Improving Forage Productivity by Using Cytoplasmic Male Sterility of Pearl Millet

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IMPROVING FORAGE PRODUCTIVITY BY USING CYTOPLASMIC MALE STERILITY OF PEARL MILLET

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ABSTRACT

Fourteen forage millet hybrids were produced by crossing 7 male fertile lines to 2 different lines of dwarf cytoplasmic male sterile (cms) lines of forage millet (*Pennisetum americanum*). Hybrids were evaluated with their male parents at the Giza experimental station in summer 1994. The evaluations included fodder yield traits and chemical composition. The objectives of the study were: 1 - to assess hybrid vigor, and 2 - to select the superior hybrids to be used in commercial production in Egypt. Present results showed that the 14 F_1 hybrids and their male parents varied significantly in green and dry yield and their components. The top productivity of green and dry yield were found for the F_1 hybrids of (cms line Tift 23 DA X ICTP 8202), (cms line Tift 23 A_1E_1 X ICTP 8202), with no significant differences between them followed by (cms line Tift 23 A_1E_1 X ICMS 7703). These hybrids also gave the highest value for crude protein % and the lowest value of crude fiber %, results which suggest that local F_1 hybrids can be used an a commercial scale in Egypt.

KEYWORDS

Forage productivity, male sterility, forage pearl millet, *Pennisetum americanum*, hybrids

INTRODUCTION

Pearl millet is the most important constituent of the genus *Pennisetum*. It is a dual-purpose crop. It provides grain for human consumption and fodder for cattle. In Egypt, animals suffer from deficiency of green fodder in summer time. Forage pearl millet as well as forage sorghum can be used to solve this problem. Forage pearl millet is considered the best forage grass as it gives good forage quality, has remarkable ability to grow in areas of low rainfall and grows better than any annual grass in sandy and light clay soil. Breeding of forage pearl millet in Egypt was initiated very recently. Little effort has been made to develop hybrid cultivars using cytoplasmic male sterile lines of pearl millet. Several workers have reported heterosis in grain millet hybrids up to 80% by Duendeba et al. (1993) and 397% by Kushwah et al (1992) when compared to their parents. High percentages of heterosis of forage millet were reported by Patil et al. (1992) and Burton et al. (1980). Similar results were also reported by Younis et al (1988) for forage sorghum. Also, forage quality of pearl millet has been improved by breeding later maturity cultivars Burton et al. (1989), Makeri and Ugherughe (1992) determined C.P. and C.F. of forage millet ranged from 14.1 to 20.3% and from 28.0 to 30.8%, respectively. The objectives of this study were 1) to determine the manifestation of heterosis in forage hybrid millet 2) select superior hybrids to be used in commercial production in Egypt.

MATERIALS AND METHODS

This investigation was conducted at the Giza Experimental station. Two lines of dwarf cytoplasmic male sterile (cms) of forage millet (*Pennisetum americanum*) were used as female parents (Tift 23 A_1E_1 (ms_1) and Tift 23 DA (ms_2)). These lines were found to be stable for the male sterile trait under Egyptian conditions. Seeds of these lines were obtained from the USA. Seven line of pearl millet were used as male parents: ICMV 88101 (M_1), WCC 75 (M_2), ICTP 8202 (M_3), ICMS 7703 (M_4), ICMV 87101 (M_5), ICMV 155 (M_6) and local selected variety (M_7). Seeds of these lines were introduced from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India. Fourteen F_1 hybrids were produced in the summer season of 1993 by hand crossing between female and male parents according to Table 1. In the summer season of 1994, the 14 F_1 hybrids and the male parents were planted in randomized complete blocks design with four replications. Each genotype was planted in one row, 4m in length and 0.6 m in width. Plants were spaced 0.2 m apart to ensure a constant stand of 20 plants per row. Plants were thinned to one plant per hill after 15 days from planting. Data were recorded on different traits of green fodder yield taken from three cuts during the summer season. The characters studied were: 1 - plant height in cm, 2 - number of tillers per plant, 3 - stem diameter in cm, 4 - length of the 5th leaf in cm, 5 - width of the 5th leaf cm and green and dry fodder yield per plant (kg). Data for fodder characters under study were statistically analyzed according to Steel and Torrie (1960).

Percentage heterosis over the better parent was computed by using the following equation:

$$\text{Heterosis \%} = \frac{F_1 - BP}{BP} \times 100$$

where F_1 and BP are the means of the F_1 hybrids and better parent, respectively.

Crude protein (CP) %, crude fiber (CF) %, Fats (EE) %, and Ash % were determined over cuts in dry matter (DM) for the 14 F_1 hybrids and their male parents according to A.O.A.C. (1980).

