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ISOLATION OF DROUGHT RESISTANT UPLAND COTTON (*GOSSYPIUM HIRSUTUM*)HYBRIDS THROUGH ECONOMIC HETEROSIS

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ABSTRACT

In order to isolate drought resistant cotton hybrids through economic heterosis, a field experiment was conducted at Seri Farm, 10 kilometers in the south of Hyderabad, during 2007 and 2008. Six parents and 15 F_1 hybrids were planted under well watered and water stressed treatments to assess their drought resistance. Results revealed that statistically there was highly significant difference among parents and hybrids. Compared to well watered treatment, parents grown in water stressed treatment produced 42% lower seed cotton yield plant^{-1}. Similarly hybrids grown in water stressed treatment gave 37% lower yield than the hybrids grown well watered treatment. Among 15 hybrids tested, three (CRIS-342 x CRIS 121, CRIS-342 x alandri and CRIS-121 x NIAB-78) were isolated as drought resistant genotypes.

Keywords: F1 generation, Parents, Seedcotton yield, Useful heterosis, water stress.

INTRODUCTION

Improving seedcotton yield has been an ultimate objective of many cotton breeding programs, especially under adverse environment conditions. In particular, the environment where water availability is the most limiting factor. Drought stress is among the most important environmental factors that influences the yield components of cotton. Reduction in seedcotton yield is mainly attributed to deficient soil moisture. Thus, breeding cotton for stress environment depends on its ability to resist drought (Fischer and Maurer, 1978).

Plant breeders and physiologists are of the opinion that the well adapted and higher yielding genotypes can be breed in drought areas. They can be managed more effectively and efficiently, if their drought resistant

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characteristics are properly identified and used as selection criteria in objectively defined breeding programs (Blum 1983; Rsenow *et al.,* 1983; Bidinger *et al*., 1982; Garrity *et al*., 1982). Drought can also be managed by modifying plant morphology or incorporating some traits that can successfully help the plants to cope with drought stress (Yordanov *et al*., 2000). The genetic modification is thus the most successful and cheapest strategy to cope with drought stress. Since modifications within plant morphology and physiology introduced through breeding are heritable, once introduced into a breeding material it will be a permanent source of drought resistance. Heritable changes within a crop with the aim of improving drought resistance can be broadly considered as breeding for improved drought resistance.

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 higher yielding than 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 which can perform better under unfavorable conditions (water stress environment).

Gamal *et al*. (2009) conducted study on heterosis estimation under drought conditions and reported that the average reduction in seedcotton yield plant^{-1} under drought stress was 42 and 37.4% and in lint yield plant^{-1} was 46.2 and 40.5% for the parent and their F_1 hybrids, respectively. Soomro (unpublished data) conducted an experiment during the years 2001 and 2002 to explore the heterosis in 15 F_1 hybrids along with the performance of six parents regarding seedcotton yield plant^{-1} under three irrigation treatments (2, 4 and 7 irrigations). Statistically, all the parents and hybrids exhibited significant variation among them. Parents Marvi, CRIS-134 and CRIS- 52 showed better performance regarding seedcotton yield plant^{-1} under all the three irrigation treatments. Hybrids, Marvi x CRIS-134, Marvi x CRIS-191 and CRIS-52 x CRIS-191 showed positive and constantly higher heterosis estimates over mid and better parent values under all irrigation treatments. Other workers including, Soomro *et al*. (2005) investigated economic heterosis in twelve F_1 hybrids and two commercial checks. They recorded maximum increase of 61.3% over CIM-499 by hybrid H-448 for number of bolls plant^{-1} and 105.1% over CIM-499 by hybrid H-458 for seedcotton yield plant^{-1}. Leghari *et al*. (2005) evaluated 12 F_1 intra specific crosses belonging to *Gossypium hirsutum* L., for combining ability effects (general and specific) for three economic traits viz. ginning outturn %age (GOT), staple length and seedcotton yield plant^{-1}. Mean squares revealed that GTO% and seedcotton yieldplant^{-1} were significant, except staple length. 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 seedcotton yield. The SCA effects were highly significant in hybrid Stoneville-213 x NIAB-78. Soomro and Baloch (2005) reported that out of twelve F_1 hybrids, 10 showed positive heterosis for number of bolls, 9 for boll weight and 10 for seedcotton yield plant^{-1} in the range of 4.35 to 86.69%, 0.83 to 31.08% and 12.83 to 52.63%, respectively.

