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HETEROSIS IN MULTIPLE ENVIRONMENTS FOR YIELD COMPONENTS AND ITS RELATION WITH GENETIC DIVERGENCE IN COTTON

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ABSTRACT

Heterosis for four major yield components of *G. hirsutum* L. cotton was estimated in a half diallel cross of nine genetically diverse parents. The heterosis in a single environment was 102.3% for boll number, 51.6% for boll weight and 139.3 and 169.4% for seed cotton and lint yield, respectively. Boll number appeared to be the major component of yield heterosis. G x E interaction was detected for all the four traits studied. The hybrids Laxmi x Kop-557 at Rahuri, Kop 557 x Kh-2 and Kop-557 x AC-738 at Padegaon, and Kop-557 x Kop-495 at Jalgaon, were most heterotic, while Reba-B-50 x Kh-2 and Laxmi x MCU-5 with standard heterosis of 47.1 and 25.3%, respectively, for seed cotton yield over H-4, were most promising. High heterotic crosses are not necessarily high yielding. While selecting parents for hybrid breeding programme on the basis of genetic divergence, their per se or cluster mean performance also needs to be considered.

Key words: Heterosis, multiple environments, genetic divergence.

The phenomenon of hybrid vigour in cotton has been confirmed beyond doubt [1] and its commercial exploitation has achieved a spectacular success in India, as is evident from the wide spread of Hybrid-4, Varalaxmi and DCH-32. However, much remains to be done for stabilizing and improving production by developing high yielding, stable varieties and hybrids both for rainfed and irrigated conditions. The varying magnitudes of heterotic effects observed suggest the need for assessing the hybrids/genotypes in multiple environments rather than to rely on a single environment. Efforts in the present study are, therefore, made to assess various hybrids for their heterotic responses under different environments.

MATERIALS AND METHODS

Thirty six crosses of nine parents of *G. hirsutum* L., *viz.*, Laxmi, Reba-B-50, Kop-557, MCU-5, SVM, AC-738, 064, Kop-495 and Kh-2, selected on the basis of genetic diversity, cluster means for economic and other desired attributes [2], crossed in half diallel, were evaluated along with the parents and three released hybrids including H-4 at three locations, Rahuri, Padegaon and Jalgaon, in randomized block design with two replications during 1983. Each genotype was represented by two rows, each with ten plants, at a spacing of 90 x 90 cm at Rahuri and Padegaon (irrigated) and at 60 x 60 at Jalgaon (rainfed). Observations were recorded on five randomly selected plants per replication in each treatment on seed cotton yield and its component characters like bolls per plant, boll weight, and lint yield per plant. Heterosis was estimated over better parent (BP) and tested for significance as per the procedure of Sharma and Singh [3]. BP heterosis for pooled means over locations was also estimated. Genotype x environment (G x E) interaction was determined as per Eberhart and Russell [4]. Relationship of heterosis with genetic divergence was estimated by D^2 Statistic as described by Rao [5].

RESULTS AND DISCUSSION

Multienvironment testing is necessary to properly evaluate hybrid combinations. Data of such testing from the present study revealed that the range of seed cotton yield of the parents and hybrids at Rahuri was form 85.7–140.9 and 82.0–220.2 g, respectively. At Padegaon, it ranged from 55.7–117.1 g in the case of parents and from 61.4–190.5 g for hybrids. However, at Jalgaon, the range was 49.8–113.5 g for parents and 62.6–174.9 g for hybrids, indicating wider differences in hybrid means than the parental means. Similar differences were also noted for the three other characters studied at all the locations.

Highly significant pooled deviation (nonlinear) for all the characters studied (Table 1) and significant linear component of G x E for boll number, seed cotton and lint yield per plant indicated the presence of G x E interaction for these traits which suggested the necessity of identifying promising/most heterotic crosses for specific locations.

Table 1. Analysis of variance for genotype x environment interaction

Source	d.f.	Boll No. per plant	Boll weight	Seed cotton yield per plant	Lint yield per plant
Genotypes	47	117.7**	0.25**	1620.6**	225.8**
Environments	2	4501.3**	12.15**	6508.6**	2063.1**
Genotypes x environments	94	60.6**	0.12**	831.5**	108.6**
Environment (linear)	1	9002.7**	24.30**	13017.2**	4126.1**
Genotypes x environments (linear)	47	79.7**	0.11*	981.4*	129.1*
Pooled deviation	48	40.6**	0.13**	666.5**	86.1**
Pooled error	141	4.6	0.02	52.7	7.6

*,**Significant at P = 0.05 and 0.01, respectively.