RESULTS AND DISCUSSION

Performance of 14 F_1 hybrids and their male parents: Average of plant height, stem diameter, no. of tillers, 5th leaf length and width and total green and dry yield over 3 cuts were determined and presented in Table 1. Data showed that significant differences were obtained among the F_1 hybrids and between the hybrids and their male parents for most characters studied. The highest values of plant height were obtained from the F_1 hybrids (ms_2 X M_3), (ms_1 X M_3) with no significant differences between them, followed by the other F_1 hybrids (ms_1 X M_6) and ms_2 X M_4), while the lowest values were obtained from the F_1 hybrids (ms_2 X M_7) and male parent (M_3). Also the highest values of stem diameter were from the F_1 hybrid (ms_1 X M_5) and male parents (M_1) and (M_2), while the remaining F_1 hybrids gave almost the same values with no significant differences between them. The highest value of number of tillers per plant was from the F_1 hybrids (ms_1 X M_3) and (ms_1 X M_4) with no significant differences between them, followed by the F_1 hybrids (ms_2 X M_1) and (ms_2 X M_3). On the other hand, the lowest values were from the F_1 hybrid (ms_1 X M_1) and male parent (M_4), while the remainder hybrids were almost the same. The highest values of the 5th leaf length and width were from the F_1 hybrid (ms_2 X M_7). Regarding total green and dry yield per plant over 3 cuts data reported that the highest productivity of both green and dry matter yield was from the F_1 hybrids (ms_2 X M_3), (ms_1 X M_4) and (ms_2 X M_1), with no significant difference between them. On the other hand, the lowest productivity was from the F_1 hybrid (ms_2 X M_7) and male parent (M_4). Generally, the highest productivity of green and dry yield of the Superior F_1 hybrids was attributed to the highest values of tillers, 5th leaf length and width and plant height. These results are in agreement with those obtained by Patil et al. (1992), Burton et al. (1980) and Younis et al. (1988).

Heterosis: The amount of heterosis for forage traits over three cuts was determined and presented in Table 2. When the means of the F1 hybrids were compared with the means of the better parents, the results indicated that some F_1 hybrids were higher than their better parents for most characters studied indicating different degrees of heterosis. Hybrids showing statistical significance for 6 factors are shown below.

Factors	Hybrids
Plant height	(Ms_1 X M_3) (Ms_2 X M_3)
Tillering	(Ms_1 X M_1) (Ms_1 X M_2) (Ms_1 X M_3) (Ms_1 X M_4) (Ms_2 X M_1) (Ms_2 X M_2) (Ms_2 X M_3) (Ms_2 X M_4)
The 5th leaf length	(Ms_1 X M_6)
The 5th leaf width	(Ms_1 X M_3) (Ms_2 X M_3) (Ms_2 X M_1)
Green yield/plant	(Ms_1 X M_4) (Ms_2 X M_1) (Ms_2 X M_3) (Ms_2 X M_4)
Dry yield/plant	(Ms_1 X M_2) (Ms_1 X M_3) (Ms_1 X M_4) (Ms_2 X M_1) (Ms_2 X M_3) (Ms_2 X M_4)

These results are generally in agreement with those obtained by Burton et al. (1980), Patel et al. (1992) and Younis et al (1988).

Chemical Composition: Comparing the various chemical constituents among the 14 F_1 hybrids and their male parents in this investigation (Table 3), data showed that slight variations were obtained among the 14 F_1 hybrids and their male parents for CP% and CF%. The F_1 hybrids (Ms_1 X M_3), (ms_2 X M_1) and (ms_2 X M_3) gave the highest values of CP and the lowest value of CF. Also results are reported that the values of ether extract (EE) and ash were almost the same in all F_1 hybrids and their male parents. These results are in line with observations given by Makeri and Ugherughe, 1992 and Burton et al., 1986.

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Table 1
Performance of 14 F_1 hybrids and their male parents of fodder yield traits of pearl millet in summer 1994.