The objective of present study was to develop and isolate hybrids which can resist water stress environment and perform better in drought conditions.

MATERIALS AND METHODS

Six commercial upland cotton varieties namely CRIS-342, CRIS-467, CRIS-121, Shahbaz, NIAB-78 and Qalandri were chosen as parents for this study. A high yielding commercial variety CRIS-134 was also planted as the check variety in both the treatments (well watered and water stressed) to compare the performance of six parents and 15 hybrids against this variety. The seeds were planted at Seri Farm approximately 10 kilometers in the south of Hyderabad on main Hyderabad–Tando Mohammad Khan road. During the year 2007, above six cotton varieties were sown in the field and crossed in all possible combinations excluding reciprocals in order to obtain a total of 15 F_1 hybrid combinations.

In 2008, seed of the selected six parental varieties and 15 F_1 hybrids was sown at Seri Farm on two experimental sites. The first experiment was conducted under well watered conditions and was irrigated with first irrigation after 40 days of planting and the subsequent irrigations at a 12 days interval. The experiment received a total of eight irrigations. Meanwhile, the second experiment was carried out under the water stressed conditions, which received only four irrigations during the whole season. The first irrigation was applied 50 days after planting while the subsequent three irrigations were applied at a 20 days interval (after 70, 90 and110 days of planting). The experimental layout at each site was a Complete Randomized Block Design with three replications. The parents and the F_1 hybrids were represented by two rows of plants block^{-1}. Each row was 4 meter long, spaced at 60cm apart with plants spaced at 25 cm within rows. The agricultural practices recommended for cotton production were applied throughout the growing season. Measurements were recorded on a random sample of ten guarded plants for parents and the F_1 hybrids in each of the two experiments. Statistical analysis

(ANOVA) was performed following the method of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Mean squares computed through analysis of variance are depicted in Table 1 which demonstrate that both the treatments showed highly significant difference among the genotypes (6 parents and 15 F_1 hybrids). Mean performance regarding seedcotton yield plant^{-1} (g) of six parents and 15 hybrids for both the treatments is depicted in Table 2. On the average of all the parents, 44.88g seedcotton yield plant^{-1} was obtained in well watered treatment, while the water stressed treatment produced 26.02g of the seedcotton yield plant^{-1}.On the average, 42.02% yield reduction was noted under the water stressed treatment as compared to well water treatment. This overall reduction in yield is some what at a higher level but considering the water storage in the area this could be tolerable. Gamal *et al*. (2009) also reported similar results and recorded considerable yield loss given by the parents in their study.

Individually, CRIS-342 excelled all other varieties in both the irrigation treatments by producing 54.72g seedcotton yield plant^{-1} in well watered and 46.72g of seedcotton yield plant^{-1} in water stressed treatment. CRIS-121 ranked second (51.91g) and CRIS-467 ranked third (50.74g) in well watered treatment but these two varieties showed considerably higher reduction in yield under water stressed treatment (14.02 and 25.83%reduction, respectively) showing that varieties could not withstand the shock of water stress in comparison to CRIS-342 which showed minimum reduction (46.72) in seedcotton yield plant^{-1} under water stressed condition proving that it can tolerate the drought or shortage of water at greater extent. The Shahbaz variety did not show good performance in both irrigation regimes and was found as drought susceptible variety. Table 2 further demonstrated that on the average, F_1 hybrids produced 54.64g of seedcotton yield plant^{-1} under well watered treatment and 34.21g under water stressed condition. The reduction in yield due to water stressed treatment was recorded as 37.40%. The performance of F_1 hybrids remained better as compared to their parents in yield reduction %age as the hybrids recorded approximately 6% less yield loss (42.02 – 37.40 = 6%) as compared to their parents.

Table 1.Mean squares from analysis of variance for seedcotton yield plant^{-1} (g) for six parents and 15 F_1 hybrids grown in two irrigation treatments.