Heterosis for boll number per plant ranged from –37.8% (MCU-5 x 064) to 59.5% (MCU-5 x SVM) at Rahuri, from –23.8% (Kop-557 x Kop-495) to 102.3% (Kop- 557 x AC-738) at Padegaon, and from –30.9% (Kop-557 x 064) to 57.9% (Kop-557 xKop-495) at Jalgaon with significant estimates in the case of 14, 15 and 22 crosses at the respective locations. The parents involved in the crosses showing the highest and lowest values of heterosis at different locations showed that a parent in combination with one parent exhibiting lowest estimate of heterosis can also exhibit the highest magnitude of heterosis with other parent which may be due to specific combining ability of the other parent involved. The BP heterosis for boll weight was to the tune of 25.6% (AC-738 x Kop-495), 8.9% (MCU-5 x Kop-495), and 51.7% (Kop-557 x Kop-495) at Rahuri, Padegaon and Jalgaon, respectively. The magnitude of heterosis was, thus, higher for boll number than for boll weight. Similar observation was also reported by Bhandari [6]. Significant heterosis for bolls per plant, boll length and breadth [7], and high heterosis for bolls per plant [8, 9] has also been reported. Out of the four crosses exhibiting significant BP heterosis for boll number at all the locations (Table 2), three crosses, viz., Laxmi x MCU-5, MCU-5 x SVM, and MCU-5 x Kh-2, also appeared among the first five promising crosses (Table 3), recording standard heterosis (percentage increase over the check, H-4) above 25%, indicating consistency in their performance over locations. The number of crosses showing significant positive heterosis for boll weight was variable (7 at Rahuri, 2 at Padegaon and 24 at Jalgaon). Similarly, none of the crosses exhibited significant BP heterosis at all the locations (Table 2).

The crosses exhibiting significant BP heterosis at Rahuri, Padegaon and Jalgaon, respectively, were 18, 20 and 23 for seed cotton yield, and 16, 22 and 23 for lint yield. The range of BP heterosis for seed cotton yield at Rahuri, Padegaon and Jalgaon was –36.9–74.7%, –33.3–123.4%, and –34.1–139.3, respectively; and for lint yield –22.7–89.9%, –33.1–116.2% and –37.9–169.4% at the respective locations. The range thus indicated varying magnitude of heterosis at different locations, exhibiting pronounced effect of environment in the expression of these characters. Inconsistency in heterosis over environments in respect of both these characters was also observed by Deshpande [10]. This may be due to presence of strong G x E interaction as indicated by significant and higher estimates of linear and nonlinear components of G x E (Table 1), which confirms the earlier report [11]. High heterosis (13.6–108.8%) for seed cotton yield [6] and significant heterosis for both the yield components were reported earlier [9, 10, 12]. In this study, maximum heterosis was observed for lint yield, followed by seed cotton yield and bolls per plant.

It was interesting to note that more or less the same set of crosses (Table 2) exhibited significant/higher magnitude of positive heterosis at all the locations for seed cotton and lint yield. Moreover, most of the crosses, which had high/significant heterosis for boll number, also had high and significant heterosis for these traits. However, no such parallelism was observed for boll weight. This showed that boll number per plant is the major component contributing to yield heterosis. Similar observation was also reported by

[13]. However, Meredith and Bridge [14] observed heterosis for boll size contributing to yield. This may be due to close association of boll number and boll weight with yield, which are negatively correlated with each other [15]. Out of the first five heterotic hybrids (Table 2) for these two traits, three crosses involved MCU-5, the most divergent line [2], which confirms the role of genetic divergence in heterosis. Prasad and Siddique [16] also observed the highest heterosis in the cross involving this parent. Considering the BP heterosis observed for seed cotton and lint yield, the crosses Laxmi x Kop-557 at Rahuri, Kop-557 x Kh-2 and Kop-557 x AC-738 at Padegaon, and Kop-557 x Kop-495 at Jalgaon were the most heterotic, which also indicates important contribution of the parent, Kop-557 in producing the most heterotic crosses. However, the crosses Laxmi x MCU-5, MCU-5 x SVM, and Reba-B-50 x Kh-2 were promising in this respect over locations.

