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Short Communication

Evaluation of newly developed male sterile lines and restorer lines for their combining ability in pearl millet (*Pennisetum glaucum* L. R. Br.)

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Pearl millet is grown on about 9.62 million hectares in arid and semi-arid regions of India, which 15 nearly 40% of the world area for this cereal. It is the fourth most important cereal crop of this country, and is grown chiefly in Rajasthan, Uttar Pradesh, Maharashtra and Haryana, which account for 90% of the area. While the area is on the decline, the total production and productivity of pearl millet In India are on the increase, mainly attributed to the cultivation of improved cultivars. All pearl millet hybrids cultivated in India are based on the A, cytoplasm. When devastating epidemics of downy mildew caused by *Sclerospora graminicola* (sacc.) Schroet, nearly wiped out the crop in the 1970's following the introduction of hybrids, A_1 cytoplasm was linked with the susceptibility to this disease [1]. However, studies shown by Anand Kumar *et al.* [2], Yadav *et al.* [3], and Dave [4] indicate that the main reason for downy mildew out break was due to the lack of genetic diversity among cytoplasmic male sterile (CMS) lines and elite restorers rather than any deleterious effects of the A_1 cytoplasm Itself. The present study was therefore, attempted to assess the combining ability of a set of newly developed CMS lines and restorer lines to identify superior cross combinations for further commercial exploitation.

Four newly developed CMS lines namely MS 576 A, MS 411 A, MS 273 A and MS 379 A, bred at IARI New Delhi, along with two checks MS 841 A and MS 5054 A were used as female parents. The six male sterile lines were crossed with 34 inbred lines in a line × tester design [5] during kharif 2000 to generate 204 hybrid combinations. These 204 hybrids with 40 parents were planted in a randomized block design with three replications during kharif 2001 at IARI, New Delhi. The parents and F_1's were randomized among themselves and sown in adjoining blocks [5]. All the hybrids and parents were evaluated in a 3 m long single row plot with spacing of 45cm × 15cm between the rows and plants, respectively. Data were recorded on ten randomly selected plants from each plot on days to 50% flowering, plant height, number of effective tillers/plants, ear length, ear girth, 1000 grain weight and grain yield per plant. The combining ability analysis was done according to procedure of Kempthorne [6].

Analysis of variance had shown highly significant differences due to genotypes for all traits, indicating the presence of sufficient variability among CMS lines, restorers and CMS lines × testers (data not presented). A perusal of *gca* effects revealed that among CMS lines, MS 411 A is the best general combiner for grain yield, 1000 grain weight, ear girth and plant height followed by MS 576 A and MS 841 A for grain yield and Its components (Table 1). MS 84IA, MS 5054A and MS 379A are the best combiners for earliness. These CMS lines thus possess desirable gene combinations and may be exploited for further pearl millet improvement programme. Among the pollen parents used as testers, PPMI 493, PPMI 814, PPMI 575, PPMI 721, D 23, PPMI 807, PPMI 162, PPMI 295, PPMI 85, PPMI 301, PPMI 641, PPMI 465, PPMI 813, PPMI 872, PPMI 808 and PPMI 379 are highly desirable, as they are best combiners for grain yield. These established restorers further offer scope for their exploitation in the hybrid development programme. The restorer PPMI 362 is the best general combiner for days to flowering and effective tillers. This is also substantiated by the fact that the restorer PPMI 362 is the pollinator for one of the best early maturing hybrid namely Pusa 362 (MS 263A × PPMI 362) tested in the Hybrid Project Trial conducted by the AICPMIP during 2001 [7]. It flowered at par with the best early maturing hybrid HHB 67 and out yielded it by 20% [7]. The *sca* effects along with *perse* performance of hybrids give an idea about the practical utility of hybrid combinations for heterosis breeding. A perusal of *sca* effects (data not presented) for grain yield revealed that a total number of 87 hybrids have shown significant

Table 1. General combining effects of six lines and 34 testers of pearl millet for seven different characters

