

# Millet Research Reports

## Genetic Enhancement and Breeding

### Pearl Millet Male-sterile Population NCD<sub>2</sub>A<sub>4</sub> and its Counterpart Maintainer Population NCD<sub>2</sub>B<sub>4</sub>

KN Rai\*, AS Rao and AK Singh (ICRISAT, Patancheru  
502 324, Andhra Pradesh, India)

\*Corresponding author: k.raai@cgiar.org

The pearl millet (*Pennisetum glaucum*) population NCD<sub>2</sub>B<sub>4</sub> is a *d*<sub>2</sub> dwarf population developed as a maintainer of the A<sub>4</sub> cytoplasmic-nuclear male-sterility system (Hanna 1989). NCD<sub>2</sub>A<sub>4</sub> is the male-sterile counterpart of NCD<sub>2</sub>B<sub>4</sub> in the A<sub>4</sub> cytoplasmic background. Both populations were developed at ICRISAT, Patancheru, India. NCD<sub>2</sub>B<sub>4</sub> was derived from NCD<sub>2</sub> by three cycles of recurrent selection for male-sterility maintenance ability of male-sterile line 81A<sub>4</sub> (Rai et al. 2000). In each cycle, 123 to 392 plants of NCD<sub>2</sub> were selfed as well as testcrossed onto 81A<sub>4</sub>; of these, 76 to 131 testcrosses that were fully male-sterile were selected. In each cycle, S<sub>1</sub> progenies of the NCD<sub>2</sub> plants that produced these male-sterile testcross hybrids were recombined by hand to produce the seed of the next cycle bulk. The frequency of male-sterile testcrosses increased from 36% for the C<sub>0</sub> cycle to 88% for the C<sub>1</sub> and 100% for the C<sub>2</sub> cycle. The NCD<sub>2</sub> C<sub>3</sub> bulk produced by recombining 116 S<sub>1</sub> progenies of those plants from NCD<sub>2</sub> C<sub>2</sub> that produced fully male-sterile testcross progenies was designated as NCD<sub>2</sub>B<sub>4</sub> maintainer population.

Initially, the NCD<sub>2</sub> C<sub>0</sub> bulk was crossed onto 81A<sub>4</sub> to produce the topcross F<sub>1</sub> hybrid. During the 1994 postrainy hot summer (hereafter referred to as 'dry') season, 20 male-sterile plants of this hybrid were crossed with bulk pollen from 160 plants of the NCD<sub>2</sub> C<sub>1</sub> bulk to produce NCD<sub>2</sub>A<sub>4</sub>-BC<sub>1</sub>. Two subsequent backcrosses were made on about 50 male-sterile plants of backcross populations using the bulk pollen from more than 200 plants of the C<sub>2</sub> and C<sub>3</sub> cycle bulks of NCD<sub>2</sub>. Five additional backcrosses were made with the NCD<sub>2</sub>C<sub>3</sub> bulk (ie, NCD<sub>2</sub>B<sub>4</sub>) crossed onto male-sterile plants of the advancing backcross populations. The NCD<sub>2</sub>A<sub>4</sub>-BC<sub>8</sub> produced as the final backcross generation was designated as NCD<sub>2</sub>A<sub>4</sub>.

Comparison of male-sterility of NCD<sub>2</sub>A<sub>4</sub>-BC<sub>3</sub> with a commercial male-sterile line with the A<sub>1</sub> cytoplasm (841 A<sub>1</sub>) used as a control showed that both had similar

and low frequency of pollen shedders (0.2 to 1.0%) in the 1998 rainy season and 1999 dry season at Patancheru (Table 1). Further evaluation of a completely male-sterile version NCD<sub>2</sub>A<sub>4</sub> (=NCD<sub>2</sub>A<sub>4</sub>-BC<sub>8</sub>) during the 2000 dry season showed that it had no pollen shedders, while 841 A<sub>1</sub> had up to 0.1 % pollen shedders.