Table 2. First five crosses exhibiting significant/high magnitude of positive BP heterosis at each location with genetic divergence between their parents

Cross	Genetic distance (D) between parents involved	BP heterosis (%)		
		Rahuri	Padegaon	Jalgaon
	Bolls/plant			
MCU-5 x SVM	18.5	59.5**	88.2**	31.6**
MCU-5 x Kh-2	26.0	42.5**	88.6**	35.5**
Laxmi x MCU-5	17.8	41.2**	24.7**	34.3**
Reba-B-50 x Kh-2	15.8	17.9**	39.1**	15.6*
Laxmi x AC-738	19.1	35.2**	12.1	47.3**
SE ±	—	2.6	1.9	1.8
	Boll weight			
MCU-5 x Kop-495	20.7	22.5**	9.0*	2.0
064 x Kop-495	16.5	3.9	10.9*	26.2**
SVM x Kop-495	13.8	4.1	2.5	42.2**
Kop-557 x Kop-495	15.8	3.3	2.5	51.7**
MCU-5 x 064	14.1	6.0	0.4	20.7**
SE ±	—	0.1	0.2	0.2
	Seed cotton yield/plant			
Reba-B-50 x Kh-2	15.8	56.3**	44.1**	33.8**
Laxmi x MCU-5	17.8	52.1**	22.1**	52.2**
MCU-5 x SVM	18.5	43.3**	96.1**	55.7**
SVM x Kop-495	13.8	59.5**	13.2*	85.3**
MCU-5 x Kop-495	20.7	25.1**	27.0**	20.1*
SE ±	—	7.5	6.5	8.0
	Lint yield/plant			
Reba-B-50 x Kh-2	15.8	55.8**	49.3**	39.1**
Laxmi x MCU-5	17.8	50.9**	22.2**	60.7**
MCU-5 x SVM	18.5	37.6**	111.1**	66.0**
MCU-5 x Kop-495	20.7	21.1**	19.4**	26.7**
Laxmi x Kop-557	18.1	89.9**	17.6**	36.3**
SVM x Kop-495	13.8	61.7**	12.3**	94.3**
SE ±	—	2.8	2.4	3.1

*,**Significant at P = 0.05 and 0.01, respectively.

RELATIONSHIP OF MEAN PERFORMANCE, GENETIC DIVERSITY AND HETEROSIS

The genetic distances (D values) between the parents of the first five heterotic crosses

(Table 2) revealed that the crosses involving the parents with high genetic diversity among them (D = 13.8–26.0) recorded high heterosis. The crosses MCU-5 x 064, SVM x Kh-2 and Reba-B-50 x Kop-495 exhibiting the lowest (highest undesirable) heterosis for seed cotton yield at Rahuri, Padegaon and Jalgaon, respectively, though in general involved parents with low genetic diversity (D = 14.1, 13.6 and 9.1, respectively), some had substantial genetic diversity (D = 14.1), suggesting that the crosses with highly diverse parents are likely to exhibit the highest magnitude of undesired heterosis if due consideration to their per se performance is not given. Similar observations were made in maize [17]. In the case of boll weight, which showed relatively lower magnitudes of heterosis, the genetic distances between the parents (D = 13.8–20.7) of the most heterotic crosses were also smaller compared to other yield components studied.

The data in Table 3 show that i) the highly heterotic crosses may not be necessarily high yielding, ii) heterosis for lint yield appears to be related to heterosis in seed cotton yield which is, in turn related to heterosis for bolls per plant and, iii) the hybrids Reba-B-50 x Kh-2 and Laxmi x MCU-5, having high heterotic effects in desired direction for most of the characters at all the three locations with increase in seed cotton yield over H-4 to the extent of 47.1 and 25.3%, respectively, may prove their worth if tried on large scale and in different environments. The hybrids having low yielding ability are generally good in ginning and fibre properties but a compromise between these characters is possible. The latter hybrid, in this respect is promising [18]. The study, in addition to identification of hybrids for specific locations as well as over locations, thus, shows that while selecting parents for hybrid

Table 3. Mean seed cotton yield and BP heterosis (pooled) in the ten promising hybrids for different yield components

Cross	Seed cotton yield per plant (g)	Standard heterosis over H_4 (%)	BP Heterosis (%) for different traits			
			seed cotton yield per plant	bolls per plant	boll weight	lint yield per plant
Reba-B-50 x Kh-2	173.6	47.1	45.6	22.7	16.0	48.9
Laxmi x Reba-B-50	160.2	35.8	34.4	35.1	1.7	31.3
MCU-5 x Kh-2	155.3	31.2	71.7	54.3	0.3	66.7
MCU-5 x SVM	148.8	26.1	68.8	57.8	8.2	72.7
Laxmi x MCU-5	147.9	25.3	48.8	38.3	7.3	50.8
Reba-B-50 x AC-738	147.7	25.2	23.9	12.4	10.3	25.3
AC-738 x Kop-495	146.3	24.1	58.2	31.5	18.1	57.9
Reba-B-50 x MCU-5	146.2	23.9	22.6	11.9	5.7	21.7
SVM x Kop-495	145.3	23.2	57.1	37.7	18.1	56.8
Laxmi x 064	141.6	20.0	34.9	33.4	8.0	29.5
H-4	117.9	—	—	—	—	—

breeding programmes on the basis of genetic divergence, their per se or cluster mean performance needs to be considered.

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