Sources of Variation	D.F	Well watered	Water stressed
Replications	2	83.55	72.05
Genotypes	20	134.28*	321.93*

*Significant at 0.01 probability level

Table2. Mean performance of six parents and 15 hybrids for seedcotton yield plant^{-1} (g) under well watered and water stressed treatments, during 2008.

Parents	Well watered	Water stressed
CRIS-342	54.72 b	46.72 ab
CRIS-467	50.74 bc	25.83 c
CRIS- 121	51.91 bc	30.41 bc
Shahbaz	27.64 d	14.02 d
NIAB- 78	36.51 c	19.15 cd
Qalandri	35.01 c	20.01 cd
Parents Mean	44.88	26.02
Reduction %	42.02%	---
CRIS-134(commercial Check)	49.45	29.33
Hybrids		
CRIS-342 x CRIS- 467	52.54 bc	36.42 b
CRIS-342 x CRIS-121	63.21 a	46.02 ab
CRIS-342 x Shahbaz	51.77 bc	29.77 c
CRIS-342 x NIAB-78	52.24 bc	47.03 a
CRIS-342 x Qalandri	61.48 a	38.87 b
CRIS-467 x CRIS-121	49.96 bc	34.85 b
CRIS-467 x Shahbaz	52.24 bc	43.78 ab
CRIS-467 x NIAB-78	54.57 b	28.22 c
CRIS-467 x Qalandri	58.13 ab	37.83 b
CRIS-121 x Shahbaz	56.84 ab	25.74 c
CRIS-121 x NIAB-78	59.91 a	49.11 a
CRIS-121 x Qalandri	52.65 bc	32.11 bc
Shahbaz x NIAB-78	50.48 bc	22.93 cd
Shahbaz x Qalandri	55.06 b	25.89 c
NIAB 78 x Qalandri	48.45 bc	14.53 d
Hybrid Mean	54.64	34.21
Hybrid Reduction %	37.4%	--

Means followed by similar letter do not differ significantly according to DMR test.
Reduction% of P= Parent well watered – Parent water stressed/Parent well watered x100.
Reduction % of H= Hybrid well watered – Hybrid stressed/Hybrid well watered x 100.

Three hybrids CRIS-342 x CRIS-121 (63.21g), CRIS- 342 x Qalandri (61.48g) and CRIS-121 x NIAB- 78 (59.91g) remained top yielding hybrids under normal or well watered treatment and were also statistically at par with each other. Thus three hybrids were among the top yielding hybrids under water stress conditions also hybrid CRIS-342 x NIAB-78 produced second higher yield (47.03g) under water stress treatment, this hybrid produced lesser yield (52.24g) in well watered treatment thus proved that it can resist drought or shortage of water to a greater extent. Drought susceptible hybrids recorded were NIAB-78 x Qalandri (14.53g), Shahbaz x Qalandri (25.89g), CRIS-121 x Shahbaz

(25.74g) as these hybrids gave lower seedcotton yield plant^{-1} under water stressed conditions. The results of present study are in line with those of Gamal*et al*. (2009). This study suggests that for the development of drought resistant hybrids and ultimate varieties, these specific crosses i.e. (CRIS-342 x CRIS- 121, CRIS-342 x Qalandri and CRIS-121 x NIAB-78) can be used as successful hybrids.

Usually heterosis is estimated as % increase or decrease of F_1 hybrids over mid parent or better parent values but a term of useful heterosis was suggested by Fonseca (1965) which interprets "% increase of F_1 hybrids over prevailing high yielding commercial variety". In this particular study, a commercial variety CRIS-134 was also tested for its seedcotton yield plant^{-1} under both the treatments. Table 3 showed useful heterosis estimates for seedcotton yield plant^{-1} under water stressed conditions. Highest useful heterosis was recorded by CRIS-121 x NIAB-78 (40.276%) followed by CRIS-342 x NIAB-78 (37.635%) and CRIS-342 x CRIS-121 (36.266%) under water stress condition.

Table3.Useful heterosis estimates for seedcotton yield plant^{-1}under water stressed treatments during 2008.

