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Research Article

Heterosis and combining ability studies in upland cotton for yield characters

R. Pushpam*, K. Thangaraj and T. S. Raveendran
Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University,
Coimbatore – 641003
*E mail : pushpa_parthiban@yahoo.co.in

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Abstract
Ten Gossypium hirsutum lines tolerant to jassids were selected as donors along with three standard varieties *viz.,* MCU 5, MCU 7, MCU 12 for crossing programme. This study indicated the predominance of non additive gene effects for all the yield and yield contributing characters which signifies the scope for exploitation of heterosis. Among the lines, DHY 286, Badnawar 1 and SVPR 2 were found to be good general combiners for single plant yield. Among the jassid resistant parents, DHY 286 was found to possess more favourable genes for number of bolls per plant, boll weight, single plant yield and seed index. The highly resistant parent KC 2 was observed as good general combiner for bolls per plant and this parent can be used in breeding programme for improving yield coupled with resistance. The tester MCU 5 is a good general combiner for yield contributing traits. By hybridizing the resistant genotypes with MCU 5, favourable gene combinations could be accomplished for the yield and yield contributing characters. The hybrids showing high *per se* performance for yield, DHY 286 x MCU 5, Badnawar 1 x MCU 5, Badnawar 1 x MCU 7 and Badnawar 1 x MCU 12 also showed resistance to jassids and deserve further exploitation.

Key words
Cotton, heterosis, combining ability, *per se* performance, jassid resistance

Introduction:

Cotton is providing livelihood directly and indirectly to over 60 million people and accounting for about 16 per cent of India's export earnings. Hybrids have occupied nearly 90% area of cotton cultivated in India. There is a constant need to develop more potential hybrids and adopt novel approaches for improving hybrid performance. The degree of economic heterosis should be considered superior, if any of the F_1 hybrids performs better than the best commercial variety released for cultivation. Further, for hybridization programme, selection of parents is an important aspect in all the crop improvement programmes. Line x Tester analysis is a useful technique for identification of suitable cross combinations and parents to be used in crossing programme. Hence, the present investigation was undertaken to study the genetic architecture of genotypes to identify the best combiners which may be hybridized either to exploit or to build up the favourable fixable genes for effecting yield improvement.

Materials and method

In this experiment, ten Gossypium hirsutum lines tolerant to jassids were selected as donors along with three standard varieties *viz.,* MCU 5, MCU 7, MCU 12 for crossing programme. Each of the lines were crossed with the testers individually in a line x tester design. The 30 hybrids and their parents were raised in a randomized block design with three replications at Department of Cotton, TNAU, Coimbatore. The parents and the F_1's were grown in a single row of 6 m length with a spacing of 75 x 30 cm. At random, 10 plants of the parents and F_1's were taken for recording observations on days to first flowering, days to first boll bursting, plant height, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight and seed cotton yield per plant. The mean data were subjected to a Line x Tester analysis and combining ability effects and variances were estimated using the model suggested by Kempthorne (1957). The above lines, testers and the resulting 30 hybrids were screened for jassid resistance / tolerance under artificial conditions.

Result and discussion

The analysis of variance revealed significant differences among parents for all characters excepting boll weight and lint index. Variance due to lines was highly significant for the characters days to first flowering, days to first boll bursting, plant height, number of sympodia, number of bolls, seed cotton yield and ginning outturn. Variance due to testers was highly significant for days to first flowering, days to first boll bursting, plant height, number of sympodia, boll number and seed cotton yield. The variance due to interaction effect of lines and testers was significant for all characters except for boll weight, seed index and lint index. The variance due to SCA was larger than the variance of GCA for all the traits indicating preponderance of non-additive gene action in the expression of these characters.

