Sci., Tech. and Dev., 31 (1): 19-25, 2012

DEVELOPMENT OF SORGHUM-SUDAN GRASS HYBRIDS FOR HIGH FORAGE YIELD AND QUALITY

ASHIQ HUSSAIN*, SARTAJ KHAN AND SAFDAR SHAFEEQ

Fodder Program, National Agricultural Research Centre, Islamabad-45500, Pakistan.

Abstract

A project titled "Development of Sorghum-Sudan grass Hybrids for High Forage Yield and Quality Characters" was executed at the Fodder Research Program, National Agricultural Research Centre (NARC), Islamabad, from 2007-2010. Germplasm comprising 24 Cytoplasmic Male Sterile (CMS) "A" and their counter "B" lines of sorghum and 16 of Sudan grass (Restorer) was collected from different sources. Nine desirable most promising parental lines (Hi-Sell A, Redlan A, ICS-276 A and their counter B lines of sorghum and SG Green leaf, SG Hi-Sell and SG Monarch) were selected on the basis of desirable characteristics for use in hybrid combinations. A total of 70 hybrid combinations were made using different parent-hybrids during summer 2008. Fourteen hybrid combinations were evaluated against standard hybrid "Pak-Sudax" at NARC during spring 2009. On the basis of four cuttings, it was found that NARC Hybrid-5, NARC Hybrid-3 and NARC Hybrid-2 performed well-yielding of green fodder yield in the range of 143.23 to 153.13 t ha^{-1} and dry matter yield range of 26.64 to 30.70 t ha^{-1} against check hybrid "Pak-Sudax" (109.54 and 19.48 t ha^{-1}, respectively). These hybrids have shown a great potential by producing 31 to 40 percent increase in green fodder yield and 37 to 49 percent dry matter yield accompanied with better crude protein contents against standard S. S. hybrid (Pak-Sudax).

Keywords: Sorghum-Sudan grass, High Forage Yield, NARC Hybrid, Pak-Sudax

Introduction

Government of Pakistan has placed considerable emphasis over the revolution of livestock industry in the country and has been advocating the white revolution. This slogan will definitely help for increasing the livestock population. Consequently the demand for fodder will increase. Shortage of fodder is already a major limiting factor for livestock production and the fodder crop sector remains neglected because of its competition with cash and grain crops. The fodder research provides an important basis for speedy development of an efficient livestock industry in Pakistan. Efficient livestock productivity is only possible when steady supply of quality forage in sufficient quantity is made available. The dependence of livestock on fodder being the cheapest source of nutrients is increasing because of higher concentrate feed price. Further, two percent reduction in fodder area every decade coupled with two scarcity periods is worsening fodder availability situation in the country. The multi-cut nature of sorghum-sudan grass hybrid (S. S. hybrid) has the superiority of higher fodder productivity over single-cut sorghum variety. It is, therefore, important to develop multi-cut and high fodder yielding hybrids with better quality and disseminate their seed and production technology among fodder growers to bridge-up fodder shortage gap.

S. S. hybrid has been grown in the country since mid-seventies, but recently it has gained more importance among the farmers due to its multi-cut nature, high fodder yield potential and availability of green fodder during scarcity periods. S. S. hybrid is planted in March to provide 3-4 cuttings till October-November. The first cut is ready for harvest about 50-60 days after planting and subsequent cuttings are taken with an interval of 30-35 days. Optimum growth of this forage hybrid occurs under hot and moist conditions. The country is relying on imported seed which is very expensive. The farmers,

***Author for correspondence E-mail: ashiqhussain1553@yahoo.com**

therefore, hesitate to purchase it on high price. The quantity of seed import and its value has been increased from 3925 to 7254 million ton with the cost from 110 to 397 million Rs. within 5 years period from 2005-06 to 2009-10. Unfortunately, production of sorghum-sudan grass hybrid seed is not undertaken by any organization in the country. Therefore, the project titled "Development of sorghum-sudan grass hybrids for high forage yield and quality characters" was undertaken to develop S. S. hybrids suitable for local conditions to improve fodder production in the country.

