International Journal of Basic and Applied Biology
Print ISSN: 2394-5820, Online ISSN: 2349-2539, Volume 2, Number 4; January-March, 2015, pp. 253-257

http://www.krishisanskriti.org/ijbab.html

MS Lines Evaluation for Fodder and Quality Traits and their Utilization in Hybrid Development Program and their Evaluation

Pummy Kumari[1], Satywan Arya[2], S.K. Pahuja[3] and U.N. Joshi[4]

[1,2,3]Forage Section, Genetics and Plant Breeding, CCS HAU Hisar
[4]Deptt. of Biochemistry, College of Basic Sciences and Humanity, CCS HAU Hisar
E-mail: [1]pummy.choudhary84@gmail.com, [2]satyarya@yahoo.in, [3]pahujask66@gmail.com, [4]unjoshi2007@rediffmail.com

Abstract—*The objective of the present study was to select the best parents and then utilize them in hybridization programme to produce hybrids that could provide palatable green fodder over longer period of time. The material was sown in randomized block design and evaluated for some agronomic and forage quality traits. Field experiments were conducted during kharif 2010 and 2011 at Research area of forage farm at CCS HAU, Hisar to estimate overall performance of hybrids. During kharif 2010, 10 MS lines and 8 pollinators were evaluated for various agronomic traits that affect the fodder yield directly or indirectly. Next year these parents were used for hybrid development programme and 30 MS based hybrids were developed from these lines. Out of these hybrids, 16 hybrids were high yielding than our best check SSG 59-3 i.e., GFY: 1233 q/ha, DFY: 271 q/ha and our best hybrids were HH 500 (1767 q/ha GFY; 326 q/ha DFY), HH479 (1733 q/ha GFY; 313 q/ha DFY), and HH485 (1733 q/ha GFY; 329 q/ha DFY respectively). The hybrid HH500 had shown 43.3% increase over our best check SSG 59-3 multicut variety. On the basis of quality analysis these hybrids were of good quality and have lower HCN value 13-151µg/g. Crude protein in hybrids ranged from 8-10.9 per cent and In vitro dry matter digestibility ranged from 24-60.8 per cent. These hybrids can be tested in larger plots and if found better than the checks, these can be tested in All India Co-ordinated trials and may be released.*

Keywords: *Sorghum, hybrid, green fodder yield and dry fodder yield*

1. INTRODUCTION

Livestock is a major component of Indian agriculture. Due to great increase in livestock population during last few years, there is huge gap in demand and supply of green as well as dry fodder. Although it is a multipurpose crop having use in food, feed, fodder and fuel utilities but it is extensively grown for fodder in the North India during summer and *kharif* seasons due to its greater adaptability, high fodder yield, better palatability and quality.

Sorghum is predominantly a self pollinated crop and development of new 'varieties' is a natural option for crop improvement. Sorghum is often cross pollinated crop i.e., there is 5 to 15% outcrossing in sorghum depending upon the wind direction, nature of genotype, and humidity (House 1985), which makes it amenable for use in population improvement and hybrid development programme to commercially exploit the heterosis to improve its productivity. Although the heterosis was demonstrated as early as 1927 in sorghum (Conner and Karper 1927), its commercial exploitation was possible only after the discovery of a stable and heritable cytoplasmic-nuclear male-sterility (CMS) mechanism (Stephens and Holland 1954) which has facilitated the application of recurrent selection procedures and hybrid cultivar development methods, respectively, in sorghum improvement. This CMS system has been designated as A_1 (*milo*) and this single cytoplasm *milo* is present in all forage sorghum hybrids (Pahuja *et al.* 1999). Subsequently, several alternative non-milo CMS systems (A2, A3 and A4) were identified and developed (Schertz 1994) for use in hybrid breeding programs to diversify the cytoplasm and nuclear genetic base of sorghum hybrids. Large numbers of A1 -based hybrids (Reddy *et al.* 2005) and a few A2 -based hybrids (Liu Qing Shan *et al.* 2000) have been released/marketed for commercial cultivation all over the globe.

