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PERFORMANCE OF THREE HIGH-TILLERING MALE-STERILE LINES AND THEIR HYBRIDS IN PEARL MILLET[1]

K.N. RAI AND A.S. RAO

Cereals Program, ICRISAT, Patancheru, Andhra Pradesh - 502324

ABSTRACT

A high-tillering and d_2 dwarf male-sterile line (ICMA 89111) of pearl millet, recently developed at ICRISAT Center, was compared with the two previously available highest-tillering male-sterile lines (5054A and 3383A) for their performance *per se* as well as for the performance of their hybrids in three environments. ICMA 89111, on an average, had at least 60% higher grain yield, 66% more seed mass, 22% more effective tillers per plant, and was 5 days later in flowering than the other two male-sterile lines. Hybrids of ICMA 89111 had, on an average, 18% higher grain yield, 28% more seed mass, were 2-3 days later in flowering, and 20-25 cm taller in height than those based on the other two male-sterile lines. All three groups of hybrids had generally similar numbers of effective tillers per plant. These features, coupled with higher downy mildew resistance of ICMA 89111, make it a promising new male-sterile line to breed high-tillering hybrids with high grain yield potential and downy mildew resistance.

INDEX WORDS : *Pennisetum glaucum*, pearl millet, grain yield, tillering, male-sterile lines, hybrids.

High-tillering ability in pearl millet [*Pennisetum glaucum* (L.) R. Br.] appears to have evolved as an important adaptive mechanism in those arid and semi-arid agricultural environments that are characterized by short growing season, unpredictable pattern of drought stress and irregular distribution of plant stands. Based on the farmers' perceptions that high-tillering plant type is associated with better stover quality, human selection might have also led to the evolution of high-tillering populations. Since the arid and semi-arid environments represent a larger proportion of pearl millet-growing area in India, most of the breeding programmes in the country have emphasized high-tillering ability as an important selection criterion in breeding hybrid parents. Most of the male-sterile lines developed in India have good tillering ability. Notable among these are 5054A and 3383A, both developed at the Indian Agricultural Research Institute (IARI), New Delhi (Pokhriyal *et al.*, 1976). Recently, a high-tillering male-sterile line (ICMA 89111) with dwarf plant height has been developed at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru. In the research reported here, these male-sterile lines and their hybrids have been compared for grain yield and its components.

MATERIAL AND METHODS

The three high-tillering male-sterile lines (5054A, 3383A, ICMA 89111) were each crossed with two high-tillering pollinators (H 77/833-2, ICMP 423), two medium-tillering pollinators (ICMP 451, ICMP 85118), and two low-tillering pollinators (ICGP 8501, ICMP 83506) during the 1990 post-rainy season. The resultant 18 hybrids and 9 parents were evaluated in separate trials grown in adjacent strips at ICRISAT Center (two environments) and Hisar during the 1990 rainy season. The two environments at ICRISAT Centre consisted of one sowing on 18 June in a Vertisol (high-yielding environment) and another sowing on 24 July in an Alfisol (low-yielding environment). The trial at Hisar was sown on 11

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July in an Entisol. These trials were sown in 2-row plots of 4 m length on ridges 75 cm apart, with a spacing of 20 cm between plants. The hybrid trial was sown in a split-plot design with pollinator factor constituting the main plots and the three hybrids with a pollinator as sub-plots. Hybrid parents were sown in a randomized complete block design. Both trials were replicated three times.

These trials were conducted at the applied fertilizer levels of 80 kg N and 40 kg P ha^{-1} at ICRISAT Center and 20 kg N and 20 kg P ha^{-1} at Hisar. Adequate rains at ICRISAT Center and timely irrigation, whenever required, at Hisar ensured that trials were not subjected to drought stress at any growth stage. Grain yields from panicles sun-dried for more than 10 days, and time taken to 50% flowering were evaluated on the plot basis. Plant height and panicle length data were taken on three random plants in each plot at Hisar and in the Vertisol field at ICRISAT Center, and on a single representative plant of each plot in the Alfisol field at ICRISAT Center. The 1000-grain mass was determined from a sample of 100 grains in each plot. Fixed effects model was assumed for the analysis of the hybrid trial and parental trial using SAS computer program (SAS Institute, 1985).

