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HETEROSIS FOR GRAIN YIELD IN PEARL MILLET (*PENNISETUM TYPHOIDES* (B.) S. & H.)

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ABSTRACT

Pronounced grain yield heterosis with varying degree and magnitude was expressed in various individual crosses under different environments. Environment-specific as well as widely adaptable hybrids and parents were identified. The top ranking hybrids were $126D_2A \times J\,1248$, 5054A x J 1623, and 5141A x A 487. The male sterile line 5054A and pollinator J 1248 were versatile for providing highly heterotic hybrids in individual as well as across the environments. Differential behaviour of heterosis under varying environments and various breeding approaches are discussed.

Key words: *Pennisetum typhoides*, heterosis stability, grain yield.

Pearl millet (*Pennisetum typhoides*) is the most important food and fodder crop of dry land agriculture in India. Several superior hybrids have been released, leading to remarkable yield advances in India. In order to realize substantial production and improvement in this allogamous crop, studies on heterosis deserve special consideration. Studies on heterosis over environments in pearl millet are scanty. The scope for exploitation of hybrid vigour depends on the direction and magnitude of heterosis in the crosses of newly developed parents. The present report describes the extent and nature of heterosis in hybrids from such parents for grain yield under five environments.

MATERIALS AND METHODS

The research material comprised four male sterile lines (MS 5054A, 5141A, $L_{111}A$ and $126D_2A$) used as females, 20 inbred lines used as males and their 80 F_1 hybrids. These 104 entries were sown in randomized block design with three replications. The experimental material was sown in five environments over three locations in Gujarat State in two seasons: (1) Jamnagar—early kharif with 60 cm spacing, (2) Jamnagar—late kharif with 75 cm

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spacing, (3) Junagadh—kharif with 60 cm spacing, (4) Rajkot—normal kharif with 60 cm spacing, and (5) Jamnagar—summer with 60 cm spacing.

Each entry was sown in a single-row plot of 6 m length. The sowing was done by dibbling the seeds at 15 cm. Nonexperimental rows were planted all around the experiment to eliminate the border effects. All agronomic operations were carried out as per norms. After sun-drying, the ears of five random competitive plants were hand-threshed and grain yield per plant recorded.

The degree of heterosis in F_1 over the better parent (BP) was calculated for individual environment as well as over the five environments (pooled) and expressed in per cent as suggested by Turner [1].

RESULTS AND DISCUSSION

The analyses of variance for grain yield indicated significant differences among the genotypes in all environments (Table 1). Further, differences amongst parents and hybrids (within group) were also significant. This revealed the existence of significant variability in the material. Comparison of parents with hybrids was significant in all environments, which indicated presence of heterosis.

Table 1. Analysis of variance (MSS) for grain yield in pearl millet under different environments

Source	d.f.	Jamnagar early sowing	Jamnagar late sowing	Junagadh	Rajkot	Jamnagar summer
Replications	2	180.9*	72.0	122.6*	170.9*	1199.8
Genotypes	103	615.2*	394.1*	398.2*	209.9*	3349.1*
Parents (P)	23	780.1*	239.9*	451.4*	180.6*	2235.9*
Hybrids (H)	79	502.3*	346.3*	366.0*	157.5*	2763.0*
P vs. H	1	5742.8*	7719.5*	1723.3*	5019.4*	75253.3*
Error	206	51.0	41.0	38.3	34.2	439.0

*Significant at $P \leq 0.05$.

Heterosis of F_1 hybrids is expressed in per cent over the better parent. The range under Jamnagar early sown environment was from –55.8 to 209.8% with 8.3% mean heterosis. Twenty six hybrids manifested positive and 15 hybrids expressed negative significant heterosis. Top ranking heterosis was depicted by the hybrid 5054A x J 1623 (209.8%), followed by 5054A x J 1248 (167.1%), and 5054A x J 2155 (146.0%). All these top ranking hybrids were derived from the crosses involving MS 5054A as female parent.

In Jamnagar late sown environment, the range of heterosis varied from –45.0 to 218.0% with mean 23.4%. Thirty one hybrids displayed positive and five hybrids significant negative heterosis. The top ranking hybrid was MS 5054A x J 1248 (218.1%), followed by 5054A x J 1623 (163.1%), and 5054A x J 2236 (111.0%). In this environment also, female parent MS 5054A gave these top ranking hybrids.

In Junagadh environment, the range was –58.3 to 149.2% with mean heterosis –14.6%. Ten hybrids expressed positive and 29 hybrids significant negative heterosis. The top ranking hybrids were 126D_2A x J 1165 (149.2%), 5141A x J 1486 (71.0%), and 126D_2A x A 792 (69.2%).

