Potential of A_4 and A_5 Cytoplasmic-nuclear Male-sterility Systems in Pearl Millet

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The A_1 cytoplasmic-nuclear male sterility (cms) system, discovered by G W Burton in 1956, has been used very successfully in breeding both grain and forage hybrids of pearl millet (*Pennisetum glaucum* (L.) R. Br.). However, research at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and University of Nebraska comparing this cytoplasm with two of the several alternative sources, designated as A_4 (Hanna 1989) and A_5 (Rai 1995), shows that the A_1 system has a number of relative disadvantages, which are significant constraints in the breeding of acceptable parental lines and the production of hybrids.

Male-sterile line 81A_1 is one of the most stable A_1-system A-lines, but a two-season study of isonuclear A-lines showed that the A_1 version had up to 0.6% pollen shedders and up to 0.4% of the nonshedding plants had 6–20% seedset under selfing. There were no pollen shedders nor did any plants set seed under selfing in 81A_4 and 81A_5 (Table 1). Therefore, the use of A_4 and A_5 cms systems in breeding male-sterile lines could practically eliminate the problem of pollen shedders and consequent excessive roguing requirements often encountered in seed production of A_1-system A-lines and their hybrids.

A significantly higher proportion of breeding lines from diverse genetic backgrounds are maintainers (B-lines) of the A_4 system than of the A_1 system (Rai et al. 1996), and the frequent reversion to partial fertility observed in backcross progenies during conversion of B-lines into A-lines with the A_1 cytoplasm does not occur with the A_4 cytoplasm (Andrews and Rajewski 1994). Also, a large proportion of progenies from B × B crosses of the A_1 cms system produces partial maintainers. While current experience with the A_4 system is not as extensive, there are indications that a majority of the progenies from B × B crosses of the A_4 system are likely to be good maintainers. Thus, the use of A_4 cytoplasm can considerably enhance the effectiveness of breeding programs to diversify the genetic base of seed parents. Almost every breeding line is likely to be a maintainer of the A_5 cms system (Rai 1995). This, along with its most stable male sterility, is an indirect indication that sterility maintenance of the A_5 cytoplasm is least influenced by modifiers. Hence, A_5 cytoplasm provides the greatest opportunity for genetic diversification of seed parents.

The quality of male fertility restoration of A_1-system hybrids, in terms of both extent and stability, appears to be a mirror image of male sterility of the seed parents. Even in commercial A_1-system grain hybrids, a majority lack complete male-fertility restoration, which is highly influenced by environmental variation, especially temperature and moisture stress. Also, inbred lines that are good restorers on one A_1-system seed parent may be poor restorers on other A-lines with the same cytoplasm. Hybrids based on A_4-system seed parents have higher and more stable fertility restoration across environments, and restorers of the one A_4-system seed parent are equally good restorers on others with this cytoplasm (Andrews and Rajewski 1994).

Table 1. Pollen shedders and selfed seed-set in pollen-sterile plants of three isonuclear A-lines of pearl millet, 1996 rainy season (R96) and 1997 dry season (D97), Patancheru, India.

		Pollen sterility		Selfed seedset				
					Plants in seed-set class (%)			
A-line	Season	No of plants	Shedders (%)	No of plants	0	1–5	6–20	>20
81A_1	R96	1618	0.6	599	97.8	2.2	0.0	0.0
	D97	1200	0.3	483	95.7	3.9	0.4	0.0
81A_4	R96	1049	0.0	671	100.0	0.0	0.0	0.0
	D97	1200	0.0	414	100.0	0.0	0.0	0.0
81A_5	R96	835	0.0	586	100.0	0.0	0.0	0.0
	D97	1167	0.0	575	100.0	0.0	0.0	0.0

A majority of the A_1-system restorers will be maintainers of the A_4 system, and A_4-restorers would obviously be less frequent in the current breeding materials of most programs. This, however, is a transient constraint in the utilization of A_4 cytoplasm in breeding restorer parents. Experience shows that restorer gene(s) of A_4 cytoplasm can be transferred into elite inbred lines much more effectively than those of the A_1 cytoplasm, and the most efficient method for doing it would be to use fertile plants in F_1 and backcross progenies as female parents carrying the sterility-inducing cytoplasm. Development of an array of genetically diverse A_4-restorers is currently underway at the University of Nebraska and ICRISAT. Restorer stocks of the A_5 cms system have now been developed that give 90–100% selfed seed-set in hybrids of 81A_5. It is yet to be determined if transfer of A_5-restorer gene(s) into elite inbred lines will be as efficient as for the A_4 restorer gene(s).

While utilization of the A_4 cms system in breeding pearl millet seed parents and restorers at ICRISAT and University of Nebraska continues, a good foundation has been laid for utilization of the A_5 cms system. Research is underway to examine the effect of the A_4 cms system on grain yield and agronomic/adaptation traits. Isonuclear A-lines in diverse genetic backgrounds and elite restorers are being developed to undertake similar studies for the A_5 cms system.

In conclusion, the A_4 and A_5 cms systems provide access to more diverse germplasm and offer new opportunities for greater exploitation of heterosis in pearl millet hybrids. However, their main value appears to be in increasing the efficiency with which parental lines can be identified and produced. Hybrid seed production with these new cms systems will be easier, and greater male fertility levels of hybrids should lead to greater and more stable seed-set, and possibly better control of floral diseases through more rapid and effective pollination.

References

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Genotypic Variability for Quality Traits in Finger Millet (*Eleusine coracana* (L.) Gaertn.)

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Finger millet (*Eleusine coracana* (L.) Gaertn.) is grown in the Aravali hill slopes and undulating marginal lands of Rajasthan for food and fodder during the rainy season. The crop is an important source of protein and energy for the tribal and poor communities. It is also a rich source of calcium and iron (Gopalan and Balasubramaniam 1981). As in other cereals, it is now well established that nutritional quality in small millets is affected by environment (Kaoutu et al. 1993; Marimuthu and Rajagopalan 1995). To assess the importance of this effect, 57 genotypes of finger millet were evaluated for such nutritional quality parameters as seed sugar, seed protein, seed calcium, and seed iron content over three years.

The material was sown during three rainy seasons of 1995, 1996, and 1997 at Rajasthan College of Agriculture, Udaipur, India. Each genotype was sown in a 3-m row at a spacing of 22.5 × 8 cm. The experiment was conducted in a randomized block design with three replications in each season. Following uniform and recommended agronomical practices in each season, 40 kg N and 20 kg P_2O_5 ha^{-1} were applied. Nitrogen (N) content of the seed was estimated by standard micro-Kjeldahl method. Values of N obtained were converted to crude protein percentage by multiplying with a factor of 6.25. Seed sugar was biochemically analyzed according to the standard method suggested by Plummer (1971). Seed calcium was analyzed according to Cheng and Bray (1951) and seed iron contents according to Chapman and Prått (1961). A number of variability parameters were computed following standard statistical methodology.

Analysis of variance showed that genotypes differed significantly. Superior genotypes were identified on the basis of their high per se performance and consistant performance over three years and over pooled basis (Table 1).