-448 for number of bolls/plant and 105.1% over CIM-499 by hybrid H-458 for yield/plant. They concluded that out of twelve, six hybrids were high yielding, therefore, may extensively be exploited for development of commercial hybrid cotton and as well as commercial varieties for getting maximum seed cotton yield.

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