

Influence of Diverse Cytoplasmic Systems on Performance of Pearl millet Hybrids

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Abstract: Seventeen cytoplasmic male sterile lines of pearl millet were crossed with genetically diverse pollinators to investigate the influence of CMS systems on the performance of resultant hybrids. The data were recorded for fertility/sterility reaction both under bag and open pollination on grain yield and days to 50% flowering. Results show that A₅, A₄, Pb601A_v, A₁ and Pb502A_G CMS system lines can be exploited to produce isonuclear male sterile lines, whereas A₂, 81A_{egg}, A₃ and A₁ CMS systems are better seed parents, producing superior grain hybrids. In general, M.S. lines Pb 601Av and HMS 14A produced early maturing hybrids, whereas rest of the hybrids on diverse CMS systems were mid-late to late. CSSC 46-2 has maximum fertility restoration genes, where as H78/711 has maximum maintainer genes.

Key words: Cytoplasmic male sterility systems, pearl millet, maintainers, restorers, hybrid.

The yield of commercial hybrids in pearl millet (*Pennisetum glaucum* (L) R.Br.) depends greatly upon the genetic make up of cytoplasmic genetic male sterile (CMS) lines and their pollinators. Commercial production of pearl millet hybrids began with the development of Tift 23A, the first male sterile line, by Burton (1958). All the commercial grain hybrids except, GHB 316 (A₃ system), bred and released till now, are based on a single source of A₁ cytoplasm. The need for diversification of CMS sources has always remained on priority for hybrid breeding program of pearl millet to minimize the risk associated with the use of one CMS source. It is a common experience that wider the genetic diversity among the parents, the greater is the chance of genetic improvement in evolving heterotic hybrids. Other diverse

kinds of cytoplasm of pearl millet reported include A₂ and A₃ (Burton and Athwal, 1967), MS 732 A (Appadurai *et al.*, 1982), Violaceum (Marchais and Pernes, 1985), Ex-Bornu (Aken'Ova, 1985), Am = A₄ (Hanna, 1989) and A₅ (Rai, 1995). The cytoplasmic sources showed a varied pattern of performance when used in hybrid breeding program (Talukdar *et al.*, 1999). In the present study the influence of different cytoplasmic genetic male sterile systems on the performance of hybrids have been examined.

Materials and Methods

A set of 197 crosses was developed by crossing 17 male sterile lines (Table 1) representing various CMS systems with 50 diverse pollinators. All the pollinators could not be crossed with all the male

sterile lines because of different flowering behavior. However, six common pollinators were crossed with all the 17 male sterile lines. The 197 crosses along with five checks (HHB 67, HHB 94, HC 4, HC 10 and MP 293) were grown in randomized block design with two replications in 4 m long, two row plots, with 60 cm row spacing and 15 cm plant to plant spacing at the CCS Haryana Agricultural University, Hisar, during 1999-2000. All the agronomic practices were followed to raise a good crop. The data were recorded on five plants in each plot and each replication for fertility/sterility reaction by tapping the head at anthesis stage. The fertility/sterility reaction was studied following Rai and Hash (1990) with some modifications. At anthesis, the plants which had shrunken anthers and shed no pollen were termed as sterile (S), seed set in some portion of panicle was classified as partial sterile (PS) or partial fertile (PF) and full of seed set under bag was termed as fertile (F). The data were also recorded on days to 50% flowering, grain and dry fodder yield per plant, plant height, ear head length, ear head girth and tillers per plant. The average of five plants represented the value for a cross in each replication.

Results and Discussion

Out of 197 hybrids evaluated for fertility/sterility, 125 crosses were found to be sterile both under bag and in open (Table 1). The maximum number of sterile crosses was obtained on A₅ (94%) followed by A₄ (92%), A_v (86%), A₁ (57%) and A_G (50%), whereas the lowest number of crosses showing sterility was obtained on A₂ CMS system (36%) (Table 1). This fact was supported by the fertility/sterility

trend of male sterile lines with common pollinators (Table 2a). Rai *et al.* (1999) also reported that A₄ and A₅ system produce the highest frequency of male sterile hybrids in pearl millet. Hence the possibility of producing B-lines from a diverse range of breeding materials has been shown to be higher for A₄ than A₁ CMS system (Rai *et al.*, 1996) and highest for the A₅ CMS system (Rai, 1995). Thus A₅ system provides the greatest opportunity for genetic diversification of A₅ lines, followed by A₄ and then by A₁ CMS system. It is interesting to note that the pollinator CSSC 46-2 restored fertility on all the CMS systems followed by ICR 161. This means the CSSC 46-2 has more fertility restorer genes and is followed by ICR 161. The pollinator H78/711 maintained sterility on all the CMS systems and was followed by HB98/144 and HB98/66 (Table 2a). This showed that H78/711 has high sterility maintainer genes.