Out of 30 crosses, 24 crosses showed significant positive heterosis for days to first flowering. For days to first boll bursting, four hybrids showed significant negative heterosis ranging from -10.00 to 7.06. In case of plant height, ten hybrids showed significant negative heterosis (Table 1). For seed cotton yield, DHY 286 x MCU 5 showed highest significant positive heterosis. In case of boll weight the hybrid DHY 286 x MCU 5 showed significant positive heterosis. Three hybrids showed significant positive heterosis for lint index, whereas, for ginning out turn only one hybrid showed significant positive heterosis. The cross DHY 286 x MCU 5 showed significant positive heterosis for single plant yield and boll weight. This cross may be used for simultaneous improvement of boll weight and seed cotton yield by reciprocal recurrent selection.

The *sca* variance was greater than the *gca* variance for all the 15 traits in this study which indicated the predominance of non additive gene action. This indicates the scope for exploitation of heterosis for the above traits. Predominance of non-additive gene action for yield was reported by many workers (Waldia *et al.,* 1980; Katageri *et al.,* 1992; Sudhanshu Jain, 1997; Abro, 2009 ; Ashokkumar *et al*., 2010).

Among the lines, DHY 286, Badnawar 1 and SVPR 2 were good general combiners for single plant yield (Table 2). DHY 286 which recorded the highest *gca* effect and also ranked first in *per se* performance. These parents with high mean performance and significant *gca* effects could produce trangressive segregants and they can be used in recombination breeding to obtain more favourable gene recombinations for seed cotton yield and associated traits. Good general combining parents have been reported for yield in many studies (Bhatade, 1982). For number of bolls per plant, DHY 286, Badnawar 1 and MCU 5 were good general combiners, and they also exhibited high *per se* performance. High combining ability with high *per se* performance for this trait was also reported by Jagtap *et al.* (1992).

KC 2, Badnawar 1 and MCU 5 were found to be good general combiners for days to first boll bursting. Combining ability studies for boll number revealed KC 2, SVPR 2, DHY 286, Badnawar 1 and MCU 5 to be good general combiners for boll number. In respect of *per se* performance, DHY 286, Badnawar 1, SVPR 2 and MCU 5 recorded higher values than other parents. The jassid resistant line DHY 286, in addition to resistance, had high *per se* performance and good general combining ability for the improvement of yield through boll number.

Among the resistant parents, DHY 286 was found to possess more favourable genes for number of bolls per plant, boll weight, single plant yield and seed index as seen from the positive and significant *gca* effects. This resistant parent also ranked first for number of bolls per plant, single plant yield, seed index, lint index and ginning outturn. While considering mean performance and *gca* effects together for selection of parents coupled with resistance, DHY 286 would be an ideal parent for improving single plant yield, bolls per plant and lint index.

Present investigation revealed that for the trait boll weight, DHY 286 and Badnawar 1 would serve as good general combiners. It was further revealed that the resistant variety Stoneville had significantly negative *gca* effect for important yield characters. *Per se* performance of this parent was also poor in most of the characters and may therefore be excluded from the crossing programme.

The highly resistant parent KC 2 was observed as a good general combiner for number of bolls per plant. So, this parent can be used in breeding programme for improving yield coupled with resistance. The resistant parent DHY 286 appeared to be a good general combiner for boll number, boll weight and single plant yield. The tester MCU 5 is a good general combiner for yield contributing traits. It may be concluded that by hybridizing the resistant genotypes with MCU 5, favourable gene recombination could be accomplished for the yield and other yield contributing characters.

In the present study, out of thirty hybrids, four hybrids *viz.,* KC 2 x MCU 7, SVPR 2 x MCU 12, DHY 286 x MCU 5, Khandwa 2 x MCU 7 showed significant positive *sca* effect for single plant yield (Table 3). Among these, only DHY 286 x MCU 5 had both the parents possessing high positive *gca* effects. Among these, two hybrids *viz*., DHY 286 x MCU 5, SVPR 2 x MCU 12 ranked first and second for *per se* performance. In the highest yielding combination DHY 286 x MCU 5, both the parents had high *gca* effects for yield. The other highest yielding combination was SVPR 2 x MCU 12 in which only one parent SVPR 2 had significant *gca* effects. The hybrids KC 2 x MCU 7, a resistant combination to jassid, had significant positive *sca* effects. However, both the parents were not general combiners for yield. Therefore, crosses in which at least one parent with high general combining ability for a particular trait is involved could be exploited for heterosis breeding. The combining ability of parents may be considered as a reliable estimate for the prediction of yield potential of a cross.