In the Rajkot environment, the average heterosis was 31.7% with range of –33.9 to 370.1%. Thirty one hybrids showed positive and two negative heterosis. The top ranking hybrid was 5014A x J1248 (370.1%), followed by 5054A x J 1623 (211.0%), and 5054A x J 2155 (162.2%). Here also, the male sterile line 5054A was common in all the top yielding hybrids.

In Jamnagar summer environment, the range of heterosis was –65.5 to 274.1% with mean heterosis 3.1%. Eighteen hybrids manifested positive and 17 hybrids significant negative heterosis. In this environment, MS 126D_2A yielded the three top ranking heterotic hybrids: 126D_2A x 1248 (274.1%), 126D_2A x J 2155 (205.4%), and 126D_2A x J 1244 (143.3%).

On pooled basis, the range of heterosis was –41.8 to 89.3% with mean heterosis 12.8%. Twenty one hybrids expressed positive and six hybrids significant negative heterosis. The hybrid MS 126D_2A x 1248 (89.3%) was top ranking, followed by 5054A x J 1623 (85.2%), and 5141A x J 487 (84.2%).

In this study, many hybrids displayed conspicuous heterosis for grain yield. The direction and magnitude of heterosis varied from cross to cross. This indicates that the mechanism of expression of heterosis was different in the various crosses under different environments. The range of heterosis under individual environments as well as over all the environments indicated wide variability for heterosis. Pronounced desired heterosis was expressed in all the environments, but more so in the Rajkot and Jamnagar environments (Table 2). There was a wide range of heterosis in Rajkot environment and Jamnagar summer season, while high mean heterosis was recorded in Rajkot and Jamnagar late kharif environments. This indicates the impact of environments on the expression of heterosis. Thus, only environmental mean will not suffice for proper selection of superior hybrids and the breeder has to consider location/season specific hybrids. Pronounced heterosis in different environments provides a better chance for selection of desirable location/season specific high heterotic crosses for grain yield. Such useful heterosis can be exploited in breeding programmes. High positive heterosis was also reported earlier [2–4].

There was differential behaviour of various hybrids in different environments for the

expression of heterosis. This indicates environmental specificity in the expression of hybrid vigour (Table 2). However, this study was carried out over five environments and it was remarkable that 15 out of 80 hybrids maintained their consistently superior performance under all environments. This indicates high stability of heterosis of these hybrids under varying environments, which can be exploited over wide areas.

Table 2. Heterotic behaviour (%) in various environments along with three top ranking hybrids

Parameter	Jamnagar early sowing	Jamnagar late sowing	Junagadh	Rajkot	Jamnagar summer	Pooled
Range of heterosis	–55.8—209.8	–45.0—218.0	–58.3—149.2	–33.9—370.1	–65.5—274.1	–41.8—89.3
Mean heterosis	8.3	23.4	–14.6	31.7	3.1	12.8
No. of hybrids having significant						
+ve heterosis	26	31	10	31	18	21
–ve heterosis	15	5	29	2	17	6
			Top ranking hybrids			
I.	5054A x J 1623 (209.8)	5054A x J 1248 (218.1)	126D$_2$A x J 1165 (149.2)	5054A x J 1248 (370.1)	126D$_2$A x J 1248 (274.1)	126D$_2$A x J 1248 (89.3)
II.	5054A x J 1248 (167.1)	5054A x J 1623 (163.1)	5141 A x J 1486 (71.0)	5054A x J 1623 (211.0)	126D$_2$A x J 2155 (205.4)	5054A x J 1623 (85.2)
III.	5054A x J 2155 (146.1)	5054A x J 2236 (111.0)	126D$_2$A x A792 (69.2)	5054A x J2155 (162.2)	126D$_2$A x J 1244 (143.3)	5141A x J 487 (84.2)

Note. Figures in parentheses indicate heterosis in percentage.

Among the parents involved in the top ranking hybrids, female 5054A performed better in Jamnagar early as well as late kharif and Rajkot environments. Likewise, in Jamnagar summer season, 126D$_2$A performed better. On pooled analysis over the environments, 21 hybrids had significant positive heterosis, of which 5054A generated nine, 5141A eight, and 126D$_2$A four hybrids. Accordingly, these females can be used for developing location/season specific or widely adaptable heterotic hybrids. Amongst the pollinators, J 1248, J 1623 and J 2155 performed better by yielding high heterotic hybrids in most of the environments and also on pooled basis. These pollinators can be identified as widely adaptable parents for breeding high heterotic hybrids. Pethani and Kapoor [5] suggested useful exploitation of such potential parents for effective breeding programme.

The very low value of mean heterosis under Junagadh and Jamnagar summer environments could be due to cancellation of the advantageous effects by negative heterosis.

This may be a result of mutual cancellation of the opposite environmental effects in the expression of heterosis.

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