	Hybrids		Plant height cm	Stem diameter cm	Tillers per plant	5th Leaf length cm	5th Leaf width cm	Green yield kg	Dry yield kg
Tift 23 A_1 E_1 (ms_1)	x ICMV 88101	(M_1)	126.96	0.92	11.60	55.71	2.93	2.07	0.29
" " "	x WCC 75	(M_2)	134.33	0.88	11.03	57.89	3.27	2.14	0.30
" " "	x ICTP 8202	(M_3)	146.96	0.95	16.54	58.97	3.73	2.28	0.59
" " "	x ICMS 7703	(M_4)	125.40	1.03	15.00	65.72	3.87	2.92	0.51
" " "	x ICMV 87101	(M_5)	119.49	1.17	8.19	61.16	3.49	1.81	0.27
" " "	x ICMV 155	(M_6)	136.21	0.99	11.39	55.16	2.82	2.22	0.24
" " "	x Local Variety	(M_7)	131.54	1.00	13.54	57.27	2.93	1.95	0.29
Tift 23 DA (ms_2)	x ICMV 88101	(M_1)	132.21	0.84	9.45	64.93	3.99	3.00	0.46
" " "	x WCC 75	(M_2)	127.62	0.95	9.88	55.72	3.03	1.90	0.25
" " "	x ICTP 8202	(M_3)	157.36	0.91	12.8	57.77	3.82	3.52	0.65
" " "	x ICMS 7703	(M_4)	135.88	0.92	11.24	58.18	2.94	1.94	0.25
" " "	x ICMV 87101	(M_5)	127.70	1.00	10.50	58.09	2.70	2.05	0.27
" " "	x ICMV 155	(M_6)	134.33	0.88	11.03	57.89	3.27	2.14	0.30
" " "	x Local Variety	(M_7)	88.76	0.87	10.68	51.83	3.02	1.55	0.22
Male parents:									
ICMV 88101		(M_1)	129.32	1.14	9.07	56.16	3.12	2.54	0.30
WCC 75		(M_2)	132.02	1.03	7.68	59.83	3.48	1.96	0.23
ICTP 8202		(M_3)	109.73	0.83	8.24	54.11	3.09	2.02	0.28
ICMS 7703		(M_4)	126.93	0.96	7.09	54.59	3.26	1.46	0.19
ICMV 87101		(M_5)	129.50	1.04	8.66	59.91	3.34	1.72	0.22
ICMV 155		(M_6)	131.38	0.94	9.84	59.30	3.13	1.95	0.25
Local Variety		(M_7)	132.77	1.14	8.78	54.49	3.43	1.78	0.25
L.S.D.			12.11	0.28	2.74	2.44	0.42	0.48	0.09

Table 2
Heterosis (%) from better parent for fodder yield traits, summer 1994.

	Hybrids		Plant height cm	Stem diameter cm	Tillers per plant	5th Leaf length cm	5th Leaf width cm	Green yield kg	Dry yield kg
Tift 23 A_1 E_1 (ms_1)	x ICMV 88101	(M_1)	- 1.86	- 23.50	21.81*	- 18.75	- 6.48	- 22.41	- 3.44
" " "	x WCC 75	(M_2)	1.71	- 17.04	30.37**	- 3.35	- 6.42	8.41	23.33*
" " "	x ICTP 8202	(M_3)	25.57*	7.36	50.18**	8.24	17.16*	11.42	46.00**
" " "	x ICMS 7703	(M_4)	- 1.22	6.79	52.73**	16.93*	15.76	50.00**	62.74**
" " "	x ICMV 87101	(M_5)	- 8.38	11.11	- 5.73	2.04	4.29	4.97	18.51
" " "	x ICMV 155	(M_6)	3.54	5.05	13.60	- 6.84	- 10.99	12.16	- 4.61
" " "	x Local Variety	(M_7)	- 0.97	- 14.00	7.96	- 12.60	- 16.72	8.73	3.44
Tift 23 DA (ms_2)	x ICMV 88101	(M_1)	1.68	- 35.71	32.56**	- 1.89	21.80**	91.53**	33.33**
" " "	x WCC 75	(M_2)	- 3.44	- 7.37	22.26*	- 7.37	- 14.85	3.15	8.00
" " "	x ICTP 8202	(M_3)	30.84**	8.79	35.63**	6.34	19.10*	42.66**	56.00**
" " "	x ICMS 7703	(M_4)	7.12	- 4.34	36.92	6.17	- 10.88	24.74*	24.00*
" " "	x ICMV 87101	(M_5)	- 1.51	- 4.00	17.52	- 3.13	- 22.96	4.87	7.47
" " "	x ICMV 155	(M_6)	2.16	- 6.82	10.78	- 2.43	4.28	8.87	16.66
" " "	x Local Variety	(M_7)	- 33.14	- 31.03	17.79	- 24.42	- 13.20	- 14.83	- 27.27

* Significant at P= 0.05
** Significant at P= 0.01

Table 3
The range and average of chemical composition of 14 F_1 hybrids and their male parents of forage pearl millet.

Parameters	F1 hybrids		Male parents	
	Range %	Average	Range %	Average
Crude protein (CP) %	12.35 - 14.25	13.35	12.61 - 14.99	13.80
Crude fiber (CF) %	31.88 - 33.76	32.62	30.12 - 32.69	31.40
Ether Extract (EE) %	1.12 - 1.45	1.28	1.24 - 1.31	1.28
Ash %	13.11 - 16.84	14.98	13.30 - 14.84	14.14