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MUTANT HETEROSIS IN PEARL MILLET

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ABSTRACT

Mutations were induced by treating dry seeds of pearl millet (*Pennisetum americanum* L.) with EMS and gamma rays of promising inbred line K 560-230. Extent of heterosis of the mutant lines with respect to yield and its components was studied in a line × tester set of crosses involving 20 mutant lines (derivatives of K 560-230), which recorded less than 10% incidence of ergot in contrast to 50% incidence in control under artificial inoculation for two consecutive years, the promising R line K 560-230 itself, and three male steriles, i.e., MS 5054, MS 5141 and MS 81. A number of mutant lines showed higher heterosis compared to their parent, K 560-230, for majority of traits studied. Heterosis for grain yield per plot in hybrid 5141 A × 103-2 over midparent and better parent was 239.8% and 239.0%, respectively. The R line 103-2 is a mutant. Mutant heterosis for grain yield was directly related to 1000-grain weight. Highly heterotic crosses were generally good specific combiners. The present study indicates that mutagens can be used to improve the parents quickly for better yield with an added advantage of disease resistance.

Key words: *Pennisetum americanum*, pearl millet, mutant heterosis.

A number of high yielding hybrids in pearl millet (*Pennisetum americanum* L.) have been developed because of availability of better heterotic parents, the A and R lines. Induced mutations can be an additional tool to alter and improve further the heterotic capacity of the parents that have already gone into production of popular hybrids, without losing the fertility restorer genes and properties with added advantage of induced disease resistance. This possibility was explored in the investigation reported here.

MATERIALS AND METHODS

The material comprised 20 variable mutant lines derived from promising inbred line K 560-230, check line K 560-230, and three testers, i.e., the B lines of MS 5054, MS 5141 and MS 81 male steriles. The mutant lines were obtained by treating

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dry seeds of K 560-230 with ethylmethane sulphonate (EMS) and gamma rays. The mutagenic treatments proved effective in producing a wide range of morphological mutants, of which only 20 mutant lines, which recorded ergot resistance under artificial inoculation for two consecutive years, were used in this study. Pantnagar is a hot spot for ergot disease of pearl millet. Line × tester (L × T) design was followed to cross the mutant lines with testers. The material for L × T design comprised 63 crosses of 21 mutant lines with 3 testers and 24 parents, making a total of 87 entries.

The M_1 and M_2 generations were grown in 1980 and 1981. The mutants were isolated in M_2 generation and the mutant lines were established in 1982 and 1983 (M_3 and M_4), when they were exposed to artificial ergot inoculation. Agronomically desirable and ergot resistant mutant lines were selected. These mutant lines were sown on July 23, 1984 along with the testers. The desired crosses were made following the standard practice.

All the 24 parents and their 63 F_1 were sown in the experimental plot on July 18, 1985 in randomized block design with three replications. The material was planted at 15 cm within a row in 5 m long two-row plots. The row-to-row spacing was 60 cm. The data on 12 different characters were recorded on five random competitive plants of each plot. Heterosis was computed over mid- and better parents for each character.

RESULTS AND DISCUSSION

Highly significant differences among entries were observed for the characters studied.

There was manifestation of high heterosis for grain yield per plot as is evident from the superiority over midparent and better parent up to 239.8% and 239.0%, respectively. Out of 63 crosses, 52 combinations exhibited high midparent (MP) heterosis for grain yield per plot. The highest (239.8%) relative heterosis was found in cross 5141A × 103-2. Estimates of relative heterosis ranged from −25.00 to 239.8%. Compared to the better parent 45 crosses exhibited significant heterosis (BP): −43.9 to 239.0%. The same hybrid 5141A × 103-2 registered the highest economic heterosis (BP). These results are in general agreement with the observations of earlier workers [1].

High economic heterosis for grain yield per plant was exhibited by 25 crosses. The highest economic (243.5%) as well as relative (MP) heterosis (248.1%) was recorded in cross 5141A × 54-1.

