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Short Communication

Ability of New Pearl Millet Restorers to Produce High Yielding Hybrids for Moisture Stress Environments

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Pearl millet [*Pennisetum glaucum* (L.) R. Br.], a hardy cereal crop is grown in marginal environments. It is grown in the harshest environments where other cereals like maize and sorghum cannot be cultivated, and hence is important for food and nutritional security of the poor people residing in critically dry and hottest regions of arid and semi-arid tropics. In India, pearl millet is cultivated in 9.43 million hectares. Rajasthan represents 47% of the total pearl millet growing area, with average productivity of about 400 kg ha^{-1}, which is lower than the national average of 690 kg ha^{-1}. Adoption of hybrids, has been very poor in Rajasthan state, primarily due to non-availability of suitable hybrids for the areas characterized by adverse agro-climatic conditions and moisture stress. Presently only a few hybrids like HHB 67, ICMH 356 and RHB 121 suited to the harsh conditions of arid regions are available, farmers have hence limited choice. Therefore, there is a need to develop high yielding hybrids, using parents specifically adapted to the harsh conditions of western Rajasthan capable of producing higher grain yield. This will add to the cultivar diversity, giving more choice to the farmers besides increasing productivity.

Three male-sterile lines of pearl millet viz., ICMA 98111, 841 A and ICMA 94111 were crossed during 2004 with ten new inbred restorers viz., CZI 2002/1, CZI 2002/4, CZI 2002/5, CZI 2002/6, CZI 2002/8, CZI 2002/13, CZI 2002/14, CZI 2002/17, CZI 2002/20 and CZI 2002/21 in a line x tester mating design to produce thirty hybrid combinations. These hybrids were evaluated during the rainy season of 2005 in a randomized block design with three replications along with two check hybrids, HHB 67 and ICMH 356 at the Central Arid Zone Research Institute, Jodhpur. Each entry was planted in two rows of 4 m length. The row-to-row distance was 60 cm, while plant-to-plant distance was maintained at 15 cm. The trial was fertilized with 40 kg N ha^{-1} and 20 kg P ha^{-1}. During the season the crop received a precipitation of 243 mm. However the rainfall was not uniformly distributed. The season was unique in the sense that the crop experienced two long dry spells: first immediately after planting (only 22 mm of rainfall was received in 25 days), this dry spell was broken by about 106 mm rainfall received in a period of seven days covering last days of July and first two days of August. This was followed by a long dry spell when only 26 mm of rainfall was received in the months of August and

Table 1. Anova for line x tester analysis for various traits in pearl millet

Sources of variation	df	Grain yield	Days to flowering	Panicle length	Panicle weight/plot	Threshing ratio
Hybrids	29	22640**	5.37*	8.85*	106338**	0.0237*
Lines	2	24384**	14.23**	53.43**	337372**	0.0117
Testers	9	42776**	8.54*	11.00*	115225	0.0264*
Line x tester	18	12379**	2.80*	2.82	76225*	0.0102**
Error	58	3207	1.08	4.49	29638	0.0044
σ^2 GCA		1557.5	0.529	1.371	10085	0.0006
σ^2 SCA		3057.3	0.575	0.001	15528	0.0020

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

during flowering and grain filling stages resulting in poor seed setting. The long dry spells provided an opportunity to test the surviving ability of hybrids under severe moisture stress. The observations were recorded in each entry on five randomly selected plants in each replication for days to 50 percent flowering, plant height, effective tillers/plant and panicle length. Panicle weight and grain yield were recorded on plot (g) basis. Threshing ratio, a measure of terminal stress tolerance, was calculated as ratio of the grain yield to panicle weight. The data were subjected to the line x tester analysis as suggested by Kempthorne (1957).