Parents	Characters						
	Days to 50% flowering	Plant height (cm)	Elective tillers/plant	Ear length (cm)	Ear girth (cm)	1000 grain weight (g)	Grain yield/plant (g)
Lines							
MS 273A	0.89**	−0.56	0.08	−0.20	0.35	0.06	−3.11**
MS 576A	0.06	−0.57	−0.16	0.60	0.17	−0.76**	9.65**
MS 411A	1.25**	9.16**	−0.22	−0.66	0.28	1.29**	12.30**
MS 379A	−0.25**	−2.37*	−0.07	−0.70	−0.01	0.74**	−7.48**
MS 5054A	−0.95**	0.93	0.44	−1.01**	−0.62*	−0.89**	−15.38**
MS 841A	−0.99**	−6.59**	−0.08	1.97**	−0.17	−0.43	4.03**
S.E.(gj) ±	0.287	0.952	0.197	0.383	0.299	0.272	0.634
Testers							
PPMI 69	−1.34**	−2.04	−0.01	−1.55**	−0.14	−0.15	−4.14**
PPMI 85	−0.73	−5.82	0.07	0.20	0.00	−1.16	7.99**
PPMI 162	−0.57	1.41	−0.11	−0.36	−0.01	−0.77	9.02**
PPMI 190	−2.23**	9.02	−0.31	0.04	0.07	0.69	−1.00
PPMI 295	3.93**	−18.93	−0.16	0.05	0.40	0.85*	8.68**
PPMI 301	−0.68	−5.48	o.oo	−0.83	0.11	0.17	7.70**
PPMI 362	−2.73**	−4.76	0.19	−1.56**	−0.43	−0.96*	−10.91**
PPMI 379	−0.62	−7.32	−0.07	−2.55**	0.05	0.57	0.84
PPMI 465	0.27	5.24	−0.24	2.87**	0.14	0.50	5.05**
PPMI 479	−1.23**	1.91	−0.07	−0.78	1.31	−1.12**	−6.95**
PPMI 484	−0.73	3.91	0.11	−1.25*	−0.13	0.04	−0.81
PPMI 493	0.32	5.52	−0.28	1.82**	0.17	0.78	16.33**
PPMI 575	0.77	5.13	0.15	−0.68	0.08	0.46	14.01**
PPMI 605	0.16	−22.65	0.09	−0.09	0.15	0.06	−6.49**
PPMI 641	0.66	−3.26	0.14	1.88**	−0.02	0.05	6.38**
PPMI 721	−0.40	6.41	−0.17	0.05	0.35	1.20**	10.31**
PPMI 738	0.82	0.63	0.09	−1.77**	−0.10	−0.18	−14.11**
PPMI 739	−0.29	−3.71	0.14	−2.13**	−0.04	−0.24	−11.16**
PPMI 761	0.60	−2.71	0.07	−3.80**	−0.14	−0.32	−10.48**
PPMI 767	−0.79	−9.21	0.26	−4.72**	−0.25	−0.96	−1.79
PPMI 807	−0.34	3.07	0.08	0.48	−0.05	0.50	9.55*
PPMI 808	3.38**	7.35	−0.13	1.65**	0.42	1.77**	1.31
PPMI 809	−0.62	6.29	0.06	2.45**	0.02	0.40	−0.80
PPMI 812	0.82	5.52	0.21	2.79**	−0.53	−1.27**	−5.21**
PPMI 813	2.49**	1.57	−0.10	0.25	0.10	0.46	3.72**
PPMI 814	2.77**	13.74	−0.03	1.59**	0.40	1.31**	15.73**
PPMI 834	−0.23	5.74	−0.18	0.77	−0.34	−0.38	−6.96**
PPMI 845	−1.51**	4.13	−0.17	0.03	−0.53	−0.59	−13.45**
PPMI 856	−2.01**	2.85	0.02	0.55	−0.52	−1.16**	−18.60**
PPMI 860	−1.79**	3.24	0.18	1.35*	−0.47	0.15	−9.77**
PPMI 862	−0.51	0.07	0.17	1.13	−0.36	−1.00*	−3.92**
PPMI 872	−0.12	3.68	0.23	0.18	−0.05	−0.54	2.29*
D 23	−0.23	5.63	−0.25	1.54**	0.07	0.39	10.06**
IPC 1664	2.71**	−16.15	−0.01	0.41	0.27	0.48	−2.46*
S.E. (gj) ±	0.443	1.485	0.304	0.591	0.461	0.420	0.978

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

sca effects for grain yield out of which 17 hybrids were based on MS 411A, 17 on MS 841A, 14 on MS 576A, 13 on MS 273A, 13 on MS 379A and 13 on MS 5054A. This again substantiates the fact that the MS 411A is the best combiner among the male sterile lines.