Adoption of the first commercial hybrid (CSH 1) in India over much of the rainy season sorghum area, while local varieties are confined to fairly narrow specific environmental niches stands testimony to the wide adaptability of hybrids over varieties (House *et al.* 1997). Currently, over 95% of the sorghum area is planted to the hybrids in USA, Australia and China. In India, over 85% of the rainy season sorghum area is planted to hybrids.

To judge the suitability of hybrid parents for any hybrid development programme is based on *gca* and *sca* (Genetic combining ability and specific combining ability) effect of the cytoplasm. Most of the CMS (A1 or the A2) based lines were better general combiners for grain yield than those based on their male-fertile cytoplasm. The A-lines being male sterile appear to maximize their fitness in hybrid combinations with

the R-lines compared to their counterpart B-lines (with inherent male-fertility). This resulted in superior average performance by A × R crosses compared to B × R crosses. The assessment of gca effects of hybrid parents is important to judge their suitability for developing hybrids, as the mean performance of parental lines need not always be a good indicator of their gca effects (Ramesh *et al.* 2006). Thus the objective of the present studies was to select the best parents and then utilized them in interspecific hybridization programme to produce hybrids that could provide palatable green fodder over longer period of time.

2. MATERIALS AND METHODS

Breeding material consisting of male sterile lines and pollinators was sown in 4m x 5rows of MS lines and 4m x 10 rows of pollinators during *kharif* 2010 at Research area of Forage farm at CCS HAU, Hisar and they were evaluated for various agronomic traits that affect the fodder yield directly or indirectly. Next year these parents were used for hybrid development programme and 30 MS based hybrids were developed from these lines and we have evaluated these hybrids for various agronomic, fodder and quality traits along with check SSG 59-3. (released variety) were tested at Hisar during *Kharif* 2011.

Hisar is located at 29.09°N 75.43°E in western Haryana. Hisar has very hot summers and relatively cool winters. The maximum day temperature during the summer varies between 40 to 46°C. Relative humidity varies from 5 to 100 per cent. The average annual rainfall is around 350 mm most of which occurs during the months of July and August. Dew is observed in December and January. The hybrid evaluation trial is sown in randomized block design having plot size 20$m^2$with row to row and plant to plant spacing 0. 45cm and 15 cm, respectively for evaluating them along with check for various yields and forage quality related traits.

Data was recorded for plant height, number of tillers, leaf length, leaf breadth, stem girth, number of leaves/plant, green (GFY) and dry fodder yield (DFY) after I^{st} and 2^{nd} cut. Plant height, number of tillers, leaf length, leaf breadth, stem girth, number of leaves/plant was measured from five randomly chosen plants. First cut was taken at 50% flowering and green fodder yield was taken. For DFY, 500 g of green fodder was dried and then weighed to calculate DFY q/ha. The data recorded were analyzed for mean, coefficient of variation and critical difference by OPSTAT.

3. RESULTS AND DISCUSSION

All the evaluated MS lines and pollinators had shown good agronomic performance for various agronomic traits that affect the fodder yield directly or indirectly (Table 1).

Table 1: Evaluation of MS lines and pollinators for various agronomic traits during *Kharif* 2010