Fertility restoration ability of pollinators in different CMS systems of sterility is presented in Table 1. It is evident from our results that maximum number of fertile crosses was obtained on A₂ (64%) followed by 81A_{egg} (60%), A₃ (54%), Pb502A_G (50%) and A₁ (44%) (Table 1). Very few restorers were obtained on A₅, A₄ and Pb601A_v. Some partially sterile hybrids were obtained on A₂ and Pb601 A_v CMS systems indicating their instability. Burton (1972, 1977) and Clement (1975) reported that the occurrence of male-fertile plants or CMS plants with fertile sectors originate because of nuclear or cytoplasmic (plasmon) mutations.

Mean performance of hybrids based on A₃, A₂, A₄ and 81 A_{egg} CMS systems are comparable to those of the hybrids

Table 1. Origin and fertility/sterility trend of cytoplasmic male sterile lines used in study

Cytoplasm	Source of cytoplasm	CMS lines	Developed at	No. of crosses			Percentage of	
				Total	Sterile	Fertile	Sterile crosses	Fertile crosses
A ₁	Tift 23A	81A, 94111A, 94222A, 95111A, 95222A, 96111A, HMS 14A	ICRISAT, Patancheru CCS, HAU, Hisar	44	25	19	56.82	43.18
A ₂	L66	Pb 310A ₂ , Pb313A ₂	PAU, Ludhiana	22	8	14	36.36	63.64
A ₃	L67	Pb402A ₃ , Pb405A ₃ , Pb406A ₃	PAU, Ludhiana	39	18	21	46.15	53.85
A ₄	Monodii	81A ₄	ICRISAT, Patancheru	25	23	2	92.00	8.00
A ₅	LSGP	81A ₅	ICRISAT, Patancheru	18	17	1	94.44	5.56
81A _{egg}	ICMA 90111	81A _{egg}	ICRISAT, Patancheru	10	4	6	40.00	60.00
Others	Gero	Pb502A _G	PAU, Ludhiana	10	5	5	50.00	50.00
	Viol- aceum	Pb601A _V	PAU, Ludhiana	29	25	4	86.21	13.79

based on A₁ cytoplasm (Table 2b). This shows that male sterile lines based on these cytoplasmic systems may be exploited for

commercial hybrids and widening the genetic base of the grain hybrids. The results are in consonance with those of Virk and

Table 2a. Fertility sterility reaction of hybrids of diverse male sterile lines with four to six pollinators

Female lines	Male lines					
	78/711	ICR 161	HB 98/66	CSSC 46-2	HB 98/104A	HB 98/144
81A ₁	S	S	S	F	-	-
Pb313A ₂	S	F	F	F	F	-
Pb406A ₃	S	F	S	F	F	S
81A ₄	S	F	S	F	S	S
81A ₅	S	S	S	S	S	S
Pb502A _G	S	F	S	F	F	S
Pb601A _V	S	S	S	F	-	S

- Crosses not made.

