DOI: 10.15740/HAS/AU/12.TECHSEAR(7)2017/1904-1908 *Agriculture Update*
Volume **12** | TECHSEAR-7 | 2017 | 1904-1908
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RESEARCH ARTICLE :

Suitability of alternate cytoplasm based hybrids for summer adaptation in pearl millet [*Pennisetum glaucum* (L.). R. Br.]

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ARTICLE CHRONICLE :
Received :
19.07.2017;
Accepted :
03.08.2017

SUMMARY : Pearl millet occupies a prominent place after rice and wheat in India. It is predominantly grown in rainy season with significant increase in area under summer grown pearl millet. The hybrids grown during summer have poor seed set though a few hybrids with good seed production potential are reported. A study was taken upto compare the A1 CMS system (97111A_1 and 98222A_1) with A4 CMS (99222A_4) and between high yielding (97111) and drought tolerant (98222, 99222) backgrounds. Of the 66 hybrids evaluated, the hybrid 97111A × R42 was the best performing with a grain yield of 6.27 t/ha. The hybrids based on 97111A performed better for plant height and panicle emergence while those based on 98222A were early to flower, had more number of tillers, had greater panicle width and panicle weight. The hybrids based on A_4 CMS based female parent 98222A had more panicle length, grain yield and panicle harvest index. it has been observed from the current study that the A_4 cytoplasm based hybrids in drought tolerant genetic background perform well as compared to A_1 CMS based hybrids. For summer adaptation, the grain yield was positively associated with plant height, panicle length, panicle weight and panicle harvest index.

KEY WORDS :
Pearl millet, A_4 cytoplasm, Hybrid, Summer, Panicle, Harvest index

How to cite this article : Reddy, P. Sanjana and Meena, R.S. (2017). Suitability of alternate cytoplasm based hybrids for summer adaptation in pearl millet [*Pennisetum glaucum* (L). R. Br.]. *Agric. Update*, **12**(TECHSEAR-7) : 1904-1908; **DOI: 10.15740/HAS/AU/12.TECHSEAR(7)2017/1904-1908.**

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BACKGROUND AND OBJECTIVES

Pearl millet occupies a prominent place after rice and wheat in India. The crop is well adapted to drought-prone areas, low soil fertility and high temperature situations. It is a predominantly cross-pollinated crop with 75–80% out-crossing and the heterosis can be exploited through hybrids.

Pearl millet is cultivated as an irrigated summer season (February–June) crop in parts of Gujarat, Rajasthan and Uttar Pradesh in India where where air temperatures during flowering can go as high as 46-48°C. Such high temperatures coinciding with flowering can cause spikelet sterility, leading to drastic reduction in grain yield. Most of the hybrids fail to set any seed at that high temperatures, but a few set excellent seed, and have wider farmers acceptance. Large genetic variation

for tolerance to heat at reproductive stage has been observed and heat tolerant lines have been identified among the maintainer lines and populations (Yadav *et al.,* 2012).

The A_1 cytoplasmic-nuclear male sterility (CMS) in pearl millet was discovered at Tifton, Georgia, USA (Burton 1958). The A_1-CMS system is most widely exploited and formed the basis for hundreds of commercial hybrids in India. In 1971, there was a drastic reduction in pearl millet production due to vulnerability of hybrids to downy mildew pathogen, *Sclerospora graminicola* (Sacc.) Schroet (Safeeulla, 1977). This was due to single source of cytoplasmic male-sterility used (Anand Kumar *et al.,* 1983). This dependence on single cytoplasm makes the pearl millet hybrid seed industry vulnerable to disease and insect-pest epidemics. A critical appraisal revealed that failure of these hybrids was mainly due to lack of diversity in the parental lines, as all the hybrids were first based on Tift 23 A_1 and then on 5141A_1 (Govila, 2001). Other diverse kinds of cytoplasm of pearl millet reported include A_2 and A_3 (Burton and Athwal, 1967), MS 732 A (Appadurai *et al.,* 1982), Violaceum (Marchais and Pernes, 1985), Ex-Bornu (Aken'Ova, 1985), A_4 (Hanna, 1989) and the A_5 CMS system (Rai, 1995). However, none of them was used by breeders in the public and private sector in India because of the paucity of restorers (R-lines) of this CMS system. However, development of restorers for the A4 and A5 CMS system is initiated at ICRISAT, Patancheru and IIMR, Hyderabad.

Suitability of the many different sources of cytoplasm for development of successful pearl millet hybrids suitable for target locations is also challenging. The present study focuses on the estimation of the potential ofA_4 cytoplasmic male sterile source as against the A_1in pearl millethybrids for grain yield and summer adaptation.