S No.	MS Line	Plant Height (cm.)	Leaf Length (cm.)	Leaf Breadth (cm.)	Stem Girth (cm.)	No. of Leaves/plant	No. of tillers/plant
1	467A	155.0	60.0	8.0	7.9	25.0	3.2
2	631A	140.0	62.0	6.2	7.2	18.0	2.1
3	632A	100.0	59.0	6.0	5.1	25.0	3.2
4	637A	115.0	54.0	5.5	4.6	22.0	2.8
5	687A	95.0	45.0	5.7	3.5	21.0	2.6
6	725A	155.0	66.0	10.5	6.0	24.0	3.1
7	733A	120.0	70.0	6.9	6.0	19.0	2.4
8	753A	170.0	73.0	9.0	7.5	23.0	3.2
9	2219A	90.0	79.0	6.3	6.9	22.0	2.6
10	41154A	102.0	70.0	10.1	7.5	22.0	2.8
Pollinators							
1	SSG 59-3	280.0	78.0	4.1	4.7	45.0	4.7
2	SSG 9	3.2	75.0	4.4	4.8	39.0	4.8
3	SSG(PSSG)	292.0	76.0	4.3	4.6	46.0	5.0
4	S 437-1	270.0	80.0	7.1	6.3	18.0	1.2
5	S 490	288.0	82.0	6.6	6.5	14.0	1.0
6	S 540	252.0	75.0	6.4	6.2	14.0	1.0
7	S 541	280.0	80.0	6.9	5.8	16.0	1.3
8	G 46	278.0	79.0	5.4	5.3	27.0	2.5

3.1. MS lines evaluation

Ten MS lines were evaluated for various agronomic traits like plant height, number of tillers, leaf length, leaf breadth, stem girth and number of leaves/plant. Range for all traits varied from plant height (90-170 cm), number of tillers/plant (2.1-3.2), leaf length (45-79 cm), leaf breadth (5.5-10.5 cm.), stem girth (0.35-7.9 cm) and number of leaves/plant (18-25).

3.2. Evaluation of pollinators

All the eight pollinators were evaluated for various agronomic traits like plant height, number of tillers, leaf length, leaf breadth, stem girth and number of leaves/plant. Range for all traits varied from plant height (90-170 cm.), number of tillers/plant (2.1-3.2), leaf length (45-79 cm), leaf breadth (5.5-10.5 cm.), stem girth (0.35-7.9 cm.) and number of leaves/plant (18-25).

3.3. MS based Hybrid evaluation

In Hybrid evaluation programme, highly significant differences were observed among hybrids for plant height, number of tillers, leaf length, leaf breadth, stem girth, number of leaves/plant, total green and dry fodder yield (Table 2). In hybrids value for agronomic traits ranged from plant height (98.3-213 cm.), number of tillers/plant (1.5-4.7), leaf length (67.3-96.5 cm), leaf breadth (5.2-8.2 cm.), stem girth (0.45-0.62 cm.) and number of leaves/plant (18-25), leaf stem ratio (0.25-0.67), TSS % (9.8-17%).

Table 2: Evaluation of MS based hybrids for various agronomic and fodder yield traits along with check during *Kharif* 2011