The hybrid DHY 286 x MCU 5 had high significant positive *sca* effect; both of its parents are good general combiners; highest *per se* performance for yield and also highly resistant to jassid. So, in resistant breeding programme, the best hybrid DHY 286 x MCU 5 is very much useful for combining high yield and jassid resistance. This hybrid is also having high *per se* performance for associated traits *viz.,* number of sympodia, number of bolls per plant, boll weight and ginning out turn. Hence, the hybrid DHY 286 x MCU 5 was found to be superior for high yield and jassid resistance. The hybrids showing high *per se* performance for yield viz., DHY 286 x MCU 5, Badnawar 1 x MCU 5, Badnawar 1 x MCU 7, Badnawar 1 x MCU 12, also showed high resistance to jassids and deserve further exploitation.

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Table 1. Standard heterosis for various characters in upland cotton

Characters	Number of crosses with desirable heterosis	Range of desirable heterosis	Best crosses
Days to first flowering	24	5.52 – 30.67	B 1007 x MCU 5 Laxmi x MCU 5 B 1007 x MCU 7 Laxmi x MCU 12 Laxmi x MCU 7
Days to first boll bursting	5	-10.00 – 7.06	DHY 286 x MCU 12 SRT 1 x MCU 7 SRT 1 x MCU 5 Badnawar 1 x MCU 5
Plant height (cm)	10	-20.76 – (-10.29)	KC 2 x MCU 5 Badnawar 1 x MCU 5 KC 2 x MCU 7 KC 2 x MCU 12
Boll weight (g)	2	10.24 – 11.40	B 1007 x MCU 12 DHY 286 X MCU 5
Seed cotton yield / plant (g)	1	15.35	DHY 286 x MCU 5
Lint index	3	15.32 – 21.10	KC 2 x MCU 7 SRT 1 x MCU 12 Badnawar 1 x MCU 12
Ginning Out Turn	1		B 1007 x MCU 5

Table 2. Best general combiners for various yield characters

Characters	Best general combiners
Days to first flowering	Laxmi, Stoneville, B 1007
Days to first boll bursting	KC 2, Laxmi, Badnawar 1, MCU 5
Plant height(cm)	Laxmi
Number of bolls	KC 2, SVPR 2, DHY 286, MCU 5
Boll weight(g)	DHY 286, Badnawar 1
Seed cotton yield/ plant(g)	DHY 286, Badnawar 1, SVPR 2, MCU 5
Seed index	SRT 1, DHY 286, Badnawar 1
Lint index	Badnawar 1

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Table 3. Best specific combinations for various yield characters

Characters	Best specific combiners
Days to first flowering	Badnawar x MCU 7
	SVPR 2 x MCU 12
	SRT 1 x MCU 7
	B 1007 x MCU 5
Number of bolls	B 1007 x MCU 12
	SVPR 2 x MCU 7
	SVPR 2 x MCU 12
	Laxmi x MCU 12
Boll weight(g)	SVPR 3 x MCU 5
Seed cotton yield/ plant(g)	SVPR 2 x MCU 12
	DHY 286 x MCU 5
	Khandwa 2 x MCU 7
	KC 2 x MCU 7
Seed index	KC 2 x MCU 5,
	B 1007 x MCU 12,
	Badnawar 1 x MCU 7
Lint index	SRT 1 x MCU 12
	KC 2 x MCU 7
	Khandwa 2 x MCU 12