Entry/Treatment	F_1 Hybrid	CRIS -134 (Check)	% Increase (+) or decrease (-) over check
CRIS-342 x CRIS- 467	36.42	29.33	19.467
CRIS-342 x CRIS-121	46.02	29.33	36.266
CRIS-342 x Shahbaz	29.77	29.33	1.4779
CRIS-342 x NIAB-78	47.03	29.33	37.635
CRIS-342 x Qalandri	38.87	29.33	24.543
CRIS-467 x CRIS-121	34.85	29.33	15.839
CRIS-467 x Shahbaz	43.78	29.33	33.005
CRIS-467 x NIAB-78	28.22	29.33	-3.933
CRIS-467 x Qalandri	37.83	29.33	22.468
CRIS-121 x Shahbaz	25.74	29.33	-13.947
CRIS-121 x NIAB-78	49.11	29.33	40.276
CRIS-121 x Qalandri	32.11	29.33	8.657
Shahbaz x NIAB-78	22.93	29.33	-27.911
Shahbaz x Qalandri	25.89	29.33	-13.286
NIAB 78 x Qalandri	14.53	29.33	-101.858

These results are quite encouraging in the sense that in water shortage conditions, these hybrids can give 35-40 % more seedcotton yield plant^{-1} in comparison with the sowing of CRIS-134 as commercial variety. Out of 15 F_1 hybrids, only five hybrids gave negative heterosis, hence it is suggested that while attempting to produce drought resistant hybrids do not go for the above crosses at all and choose those hybrids which have potential of 35-40% more seedcotton yield than commercial variety.

Table 4 revealed the heterosis estimates of 15 hybrids over commercial variety CRIS-134 under well watered treatment which received normal eight irrigations. Data indicated that all the hybrids gave positive heterosis against the commercial variety only one hybrid NIAB-78 x Qalandri gave negative heterosis. The range of increase of hybrids over commercial variety was recorded from (-) 2.064 to (+) 21.768. Though the higher heterosis was given by those hybrids which gave higher heterosis in water stressed conditions but the %age recorded here in well water condition was quite low which suggests that the commercial variety CRIS-134 performed very well under well watered condition but could not withstand the water stress shock, hence performed somewhat poorer in water stressed treatment.

Table4.Useful heterosis estimates for seedcotton yield plant^{-1} under well watered treatments during 2008.

Entry/Treatment	F_1 Hybrid	CRIS -134 (Check)	% Increase (+) or decrease (-) over check
CRIS-342 x CRIS- 467	52.54	49.45	5.881
CRIS-342 x CRIS-121	63.21	49.45	21.768
CRIS-342 x Shahbaz	51.77	49.45	4.481
CRIS-342 x NIAB-78	52.24	49.45	5.341
CRIS-342 x Qalandri	61.48	49.45	19.567
CRIS-467 x CRIS-121	49.96	49.45	1.021
CRIS-467 x Shahbaz	52.24	49.45	5.341
CRIS-467 x NIAB-78	54.57	49.45	9.382
CRIS-467 x Qalandri	58.13	49.45	14.932
CRIS-121 x Shahbaz	56.84	49.45	13.001
CRIS-121 x NIAB-78	59.91	49.45	17.459
CRIS-121 x Qalandri	52.65	49.45	6.077
Shahbaz x NIAB-78	50.48	49.45	2.040
Shahbaz x Qalandri	55.06	49.45	10.188
NIAB 78 x Qalandri	48.45	49.45	-2.064

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 seedcotton yield plant^{-1} was exhibited by the two hybrids CRIS- 134 x Marvi and CRIS-52 x CRIS-110, respectively. The maximum heterosis over commercial variety CRIS-134 for seedcotton yieldplant^{-1} of 40.276% 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 $^{-1}$ and 105.1% over CIM-499 by hybrid H-458 for yield plant^{-1}. They concluded that out of twelve, six hybrids remained high yielding, therefore, may extensively be exploited for developing commercial hybrid cotton and as well as commercial varieties for achieving maximum cotton productions.

CONCLUSION

It can be concluded from the study that water stress environment decreases seedcotton yield by 42% in parents and 37% in hybrids. The results of present study suggest that the scientists working on development of drought resistant cotton cultivars may also consider these findings to save resources and time.

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