S. No.	Hybrids	Plant Height (cm)	Leaf length (cm)	Leaf breadth (cm)	Stem girth (cm)	No. of leaves/plant	No. of tillers/plant	Leaf : Stem ratio	TSS %	GFY q/ha of 2 cuts	DFY q/ha of 2 cuts
Check	SSG 59-3	132.0	89.5	7.7	4.5	11.0	3.0	0.3	10.0	1667.0	322.0
1	HH464	213.0	80.5	6.8	5.3	12.5	2.5	0.3	9.8	1200.0	207.0
2	HH465	150.5	79.5	5.6	5.0	11.5	2.5	0.3	12.2	1567.0	313.0
3	HH466	137.5	88.5	6.9	4.9	10.5	3.0	0.3	11.0	1600.0	272.0
4	HH469	162.0	95.5	5.6	5.6	9.5	4.0	0.3	11.8	1668.0	333.0
5	HH470	163.0	86.5	6.5	5.7	13.0	2.0	0.4	16.0	1300.0	270.0
6	HH471	140.5	94.0	5.3	5.8	10.0	2.0	0.3	11.0	1033.0	182.0
7	HH472	165.0	79.5	6.0	5.5	11.5	2.0	0.3	11.8	1133.0	215.0
8	HH473	149.5	82.5	6.4	6.5	11.5	3.0	0.3	12.2	1300.0	239.0
9	HH475	142.5	83.5	6.9	5.6	10.5	2.0	0.3	17.0	800.0	152.0
10	HH476	130.0	79.0	5.7	4.4	10.0	2.0	0.3	11.0	1033.0	214.0
11	HH478	125.3	71.7	6.0	4.5	9.7	4.3	0.3	11.2	1733.0	313.0
12	HH479	179.0	84.5	6.5	6.2	11.5	1.5	0.3	10.0	1500.0	285.0
13	HH480	155.0	89.5	6.1	5.7	11.5	1.5	0.3	10.6	1333.0	249.0
14	HH481	133.3	76.0	8.0	5.3	11.0	3.0	0.3	12.6	1467.0	264.0
15	HH483	129.0	78.0	9.4	7.2	12.0	1.5	0.6	16.0	1267.0	253.0
16	HH484	157.5	82.0	7.5	6.4	12.5	2.5	0.3	13.0	1733.0	329.0
17	HH485	102.3	69.3	8.6	5.4	11.3	2.0	0.3	11.0	1133.0	220.0
18	HH486	128.7	70.0	7.2	4.8	10.3	2.7	0.3	12.4	1133.0	222.0
19	HH487	110.0	83.5	8.5	7.7	13.5	1.8	0.7	12.2	1667.0	293.0
20	HH489	98.3	67.3	5.2	4.5	11.0	3.0	0.6	11.6	900.0	171.0
21	HH490	115.0	77.0	7.7	5.5	10.5	4.0	0.4	11.6	800.0	160.0
22	HH492	130.7	77.7	7.3	4.7	12.0	2.0	0.7	12.0	1100.0	209.0
23	HH493	135.0	79.3	5.3	5.1	10.0	2.0	0.3	11.6	767.0	150.0
24	HH494	142.5	73.0	5.9	4.9	11.0	2.0	0.4	10.4	433.0	83.0
25	HH495	144.5	79.5	5.8	4.9	10.0	2.5	0.4	13.2	1567.0	298.0
26	HH496	176.0	82.0	8.9	6.5	17.5	3.0	0.3	16.0	700.0	131.0
27	HH497	140.5	88.5	7.8	6.7	11.5	4.5	0.3	11.0	1533.0	288.0
28	HH498	188.3	80.7	6.5	5.5	11.0	4.7	0.3	12.6	1033.0	203.0
29	HH499	172.5	96.5	8.2	6.2	11.5	3.5	0.3	12.0	1767.0	336.0
30	HH500	132.0	89.5	7.7	4.5	11.0	3.0	0.3	10.0	1667.0	322.0
	C.D.									92.5	43.4
	C.V.									9.07	13.7

Among hybrids value of quality traits for HCN varied from 13-151µg/g, crude protein 8.8-10.9, i*n vitro dry matter digestibility* (IVDMD%) ranged from 24-60.8 per cent (Table:3). Similarly values for total green and dry fodder yield varied from 433-1767q/ha and 83-336 q/ha, respectively.

Table 3: Evaluation of MS based hybrids for various fodder quality traits along with check during *Kharif* 2011