In some crosses, heterosis for grain yield was due to heterosis for other characters. For instance in cross 5141A × 103-2 heterosis was significant not only for grain yield but also for number of productive tillers, seedling vigour, plant height, 1000-grain weight, days to flowering, days to maturity and grain yield/plant. However, in some other crosses as many as five characters contributed to grain yield heterosis. This indicated that the nonadditive gene action was important for grain yield heterosis in such crosses. In some cases, heterosis for grain yield was associated with significant heterosis only for a single character while the other yield components were around the midparental value. In such cases both additive and nonadditive types of gene action might have contributed to grain yield heterosis.

All the crosses showing heterosis for grain yield also exhibited heterosis for 1000-grain weight. This indicates that 1000-grain weight was responsible for heterosis of grain yield. Thus, heterosis for 1000-grain weight can be used reliably for predicting heterosis for grain yield between mutant inbred lines.

Heterosis was also observed for all other characters under study but the degree varied considerably. For most characters positive as well as negative heterosis was noticed in a wide range. The hybrids showing highest economic heterosis for different characters are listed in Table 1.

Table 1. Promising hybrid combinations exhibiting maximum heterosis over better parents

Character	Cross	Heterosis (BP), %
Total No. of tillers	81A × 123-1	80.2
Productive tillers	5141A × 36-1	166.0
	81A × 36-1	166.0
Seedling vigour	5054A × 50-1	37.2
Ear length	5054A × 145-1	43.5
Plant height	5141A × 134-1	14.1
1000-grain weight	5141A × 54-1	142.1
Days to flowering	5141A × 103-2	–11.2
Days to maturity	5054A × 123-1	–10.7
Ear density	81A × 103-2	17.6
Ear girth	81A × 34-1	3.7
Grain yield/plant	5141A × 54-1	243.5
Grain yield/plot	5141A ×103-2	239.0

A comparison of heterosis of the original line K 560-230 with mutant lines in different crosses for economic traits (Table 2) provides distinct and encouraging results for the use of mutants in hybridization with suitable parents. Induced mutations increased variability of the initial material and, consequently, the potential of heterosis breeding. Considering grain yield per plant, out of the 17 superior crosses, hybrid 5141A × 54-1 scored high order of relative (248.1%) and economic (243.5%) heterosis as compared to the original cross 5141A × K560-230. For grain yield per plot, 28 crosses expressed significantly superior and positive relative heterosis as compared to the original cross 5141A × K560-230. Cross 5141A × 103-2 exhibited

Table 2. Heterosis in crosses of lines 5141A, 5054A and 81A with K 560-230 and its mutants