Line x tester analysis (Table 1) revealed significant mean squares due to hybrids, lines, testers and LxT interaction for days to 50% flowering, panicle length, panicle weight/plot, grain yield/plot and threshing ratio, indicating presence of sufficient variability in the material for these traits. Differences were however non-significant for plant height and effective tillers per plant, this could be because early growth as well as later developmental stages were affected by two spells of drought experienced by the crop. Analysis of variance also revealed significant general combining ability (GCA) and specific combining ability (SCA) variances for most of the traits. The magnitude of variance due to SCA, which was greater than GCA for most of the traits except for panicle length, indicated the predominance of non- additive gene action desirable for improving these traits through heterosis breeding. Similar results have been reported by Lakshmana *et al.*, 2003; Sushir *et al.*, 2005. The importance of additive gene effects for panicle length, as observed in the present study, has also been reported earlier by Manga and Dubey (2004); Sushir *et al.* (2005). GCA effects of the parents (Table 2) revealed that among testers, CZI 2002/21 was the best combiner for grain yield followed by CZI 2002/5 and CZI 2002/4. For earliness, CZI 2002/4 was the best combiner followed by CZI 2002/1 and CZI 2002/6. For panicle length, CZI 2002/20 was the best combiner followed by CZI 2002/14. For panicle weight, CZI 2002/21 was the best combiner followed by CZI 2002/4. Threshing ratio is considered as an index of drought tolerance because it indicates the ability to set and fill grains under moisture stress conditions. CZI 2002/5 was found to be the best combiner for threshing ratio followed by 2002/21. Among lines, ICMA

Table 2. GCA effects of parents for various traits in pearl millet

Parent	Grain yield	Days to flowering	Panicle length	Panicle weight/plot	Threshing ratio
Tester					
CZI 2002/1	-18.44	-1.06	0.21	12.7	-0.008
CZI 2002/4	54.00**	-1.61**	-0.34	120.6	0.028
CZI 2002/5	87.90**	1.39*	-0.90	99.1	0.065*
CZI 2002/6	-61.89*	-0.72**	-0.90	-50.5	-0.066
CZI 2002/8	-89.33**	0.39	-0.23	-87.9	-0.088
CZI 2002/13	2.56	-0.61	-1.79*	14.7	-0.001
CZI 2002/14	-85.78**	0.94**	1.10*	-201.6**	-0.021
CZI 2002/17	-6.67	0.94**	0.21	-96.6	0.042
CZI 2002/20	5.67	0.28	2.10**	16.5	0.005
CZI 2002/21	112.00*	0.06	0.54	173.0**	0.044*
Line					
ICMA 98111	-30.67*	-0.20	-1.30**	-121.4**	0.022
841 A	4.97	0.77**	1.37**	46.8	-0.017
ICMA 91444	25.70*	-0.57**	-0.07	74.6	-0.004

91444 was the best combiner for grain yield, earliness and panicle weight, while 841 A was the best combiner for panicle length.

Among thirty hybrid combinations, ICMA 91444 x CZI 2002/21, 841 A x CZI 2002/21, ICMA 98111 x CZI 2002/4 and ICMA 98111 x CZI 2002/17 (Table 3) had high and significant specific combining ability effects. Most of these hybrids recorded grain yield higher than the check hybrids HHB 67 and ICMH 356. ICMA 91444 x CZI 2002/21 had the highest SCA effects as well as grain yield followed by 841 A x CZI 2002/21. Hybrid ICMA 91444 x CZI 2002/21 recorded 22% and 39% higher grain yield over HHB 67 and ICMH 356, while 841 A x CZI 2002/21 recorded 9.5% and 24.8% higher grain yield over HHB 67 and ICMH 356, respectively. Both the parents involved in the first hybrid were good combiners for grain yield and also produced the highest yielding specific hybrid combination, a desirable attribute. It was further observed that most of the high yielding hybrids were in the medium maturity group (>45 days to flowering) and hence faced severe terminal moisture stress. Check hybrid HHB 67 was the earliest maturing hybrid, hence escaped terminal stress, leading to higher grain yield, while second check ICMH 356 and other hybrids being of medium maturity group (>45 days to flowering) faced terminal stress. Since both the hybrids, ICMA 91444 x CZI 2002/21 and 841 A x CZI 2002/21 recorded significantly higher grain yield over both the checks despite severe terminal stress, hence appeared to possess terminal drought tolerance. Both the hybrids had CZI 2002/21 as male parent; a good combiner for grain yield, head weight and threshing ratio. Other

Table 3. SCA, mean performance and heterosis of promising hybrids for grain yield in pearl millet

Hybrid	SCA	Grain yield kg ha^{-1}	Per cent heterosis over checks	
			HHB 67	ICMH 356
ICMA 91444 x CZI 2002/21	100.9	1040	22.2	39.2
841 A x CZI 2002/21	70.0	931	9.5	24.8
ICMA 98111 x CZI 2002/4	65.7	790	-7.1	5.8
ICMA 98111 x CZI 2002/17	69.3	630	-25.9	-15.6
Checks				
HHB 67		810		
ICMH 356		746		
SEm±		28.6		

restorers that showed good general combining ability for grain yield were CZI 2002/4 and CZI 2002/5.

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