Table 2b. Agronomic characters of hybrids based on diverse CMS lines

Pedigree	GY (q ha ⁻¹)	DFY (q ha ⁻¹)	50% flowering (days)	PH (cm)	EL (cm)	EG (cm)	Tillers/ plant
81Ax78/711	24.33	72.91	48.0	207.5	25.5	8.7	2.5
81A1xICR161	13.39	72.91	49.0	180.0	21.0	8.3	2.0
81A1xHB98/66	27.56	72.91	46.0	147.5	21.5	7.7	1.5
81A1xCSSC46-2	26.35	83.33	49.0	216.5	23.0	8.0	2.5
L313A2x78/711	35.19	93.74	45.0	196.5	23.5	8.7	2.0
L313A2xICR161	23.43	93.74	49.0	207.5	21.0	8.7	1.5
L313A2xHB98/66	28.60	52.08	47.0	200.5	19.5	9.8	2.0
L313A2xCSSC46-2	36.89	104.16	49.0	237.0	23.5	8.9	2.5
L313A2xHB98/104a	23.49	83.33	47.0	190.0	18.5	9.2	2.0
L402A3x78/711	30.00	98.95	47.0	204.0	19.5	8.1	2.0
L406A3xICR161	34.42	109.3	50.0	200.0	25.5	7.8	2.0
L406A3xHB98/66	37.96	114.58	46.0	217.5	20.5	8.6	2.0
L406A3xCSSC46-2	42.21	125.00	49.0	234.5	27.0	8.0	1.5
L406A3x98/104a	24.79	104.16	48.0	214.0	25.0	7.4	1.0
L406A3xHB98/144	15.15	62.49	48.0	165.5	26.0	9.3	2.0
81A4x78/711	24.14	72.91	46.0	206.5	24.5	8.8	2.5
81A4xICR 161	23.20	70.71	47.0	200.1	25.0	8.2	2.0
81A4x98/66	19.87	60.61	49.0	166.3	23.2	7.8	2.5
81A4xCSSC 46-2	35.89	100.19	48.0	221.2	28.2	8.3	3.0
81A4xHB98/104a	24.12	88.54	43.0	187.0	26.0	7.9	2.0
81A4xHB98/144	15.92	62.49	48.0	153.0	22.0	8.3	1.5
81A5x78/711	32.99	93.74	48.0	191.5	23.0	7.5	3.5
81A5xICR 161	25.00	70.20	47.0	189.0	25.0	8.1	2.0
81A5xHB98/66	32.54	93.74	46.0	204.0	20.0	8.4	2.5
81A5xHB98/104a	24.50	88.54	45.0	187.0	26.0	8.4	2.5
81A5xHB98/144	16.27	52.08	48.0	140.5	22.5	8.5	1.5
L502AGx78/711	24.29	93.74	44.0	212.5	25.5	8.5	2.0
L502AGxICR161	28.12	98.95	50.0	202.5	26.0	8.5	2.0
L502AGx98/66	22.10	60.00	51.0	200.0	25.0	7.8	2.1
L502AGxCSSC46-2	24.79	88.54	50.0	207.0	25.5	8.1	1.5
LS502AGxHB98/104a	25.79	93.74	48.0	209.5	26.5	8.0	2.5
L502AGxHB98/144	22.10	62.49	47.0	153.6	22.0	8.6	1.5
L601AVx78/711	33.33	78.12	43.0	180.0	24.5	9.4	2.0
L601AVxICR161	35.12	88.54	49.0	198.5	23.5	9.3	2.0
L601AVxHB98/66	19.75	57.29	48.0	176.5	21.0	9.1	1.0
L601AVxCSSC46-2	26.12	88.54	49.0	190.0	26.0	9.3	1.0
L601AVxHB98/104	25.94	57.29	46.0	178.5	22.5	8.5	3.0
601AVxHB98/144	20.60	57.29	48.0	132.0	27.5	10.2	1.5

GY = Grain yield; DFY = Dry fodder yield; EL = Ear length; S/F = Sterile/fertile. PH = Plant height. EG = Ear girth.

Table 3. Per cent fertile crosses identified on different CMS systems

Cytoplasm	High yielding crosses	Yield (q ha ⁻¹)	Fertility status
A ₁	HMS 14A ₁ xHB98/149	37.42	F
	81A ₁ xHTP72	32.72	F
	HMS14A ₁ xICR161	32.54	F
	81A ₁ xHB98/12	30.12	F
A ₂	313A ₂ xCSSC46-2	36.89	*PS
A ₃	406A ₃ xCSSC46-2	42.21	F
	402A ₃ xHB98/133	34.94	F
	406A ₃ xHB98/104a	34.75	F
	406A ₃ xICR161	34.42	F
A ₄	81A ₄ xHB98/84	36.89	F
A ₅	-	-	-
81A _{egp}	81A _{egp} xHB98/66	33.20	F
	81A _{egp} xHB98/187	32.39	F
Pb502A _G	-	-	-
Pb601A _V	-	-	*PS
Checks	HB67	28.87	F
	HHB84	28.27	F
	HC4	24.70	F
	HC10	23.12	F
	MP293	26.20	F

*PS = Found one plant partially sterile.

Mangat (1993) and Yadav (1996), who also reported equal utility of other cytoplasmic systems in development of high yielding hybrids. High yielding hybrids identified on different CMS systems are presented in Table 3. Maximum number of high yielders over the checks were obtained on A₃ followed by A₁ and 81A_{egp} indicating their greater immediate utility in breeding superior grain hybrids.

None of the hybrids was as early in flowering as check HHB 67, which flowered in 39 days. However, the male sterile lines Pb601A_V, and HMS 14A showed promise

in giving early hybrids. Rest of the system of CMS produced mid-early group hybrids (Table 4).

The results of this study showed that A₅, A₄, Pb601A_V, A₁ and Pb502A_G CMS system sources may be exploited to develop isonuclear M.S lines in diverse genetic background. The fertility restoration ability of genetically diverse pollinators on A₂, 81A_{egp}, A₃ and A₁ cytoplasm indicated that these CMS sources may be used for commercial production of grain hybrids, which will widen the cytoplasmic genic base of hybrids.

Table 4. Classification of pearl millet hybrids based on various CMS sources for their flowering time

Cytoplasm	Days to 50% flowering			
	38-40	41-45	46-50	>50
A ₁	—	8*	24	12
A ₂	—	2	17	3
A ₃	—	1	30	8
A ₄	—	1	20	4
A ₅	—	2	15	1
81 A _{egg}	—	1	7	2
Pb502 A _G	—	1	7	2
Pb601 A _V	—	9	18	2
Check HHB67	39 days			

* Number of hybrids.

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