Trait	Cross	Heterosis BP	Heterosis MP	Number of superior crosses
Yield/plant	5141A × K 560-230 (check)	30.8**	88.5**	
	5141A × 54-1	243.5**	248.1**	
	5141A × 34-1	137.1**	169.4**	17
	5141A × 50-1	123.5**	161.6**	
	81A × 45-1	114.4**	192.8**	
	81A × 34-1	109.1**	175.2**	
Range (63 crosses)		−73.9–243.5	−72.3–248.1	
Grain yield/plot	5141A × K 560-230 (check)	39.3*	95.0**	
	5141A × 103-2	239.0**	239.8**	
	5141A × 145-1	197.2**	219.3**	28
	5141A × 50-1	175.0**	214.2**	
	5141A × 142-1	172.4**	196.9**	
	5141A × 134-1	149.8**	176.0**	
Range (63 crosses)		−43.9–239.0	−25.0–239.8	
Days to maturity	5141A × K560-230 (check)	−5.3**	−5.6**	
	5054A × 123-1	−10.7**	−10.7**	
	5054A × 36-1	−10.2**	−12.6**	12
	5141A × 123-1	−8.7**	−7.0**	
	5054A × 134-1	−7.9**	−9.6**	
	5141A × 134-1	−7.9**	−7.9**	
Range (63 crosses)		−10.7–7.3	−12.6–2.1	
1000-grain weight	5141A × K560-230 (check)	18.6*	37.2*	
	5141A × 54-1	142.1**	127.2**	
	81A × 54-1	123.7**	117.9**	42
	81A × 134-1	114.9**	132.2**	
	5141A × 134-1	110.6**	120.0**	
	5054A × 134-1	108.5**	104.2**	
Range (63 crosses)		−13.9–142.1	2.5–132.2	
Ear length	5141A × K560-230 (check)	−0.5	2.2	
	5054A × 145-1	43.5**	33.0**	
	5054A × 134-1	37.3**	47.6**	8
	5054A × 103-2	37.1**	34.2**	
	81A × 17-1	19.6*	17.9*	
	81A × 61-1	14.0*	11.0	
Range (63 crosses)		−56.7–43.5	−38.2–47.6	
Ear density	5141A × K560-230 (check)	−20.1**	−9.0*	
	81A × 103-2	17.6**	27.9**	
	5054A × 50-1	−6.7	15.7**	8
	5054A × 54-1	−2.7	13.9**	
	81A × 50-1	−5.9	13.0**	
	5054A × 75-1	−8.8*	9.0*	
Range (63 crosses)		−35.3–17.6	−24.5–27.5	
Ear girth	5141A × K560-230 (check)	−13.3**	−0.5	
	81A × 45-1	−0.8	18.7**	
	81A × 34-1	3.6	17.4**	11
	81A × 39-1	−3.3	14.2**	
	81A × 103-2	0.4	14.2**	
	81A × 61-1	2.3	13.3**	
Range (63 crosses)		−29.3-3.6	−15.4-18.7	

*, **Significant at 5% and 1% levels, respectively.

Note. For comparison of heterosis with the checks, only the best five crosses are listed in descending order for each character.

highest relative (239.8%) and economic (239.0%) heterosis, whereas the original cross 5141A × K 560–230 gave only 95.0% relative and 39.3% economic heterosis (Table 2).

For days to maturity, out of 13 superior crosses, 5054A × 36-1 hybrid showed high order of negative relative heterosis as compared to the original cross 5141A × K560-230. This hybrid also showed greater relative (MP) and economic (BP) heterosis for grain yield per plot than crosses 5141A × K560-230 and 5054A × K560-230. Thus, it is the most desirable hybrid combining earliness with high yield.

In the case of 1000-grain weight, cross 81A × 134-1 showed the highest relative (MP) and cross 5141A × 54-1 the highest economic (BP) heterosis compared to cross 5141A × K560-230. For ear length, out of eight superior crosses, hybrid 5054A × 145-1 scored significant positive, whereas cross 5141A × K560-230 showed average BP heterosis. Very few crosses exhibited positive heterosis for ear density as compared to the crosses involving the original line K560-230 and the testers used in this study. Similar results were obtained for ear girth.

Specific combining ability (sca) was also computed in all the 63 crosses under study. The crosses with high sca for grain yield exhibited high heterosis (Table 3). However, crosses with high sca effects were not the combinations of high × high gca lines.

Table 3. Relationship between sca and heterosis for grain yield per plot

Hybrid	sca	Heterosis	
		MP	BP
5054A × 17-1	191.3*	84.6**	83.3**
5141A × 90-1	188.9*	192.6**	153.7**
5141A × 142-1	178.9*	196.9**	172.4**
5141A × 145-1	241.7*	219.3**	197.2**
5141A × 147-1	201.1*	184.9**	138.3**
81A × K560-230	365.3**	138.6**	76.4**
81A × 28-1	304.2**	126.8**	74.5**

*, **Significant at 5% and 1% levels, respectively.

In mutation experiments, superior heterosis of the mutant lines was reported in maize [2–4] and *Melilotus albus* [5]. The present study has demonstrated that some disease resistant mutant lines, when crossed with tester, give better performance of hybrid vigour as compared to that shown by the parent × tester hybrid.

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