RESOURCES AND METHODS

The experimental material consisted of A-lines with A_1 cytoplasm in two genetic backgrounds (97111 and 98222) and with A_4 cytoplasm in one genetic background (99222). These were randomly crossed with 44 restorers to generate 66 hybrids. All the pollinators could not be crossed with all the male sterile lines because of differential flowering behavior. The 66 crosses were grown in randomized block design with three replications in 2 m long two row plots, with 60 cm row spacing and 15 cm plant to plant spacing.Geographically, the experimental site is situated at an altitude of about 542m above mean sea level with 17° 19' North latitude and 78° 28' E longitude.

The observations on yield and yield components were recorded on five randomly selected plants for each genotype in each replication for the traits days to 50% flowering, plant height, panicle emergence, number of productive tillers per plant, number of total tillers per plant, bristle length, spikelet density, panicle length and panicle width. The observation was recorded on the whole plot for panicle weight and grain weight. The 500-grain weight was recorded on random grain sample while panicle harvest index was derived as a ratio of grain weight to panicle weight. The analysis of variance was performed using Genstat 12th edition.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Mean performance:

Analysis of variance performed on the quantitative data (all the traits except bristle length and spikelet density) showed significant ($P \leq 0.05$) variation among the 66 pearl millet hybrids for all the traits. This is due to diversity in the cytoplasm as well as genetic background. Similar results were reported by Rai *et al.* (2006), Tara Satyavathi *et al.* (2009) and Rafiq *et al.* (2016). The mean performance of the top 18 hybrids are given in Table 1. Among them six hybrids are based on 97111A, three hybrids are based on 98222A while nine of them are based on 99222A. Among these, the hybrid 97111A × R42 was the best performing with a grain yield of 6.27 t/ha. The hybrid 97111A × R8 was early (48 days to flowering), 97111A × R14 was tall (188cm), 98222A × R55 and 99222A × R62 had three productive tillers, 99222A × R26 had greater panicle length (27.8 cm) and width (3.3cm) while the hybrid 98222A × R 55 had a higher panicle harvest index of 0.75.

Influence of cytoplasm and genetic background:

The hybrids were divided into three groups based on female parent (Table 2). The parents 97111A and 98222A were based on A_1 cytoplasm. The hybrids based on 97111A performed better for plant height and panicle

emergence while those based on 98222A were early to flower, had more number of tillers, had greater panicle width and panicle weight. The hybrids based on A_4 CMS based female parent 98222A had more panicle length, grain yield and panicle harvest index. Chandra-Shekhara *et al*. (2006) and Amiribehzadi *et al.* (2012) studied effect of cytoplasm for agronomic traits using alternate CMS sources. The female parents 98222A and 99222A were found to be drought tolerant in earlier studies. In the current study, it is found that the combination of drought tolerance and A_4 cytoplasm performed well for grain yield. The line 97111A is a good general combiner for

Table 1 : Mean performance of high yielding pearl millet hybrids evaluated during 2017 summer season

Pedigree	Days to 50% flowering	Plant height (cm)	Panicle emergence (cm)	No. of productive tillers/ plant	No. of total tillers/ plant	Bristle length	Spikelet density	Panicle length (cm)	Panicle width (cm)	Panicle weight (t/ha)	Grain yield (t/ha)	500 grain weight (g)	Panicle harvest index
97111A x R42	56	167	2.7	2.5	2.5	1.0	1.3	21.7	2.8	9.81	6.27	5.08	0.65
97111A x R35	52	157	5.4	2.2	2.4	1.0	1.3	23.7	2.9	9.77	6.24	5.02	0.63
98222A x R55	47	160	4.6	2.9	3.0	1.0	1.5	24.4	2.8	7.64	6.20	4.00	0.75
99222A x R17	56	167	3.4	1.4	1.4	1.0	1.3	25.8	2.9	8.97	6.12	5.02	0.67
97111A x R39	53	187	3.3	2.0	2.0	1.0	1.3	22.8	3.0	9.75	6.01	5.26	0.62
99222A x R11	52	178	4.3	2.0	2.0	1.0	1.3	20.0	2.9	8.68	5.98	4.70	0.69
99222A x R35	55	145	1.5	2.1	2.1	1.0	1.3	26.9	3.0	8.00	5.85	5.41	0.73
99222A x R62	45	158	5.3	2.8	2.8	1.0	2.0	22.5	2.5	7.94	5.77	5.67	0.73
99222A x R52	50	150	1.7	1.9	2.4	1.0	2.0	25.7	2.5	8.06	5.75	5.18	0.71
99222A x R26	56	185	0.7	1.4	1.4	1.0	3.0	27.8	3.3	7.70	5.60	5.63	0.73
99222A x R47	51	167	0.4	1.7	1.8	1.0	1.7	22.4	3.0	8.11	5.58	4.55	0.67
99222A x R29	51	180	-0.7	1.8	1.9	1.0	1.3	24.4	2.8	8.33	5.48	4.85	0.66
98222A x R14	49	153	1.9	1.7	1.7	1.3	1.3	23.3	3.0	8.55	5.44	5.39	0.64
99222A x R18	56	180	3.9	1.0	1.1	1.0	1.7	26.1	3.0	7.95	5.43	4.97	0.68
97111A x R8	48	172	5.7	2.7	2.5	1.0	1.0	22.4	2.6	8.66	5.42	4.44	0.62
97111A x R14	58	188	3.9	0.6	0.6	1.0	1.7	25.1	2.9	7.69	5.41	6.52	0.71
97111A x R26	51	175	4.5	0.9	0.9	1.0	1.3	25.2	3.2	7.65	5.41	5.46	0.71
98222A x R59	50	155	2.4	1.8	2.0	1.0	2.0	22.8	2.6	8.79	5.41	4.77	0.62
Mean	52	168	3.1	1.9	1.9	1.0	1.6	24.1	2.9	8.45	5.74	5.11	0.68
LSD	4.4	19.7	3.5	1.7	1.7			2.6	0.4	2.6	1.9	1.0	0.2
P Value	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.01