Evaluation of the four cycle bulks of NCD<sub>2</sub>B<sub>4</sub> in a yield trial conducted at Patancheru during the rainy and dry seasons of 1996 showed that there was no significant difference between the C<sub>0</sub> bulk of NCD<sub>2</sub> and its final C<sub>3</sub> bulk (ie, NCD<sub>2</sub>B<sub>4</sub>) for grain yield and other agronomic traits (Table 2). Although not evaluated in a replicated trial, after eight generations of backcrossing, NCD<sub>2</sub>A<sub>4</sub> and NCD<sub>2</sub>B<sub>4</sub> plants, as expected looked phenotypically similar in observation plots. In a replicated trial for two seasons at Patancheru, NCD<sub>2</sub>B<sub>4</sub> had a mean grain yield of 183 g m<sup>-2</sup>, with plant height of 1.5 m and 53 days to 50% flowering. NCD<sub>2</sub>B<sub>4</sub> has long panicles (33 cm), produces mostly one main panicle plant<sup>-1</sup> and has small seeds (7.1 g

**Table 1. Pollen shedders in pearl millet male-sterile NCD<sub>2</sub> populatioas (NCD<sub>2</sub>A<sub>4</sub>-BC, and NCD<sub>2</sub>A<sub>4</sub>) at Patancheru, India.**

Male-sterile population/line	Season	Total plants	Pollen shedders (%)
<b>Experiment 1</b>			
NCD <sub>2</sub> A <sub>4</sub> -BC <sub>3</sub>	Rainy 1996	1431	1.0
	Dry 1997	1067	0.2
841 A <sub>1</sub> (control)	Rainy 1996	1119	1.0
	Dry 1997	1333	0.2
<b>Experiment 2</b>			
NCD <sub>3</sub> A <sub>4</sub>	Dry 2000	750	0.0
841 A <sub>1</sub> (control)	Dry 2000	838	0.1

**Table 2. Mean grain yield and agronomic traits of four cycle bulks of NCD<sub>2</sub> in pearl millet during 1996 rainy and dry seasons, Patancheru, India.**

Cycle bulk	Grain yield (g m <sup>-2</sup> )	Time to 50% flowering	Plant height (m)	Panicle length (cm)	No. of tillers plant <sup>-1</sup>	1000-seed mass (g)
C <sub>0</sub>	196	53	1.5	34	1.1	7.3
C <sub>3</sub>	145	58	1.4	34	1.1	6.7
C <sub>2</sub>	180	56	1.5	34	1.1	7.1
C <sub>3</sub> <sup>1</sup>	183	53	1.5	33	1.2	7.1
SE±	5.6	0.2	0.02	0.4	0.02	0.13

1. C<sub>3</sub> bulk = NCD<sub>2</sub>B<sub>4</sub>.

1000-seed mass). The seed is light gray and hexagonal in shape. Both populations have mixed anthers of purple and cream color.

Seed of NCD<sub>2</sub>A<sub>4</sub> and NCD<sub>2</sub>B<sub>4</sub> will be maintained and distributed upon request in germplasm quantities by ICRISAT, Patancheru under the terms and conditions of the ICRISAT Breeding Materials Transfer Agreement.

## References

**Hanna WW. 1989.** Characteristics and stability of a new cytoplasmic-nuclear male-sterile source in pearl millet. *Crop Science* 29:1457-1459.

**Rai KN, Andrews DJ and Rao AS. 2000.** Feasibility of breeding male-sterile populations for use in developing inter-population hybrids of pearl millet. *Plant Breeding* 119:335-339.