S. No.	Hybrids	HCN (µg/g)	Protein (%)	IVDMD (%)	Protien yield (q/ha)	DDM yield (q/ha)
Check	SSG 59-3	92.0	8.8	34.0	0.6	2.3
1	HH464	101.0	9.6	32.4	0.4	1.5
2	HH465	25.0	9.2	24.0	0.6	1.5
3	HH466	22.0	9.2	29.2	0.6	2.0
4	HH469	37.0	9.6	35.2	0.9	3.1
5	HH470	44.0	10.5	30.4	0.5	1.5
6	HH471	51.0	10.1	32.4	0.3	1.1
7	HH472	93.0	9.6	34.8	0.4	1.4
8	HH473	33.0	9.2	30.0	0.5	1.7
9	HH475	130.0	9.2	31.2	0.2	0.6
10	HH476	64.0	10.1	34.8	0.6	2.1
11	HH478	13.0	9.2	30.0	0.5	1.7
12	HH479	65.0	9.6	28.0	0.6	1.6
13	HH480	39.0	10.1	26.4	0.5	1.2
14	HH481	91.0	10.5	34.8	0.7	2.2
15	HH483	23.0	10.1	32.0	0.4	10.3
16	HH484	65.0	10.5	35.6	0.6	2.0
17	HH485	141.0	10.1	53.6	0.5	2.6
18	HH486	108.0	9.2	38.0	0.4	1.4
19	HH487	151.0	9.6	52.0	0.6	3.1
20	HH489	149.0	10.5	32.8	0.3	1.1
21	HH490	119.0	10.9	33.2	0.4	1.3
22	HH492	146.0	10.5	53.6	0.5	2.4
23	HH493	120.0	9.2	33.2	0.2	0.7
24	HH494	56.0	10.1	35.2	0.2	0.6
25	HH495	125.0	10.5	37.6	0.7	2.6
26	HH496	139.0	9.6	29.2	0.3	0.8
27	HH497	75.0	9.2	60.8	0.6	3.8
28	HH498	85.0	9.2	35.8	0.4	1.5
29	HH499	87.0	9.6	39.2	0.7	2.9
30	HH500	92.0	8.8	34.0	0.6	2.3

Among all hybrids 467A X S 541 has shown more plant height (213 cm) as compared to check SSG 59-3 (197.5 cm). Total green fodder yield in hybrid 41154A X G 46 was 1767q/ha followed by hybrid 725A X SSG 9 (1733 q/ha) and 631A X S541 (1733 q/ha) having more than check. Similarly, total dry fodder yield was more in hybrid 41154A X G46 is 336 q/ha followed by hybrid 725A X SSG 9 (329 q/ha) and 631A X S541 (313 q/ha) as compared to check. Similar results of outperformance of hybrids as compared to local checks in forage yield were reported by Mohammad *et al.* (2012); Pahuja *et al.* 2014. For all other traits like number of tillers/plant, leaf length, leaf breadth, stem girth and number of leaves/plant all hybrids have performed not superior but almost equivalent to the check. Pothisoong and Jaisil (2011) had evaluated twenty sweet sorghum F_1 hybrids for yield potential, heterosis and ethanol production and observed significant improvement for all traits in hybrids as compared to their parents. Significant female, male and female x male interaction effects were also observed for all of the agronomic traits but female groups had a major impact on the performance of the genotypes in all the crosses. But apart from exploiting heterotic potential there is an urgent need to advance these progenies and select those with a combination of stress tolerance along with high fodder yield (Leo, 2005). Akabri *et al.,* 2012; Goyal *et al.,* 2013 developed three hybrids SURAT-1 x C-10-2, surat-4 x UP CHARI and 94002A x RSSV-9 and NSS1007A x Ramkel showing high green fodder yield over commercial cultivars and checks. Thus, these hybrids will help to overcome the problem of hybrid seed production.

In this evaluation study of forage sorghum hybrids almost in all traits hybrids have performed better as compared to check and some of the hybrids significantly excelled the introduced check in forage yield and quality. The hybrid 41154A X G46 is unique in achieving high forage yield. This has been explained by the successful parental choices involved in this hybrid, especially female parent 41154A which will be good combiners for forage yield. This hybrid is expected to meet the farmer's preference in producing high quantities of forage in a relatively short period of time having good quality and we can also use 41154A male sterile line in future for further hybrid production programme. Along with that from quality aspects also this hybrid is good having more digestibility and palatability i.e., very crucial in breeding for forage crops. Therefore, in future programs, molecular screening and large scale testing of these some hybrids would be required to strength the breeding program for hybrid development.

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