The three male-sterile lines along with three controls, including a widely used commercial male-sterile line (81A), a highly susceptible hybrid (NHB 3), and an inbred line (700651) of West African origin identified as a source of high level of stable resistance to downy mildew (Singh *et al.*, 1990) were evaluated for downy mildew resistance during the 1992 post-rainy season at ICRISAT Center. Standard screening procedures (Williams *et al.*, 1981; Singh and Gopinath, 1985) were used for evaluation in the disease nursery and in the greenhouse. Both tests were replicated five times in a randomized complete block design with generally >50 plants per plot and >100 seedlings per 2-pot replication. The downy mildew incidence (%)

TABLE 1. Grain yield and yield-components of pearl millet hybrid parents, rainy season 1990. Mean of three environments[1].

Hybrid parent	Grain yield (t ha^{-1})	Time to 50% flower (d)	Plant height (m)	Panicle length (cm)	Effective tillers $plant^{-1}$	1000-seed mass (g)
Male-sterile line						
5054A	1.14	50	1.33	18	5.1	4.6
3383A	1.14	50	1.19	16	5.5	4.7
ICMA 89111	1.84	55	1.20	18	6.7	7.8
Pollinator						
H 77/833-2	1.02	44	1.18	14	4.7	6.4
ICMP 423	1.84	53	1.86	18	4.2	8.1
ICMP 451	2.06	49	1.83	28	3.3	11.4
ICMP 85118	0.73	58	1.30	16	3.6	6.0
ICMP 83506	1.55	56	1.87	25	2.1	7.3
ICGP 8501	2.10	47	1.78	18	2.1	12.1
LSD (0.05)	0.03	1.2	0.006	0.9	0.9	0.6

[1] ICRISAT Center (18 June sowing in a Vertisol and 24 July sowing in an Alfisol), and Hisar (11 July sowing in an Entisol).

data were transformed to arc sin for the analysis of variance.

RESULTS AND DISCUSSION

The male-sterile line ICMA 89111 had a mean grain yield of 1.84 t ha^{-1}, which was about 60% higher ($P \leq 0.01$) than 5054A and 3383A (Table 1). This male-sterile line also had at least 66% higher grain mass, over 22% more effective tillers per plant, and took five more days to reach 50% flowering than the other two high-tillering male-sterile lines. All three male-sterile lines had equivalent plant height and panicle length. The six pollinators, used to make hybrids, represented a wide range of diversity (Table 1) for grain yield (0.73-2.1 t ha^{-1}), flowering (44-58 days), plant height (1.30-1.87 m), panicle length (14-28 cm), and 1000-grain mass (6.0-12.1 g). With respect to tillering ability, these pollinators represented a high-tillering group (4.2-4.7 tillers per plant), a medium-tillering group (3.3-3.6 tillers per plant), and a low-tillering group (2.1 tillers per plant).

Of the two high-tillering male-sterile lines developed earlier, only 5054A has proved useful in the development of commercial hybrids (Dave, 1987). The present study shows that ICMA 89111 is superior to 5054A for grain yield, tillering ability, and grain mass. ICMA 89111 flowered only 1-2 days later than 3383A and 5054A at ICRISAT Center. At Hisar, however, it flowered 11-12 days later, indicating its higher sensitivity to longer days in north-western India. Therefore, under southern Indian conditions this flowering behaviour of ICMA 89111 provides an opportunity to use pollinators of similar maturity as those on the other two male-sterile lines for producing early- to mid-early-maturing hybrids.

In a greenhouse seedling inoculation test carried out under high disease pressure with the ICRISAT Center isolate, ICMA 89111 had the highest level of resistance (4.6% downy mildew incidence compared to 15.5% in 5054A and 52.1% in 3383A) (Table 2). Even the resistant check 700651 was significantly more susceptible than ICMA 89111. The disease incidence levels were low under field conditions in the disease nursery but the trend remained unchanged.