Table 2 : Contribution of female parent towards hybrid performance

Trait	$97111A_1$		$98222A_1$		$99222A_4$	
	Mean	SD	Mean	SD	Mean	SD
Days to 50% flowering	53	3.3	49	3.7	51	3.8
Plant height (cm)	166	12.6	155	10.6	163	12.4
Panicle emergence (cm)	4.38	1.69	2.02	2.79	2.17	1.95
No. of productive tillers/ plant	2.2	0.9	2.38	0.95	1.85	0.55
No. of total tillers/ plant	2.37	1.01	2.41	1	1.95	0.57
Bristle length	1.08	0.3	1.06	0.13	1.08	0.17
Spikelet density	1.67	0.44	1.44	0.37	1.8	0.43
Panicle length (cm)	22.1	3.1	23.9	1.7	24.3	2.7
Panicle width (cm)	2.66	0.28	3	0.22	2.88	0.24
Panicle weight (t/ha)	7.3	1.41	7.73	1.48	7.56	1.07
Grain yield (t/ha)	4.46	0.93	4.52	1.03	4.86	0.79
500 grain weight(g)	4.91	0.58	5.25	0.79	5.09	0.48
Panicle harvest index	0.62	0.06	0.58	0.11	0.66	0.07

Table 3 : Association among the agronomic and yield traits in pearl millet hybrids evaluated during 2017 summer season

	Days to 50% flowering	Plant height (cm)	Panicle emergence (cm)	No. of productive tillers/ plant	No. of total tillers/ plant	Panicle length (cm)	Panicle width (cm)	Panicle weight (t/ha)	Grain yield (t/ha)	500 grain weight (g)
Days to 50% flowering	1									
Plant height (cm)	0.36**	1.00								
Panicle emergence (cm)	-0.15	0.12	1.00							
No. of productive tillers/ plant	-0.16	-0.44**	0.12	1.00						
No. of total tillers/ plant	-0.11	-0.46**	0.14	0.97**	1.00					
Panicle length (cm)	0.13	0.32**	-0.42**	-0.53**	-0.56**	1.00				
Panicle width (cm)	0.08	0.19	-0.49**	-0.27*	-0.36**	0.58**	1.00			
panicle weight (t/ha)	-0.14	0.22	0.08	-0.45**	-0.53**	0.36**	0.21	1.00		
Grain yield (t/ha)	-0.06	0.26*	0.09	-0.36**	-0.43**	0.27*	0.18	0.73**	1.00	
500 grain weight(g)	0.07	0.12	-0.25**	-0.29*	-0.32**	0.36**	0.41**	0.06	0.10	1.00
Panicle harvest index	0.03	0.17	0.07	-0.06	-0.04	-0.01	0.04	-0.15	0.53**	0.08

* and ** indicate significance of values at P=0.05 and 0.01, respectively

grain yield. In the current study, the top two hybrids are based on 97111A while more number of hybrids were based on 99222A.Thus there is an indication towards the superiority of A_4 cytoplasm which need to be confirmed using isonuclear A-lines and common restorers. Similar results were reported by Rafiq *et al.* (2016).

Trait associations:

The grain yield was positively associated with plant height, panicle length, panicle weight and panicle harvest index. Thus, there is a need to improving the panicle length of hybrids (or parental lines) and good seed set for obtaining hybrids for summer adaptation. Negative association was found for number of tillers (total and productive) which indicates that less number of tillers with good grain yield and filling potential will contribute towards promising hybrids for summer season.

Conclusion :

It has been a proven concept that hybrids outperform varieties in pearl millet. In the summer grown areas which have high temperatures during flowering period, it has been observed from the current study that the A_4 cytoplasm based hybrids in drought tolerant genetic background perform well as compared to A_1 CMS based hybrids. This has to be further confirmed based on isonuclearallo-cytoplasmichy brids.

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