## ICMR 98001: A Restorer Stock of A<sub>5</sub> Cytoplasmic-nuclear Male Sterility in Pearl Millet

**KN Rai\* and AS Rao** (ICRISAT, Patancheru 502 324, Andhra Pradesh, India)

\*Corresponding author: k.raai@cgiar.org

ICMR 98001 pearl millet (*Pennisetum glaucum*) restorer stock is a highly male-fertile inbred line in the A<sub>1</sub> cytoplasmic background. This line was developed at ICRISAT, Patancheru, India from one of the several pollen-fertile plants identified in a topcross hybrid produced by crossing Large-seeded Genepool-1 (LSGP-1) developed at ICRISAT, Patancheru (Rai et al. 1999) with male-sterile line 81A<sub>5</sub> that possesses the A<sub>5</sub> cytoplasm. LSGP-1 was developed by random mating 959 large-seeded (>10 g 1000-seed mass) germplasm accessions from 23 countries (Rai et al. 1999). The line 81 A<sub>5</sub> was developed by seven generations of backcrossing of a *d*<sub>2</sub> dwarf maintainer line 81B (Anand Kumar et al. 1984) into the A<sub>5</sub> male-sterility-inducing cytoplasm identified from one of the 67 pollen-sterile plants of LSGP-1 (Rai and Rao 1998).

During the 1995 postrainy hot summer (hereafter referred to as 'dry') season, 81 A<sub>5</sub> was crossed using the bulk pollen from 140 plants of LSGP-1. Of the 645 plants of the resulting topcross hybrid grown at Patancheru during the 1995 rainy season, six were pollen-fertile. Two generations of head-to-row evaluation, using seeds from open-pollinated panicles of the pollen-fertile plants in the A<sub>5</sub> cytoplasmic background, concomitant with selection

for high levels of pollen fertility, was followed by one generation of selfing of pollen-fertile plants to produce six S<sub>1</sub> progenies, one S<sub>1</sub> from each of the six rows. Six fertile plants in each S<sub>1</sub> were selfed to produce S<sub>2</sub> progenies and also testcrossed onto 81A<sub>5</sub>. During the 1997 dry season, it was observed that all plants in one S<sub>2</sub> progeny were pollen-fertile and they had 65-95% selfed seedset. Similarly, all the plants in the corresponding testcross were pollen fertile and they had 75-95% selfed seedset. Further selfing in this S<sub>2</sub> produced S<sub>3</sub> progenies. An additional selfing in this S<sub>3</sub> produced S<sub>4</sub> progenies and testcrossing of those selfed plants onto 81 A<sub>5</sub> produced testcross hybrids.

Evaluation during the 1998 dry season at Patancheru showed that all plants in one S<sub>4</sub> progeny and its corresponding testcross were pollen-fertile and they had 90-100% selfed seedset. A S<sub>5</sub> progeny (ICMA<sub>5</sub>R-1) produced from this S<sub>4</sub> progeny was designated as ICMR 98001. It was evaluated in a yield trial along with three other restorer stocks during the rainy season in 1998 and 1999 at Patancheru. ICMR 98001 gave a mean grain yield of 201 g m<sup>-2</sup> compared to 264 g m<sup>-2</sup> for an A<sub>1</sub>-system restorer line (ICMR 356) of a commercial hybrid ICMH 356. In this trial, ICMR 98001 grew 1.6 m tall, produced 1.4 panicles plant<sup>-1</sup>, and took 54 days to 50% flowering (6 days later than ICMR 356). ICMR 98001 has short (21 cm), cylindrical and compact panicles with tufted tip. It has hairy leaf blade and leaf sheath, and yellow anthers. It is a prolific pollen producer with plants having 85-100% selfed seedset. The seed is small (7.2 g 1000-seed mass), gray in color, hexagonal in shape and has spiny outer surface.

Seed of ICMR 98001 will be maintained and distributed in germplasm quantities on request by ICRISAT, Patancheru, under the terms and conditions of ICRISAT Breeding Materials Transfer Agreement.

## References

**Anand Kumar, Andrews DJ, Jain RP and Singh SD. 1984.** ICMA-1 and ICMB-1 pearl millet parental lines with A<sub>1</sub> cytoplasmic-genic male sterility system. *Crop Science* 24:832.

**Rai KN, Andrews DJ, Rao AS, Rajewski JF and Du RH. 1999.** Restorer sources of A<sub>5</sub>cytoplasmic-nuclear male sterility in *Pennisetum* germplasm and its implications in pearl millet hybrid breeding. *International Plant Genetic Resources Newsletter* 120:20-24.

**Rai KN and Rao AS. 1998.** Registration of pearl millet cytoplasmic-nuclear male-sterile line ICMA-5. *Crop Science* 38:556.