The mean grain yield of hybrids based on ICMA 89111 was 2.92 t ha^{-1}. This is at least 18% more than those based on 5054A or 3383A (Table 3). This represents a significant advance

TABLE 2. Downy mildew incidence on three high-tillering male-sterile lines, ICRISAT Center, post-rainy season 1992

Entry	Downy mildew incidence (%)	
	Greenhouse	Disease nursery
ICMA 89111	4.6 (12.2)[1]	0.6 (1.9)
5054A	15.5 (23.0)	2.6 (9.0)
3383A	52.1 (46.2)	9.2 (17.1)
Controls		
81A (Commercial)	32.4 (34.9)	2.2 (7.3)
NHB 3 (Susceptible)	96.1 (78.7)	90.6 (72.2)
700651 (Resistant)	11.0 (19.2)	1.1 (4.7)
LSD (0.05)	(4.06)	(5.65)

1. Values inside the brackets are on the arcsin scale.

TABLE 3. Grain yield and yield-components on pearl millet hybrids, rainy season 1990. Mean three environments[1].

Hybrid combination		Grain yield (t ha^{-1})	Time to 50% flower (d)	Plant height (m)	Panicle length (cm)	Effective tillers plant^{-1}	1000-seed mass (g
Pollinator (tillering group))	Male-sterile line						
Higher tillering	ICMA 89111	2.59	47	1.87	21	4.8	9.6
	5054A	2.21	45	1.72	21	5.7	6.5
	3383A	2.08	45	1.64	19	4.8	6.6
Medium tillering	ICMA 89111	3.23	52	2.09	23	3.8	10.5
	5054A	2.58	48	1.88	24	4.0	7.9
	3383A	2.58	47	1.78	23	4.1	8.1
Low tillering	ICMA 8911	2.95	49	2.03	25	3.0	11.0
	5054A	2.62	48	1.86	23	2.9	8.5
	3383A	2.56	47	1.83	25	3.2	8.6
LSD (0.05)		0.28	0.6	0.064	1.1	0.62	0.39
Mean	ICMA 89111	2.92	49	2.00	23	3.9	10.4
	5054A	2.47	47	1.82	23	4.2	7.6
	3383A	2.41	46	1.75	22	4.0	7.8
LSD (0.05)		0.163	0.3	0.036	0.6	0.33	0.23

1. ICRISAT Center (18 June sowing in a Vertisol and 24 July sowing in an Alfisol), and Hisar (11 July sowing in an Entisol).

considering that 5054A is one of the best general combiners for grain yield (Pokhriyal *et al.*, 1976; Kapoor *et al.*, 1979). With the three tillering groups of pollinators, the grain yield of hybrids on ICMA 89111 was 13 - 25% more than those based on the other two male-sterile lines. The hybrids of ICMA 89111, in general, flowered 2-5 days later and were 20 - 25 cm taller than those based on the other two male-sterile lines. The hybrids of all three male-sterile lines had equivalent panicle length. The tillering ability of pollinators had a strong effect on the tillering ability of hybrids on all three male-sterile lines. The superior tillering ability of ICMA 89111 was not reflected in the tillering ability of its hybrids. When crossed with high-tillering pollinators, hybrids of 5054A had significantly more tillers than those of ICMA 89111. The seed mass of hybrids on ICMA 89111 was at least 28% more than those based on the other two male-sterile lines, and it was up to 45% greater where pollinators had relatively smaller seeds.

The superior yield potential of hybrids on ICMA 89111 in crosses with a diverse range of pollinators was achieved primarily through larger seed mass and perhaps through greater panicle girth, but not through better tillering ability. We have observed ICMA 89111 to have a semi-spreading growth habit, a relatively longer peduncle, and excellent exsertion. These features are strongly expressed in its hybrids. Hybrids based on ICMA 89111 displayed bending stems. It is suggested, therefore, that pollinators with sturdy stems and erect growth habit be used to breed hybrids on this male-sterile line.

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