Fifteen hybrids namely MS 576A × D 23, MS 576A × PPMI 295, MS 576A × PPMI 807, MS 411A × PPMI 301, MS 841A × PPMI 295, MS 411A × PPMI 162, MS 411A × PPMI 85, MS 273A × PPMI 814, MS 576A × PPMI 575, MS 576A × PPMI 493, MS 379A × PPMI 641, MS 576A × PPMI 814, MS 273A × PPMI

Table 2. Mean value for yield and yield contributing traits of 15 top performing hybrids having grain yield per plant significantly superior to best check Pusa 605 (MS 841A × PPMI 69) with economic heterosis and *per se* performance in pearl millet

Pedigree	Days to 50% flowering	Plant height (cm)	Effective tillers/plant	Ear length (cm)	Ear girth (cm)	1000 grain weight (g)	Gram yield/plant (g)	Economic heterosis for gram yield/plant (%)
MS 576A × D 23	47.3	203	2.8	26.8	2.92	8.84	126.8**	3B.9
MS 576A × PPMI 295	54.7	206	2.6	25.1	3.60	10.65	123.3**	35.0
MS 576A × PPMI 807	49.0	206	3.1	27.6	2.74	10.72	122.4**	34.1
MS 411A × PPMI 301	46.0	201	2.8	24.4	3.07	10.39	121.9**	33.5
MS 841A × PPMI 295	48.0	198	2.9	28.0	2.77	9.54	119.5**	30.9
MS 411A × PPMI 162	49.3	210	2.9	24.5	2.79	12.21	118.7**	30.0
MS 411A × PPMI 85	50.0	207	3.2	25.1	2.98	10.45	115.1**	26.1
MS 273A × PPMI 814	50.7	213	3.1	25.4	3.08	9.77	109.5**	19.9
MS 576A × PPMI 575	48.7	209	2.6	25.3	3.08	10.03	107.2**	17.4
MS 576A × PPMI 493	49.3	209	2.9	25.4	3.36	10.25	107.0**	17.2
MS 379A × PPMI 641	49.3	198	3.5	26.8	2.60	12.16	103.2**	13.8
MS 576A × PPMI 814	50.7	214	3.2	25.5	3.36	10.31	102.8**	12.6
MS 273A × PPMI 493	47.7	206	2.9	28.2	2.86	11.78	101.9**	11.6
MS 411A × PPMI 809	48.0	213	3.0	28.6	2.95	11.16	99.9**	9.4
MS 411A × PPMI 641	47.7	204	2.9	25.0	2.92	10.68	98.8*	8.2
PUSA 605 (check)	47.0	184	3.0	26.7	2.35	8.04	91.3	
CD at 5%	1.3	15	0.6	2.4	0.25	1.20	6.5	
CD at 1%	1.7	20	0.8	3.1	0.34	1.58	8.5	

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

493, MS 411A × PPMI 809 and MS 411A × PPMI 641 were selected on the basis of highly significant *sca* effects for grain yield per plant with good per se performance in relation to grain yield (Table 2). These hybrids also showed positive significant effects for other yield contributing characters against the check Pusa 605 (MS 841A × PPMI 69). Amongst these, six hybrids exhibited highest magnitude of significant positive economic heterosis for gram yield per plant against the check Pusa 605. The top fifteen hybrids have also out yielded the check by 8.2 to 38.9%, respectively. Thus, it indicated that the parental lines (CMS lines and testers) used in this study were having diverse genetic background and hence exhibited high *sca* effects for yield and yield attributing traits. For the exploitation of hybrid vigour, new male sterile lines MS 411A and MS 576A and restorers PPMI 493, D 23, PPMI 814, PPMI 575, PPMI 295, PPMI 807, PPMI 721, PPMI 162, PPMI 85, PPMI 301, PPMI 641, PPMI 465 and PPMI 813 have been identified.

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