No systematic research work has been undertaken on sorghum-sudan grass hybrids, however, some preliminary information on genotype x environment interaction for grain yield, crude protein, forage yield and acid detergent fiber in 54 genotypes was reported by Mohammad et al. (1993). Hussain et al. (1996) reported that S. S. hybrid has the potential to produce 199 to 302 percent increased green fodder yield and 198 to 321 percent dry matter yields over single-cut sorghum variety. Hussain et al. (1995) also reported crude fiber content in the range of 30.2-31.4%, and it was found highest in cultivar No. 94. Crude protein content ranged from 5.5 to 7.6% and was highest in cultivar Hegari. Pahuja et al. (2002) evaluated 18 hybrids and two standard controls (PCH 106 and FSH 92079). HH2, HH88, HH85 and HH82 had relatively high growth rates. Sarhan et al. (1996) compared 8 imported sorghum (*Sorghum bicolor*) x Sudangrass (*S. sudanense*) hybrids. Protein and oil yields were highest in Bioseed 789, fibre yield in PSS 079 and ash yield in SV11006. Zahid et al. (2002) reported that sorghum sudan grass hybrid "ST-E" out yielded all other hybrids by producing mean green fodder yield of 104.9 t ha^{-1}. Garcia (2000) reported the potential of *Sorghum bicolor* hybrids Piper sudangrass and Sudax sorghum-sudan, and pearl millet *Pennisetum americanum* (*P. glaucum*)) hybrids Mil-Hy-100 and 3- Mil-X 4 nitrogen levels (0, 50, 100 and 150 kg N/ha) at different growth stages, in Barquisimeto, Venezuela. The crude protein yield ranged from 510 to 1686 kg/ha and was significantly affected by the different nitrogen levels. At the mid-boot stage, Mil-HY-100 and 3-Mil-X had the highest crude protein yields during the mid-boot and full blooming stages, respectively. Gupta et al. (2002) evaluated eight strains of multi-cut sorghum for their nutrient content, digestibility and yield of nutrients. The yields of crude protein and digestible dry matter ranged from 4.87-11.08 and 76.6-109.2 q ha^{-1} in first cut, respectively. In second cut, the corresponding values were 1.54-5.07 and 11.97-76.60 q ha^{-1}, respectively. The DM and CP content varied from 25.0-32.7 and 5.48-6.30 percent in first cut, respectively. In second cut, the corresponding values were 23.3-25.0 and 7.23-7.99 percent, respectively. Kadam et al. (2000) reported highly significant differences for green forage yield, dry forage yield, plant height, number of leaves per plant and leaf length in 3 male sterile lines, 13 testers and 39 line x tester hybrids of sweet sorghum. Highly significant differences for all traits were also observed between parents and hybrids, indicating the presence of heterosis for these traits.

Material and Method

a) Maintenance of CMS "A" & "B" lines of sorghum: Germplasm of sorghum and sudan grass collected from various sources was planted at NARC in summer 2007 to evaluate their maturity, yield, quality and seed production. Two rows 6m long each of "A" and "B" were planted keeping row to row and plant to plant distances of 75cm and 22cm, respectively. To obtain optimum plant population two seeds per hill were used and after emergence, only one plant per hill was kept for healthy seed production. For maintenance of Cytoplasmic Male Sterile (CMS) lines of sorghum, planting was done by keeping two sterile lines of sorghum "A" in the centre of two fertile "B" lines to allow pollination and get seed of line "A" for maintenance and crossing with sudan grass for hybrid production according to the following plan.

	CMS Entry # 1				CMS Entry # 5			
Millet 2 Lines	**Hi-Sell B 1 line**	**Hi-Sell A 2 lines**	**Hi-Sell B 1 line**	**Millet 2 Lines**	**RLB 1 line**	**RLA 2 lines**	**RLB 1 line**	**Millet 2 lines**

To avoid contamination two lines of millet were planted between different CMS entries as isolation material. Millet was planted with single row drill using 7 kg seed-rate per hectare and keeping the same row spacing mentioned above. Both "A" and "B" lines were harvested separately, dried and threshed separately and seeds were then collected.

b) Sudan grass: For maintenance and evaluation of sudan grass lines, each entry was planted in separate plot keeping row length of 6 m and row-to-row distance of 75 cm using seed-rate of 25 kg per hectare. Recommended fertilizer dressing of 120-60-50 kg/ha NPK was used. Single row drill was used for planting. To avoid contamination and obtain pure seed of each line of sudan grass, two lines of millet were planted after each sudan grass entry. Each year desirable lines of sorghum "A" and "B" and sudan grass were maintained and seed increased for hybrid production.

c) Sorghum sudan grass hybrid combinations: The selected male sterile line of sorghum "A" and sudan grass of similar maturity were planted in rows for making hybrid combination in summer 2008 by adopting the same procedure as mentioned in section "a". Sorghum lines "A" being female parents and sudan grass (restorer) were crossed for hybrid combination according to the following plan. For isolation after each hybrid combination, the millet was planted accordingly as mentioned above.

Millet	Sudan grass	CMS "A"	Sudan grass	CMS "A"	Sudan grass	Millet
2 lines	1 line	3 lines	2 lines	3 lines	1 line	2 lines

For obtaining maximum seed setting, manual pollination on daily basis until seed setting in each combination was done every morning. Each hybrid combination was harvested and seed collected. Seventy S. S. hybrid combinations were made during summer 2008. Keeping in view, the seed availability, a trial comprising 14 combinations (viz. NARC Hybrid-1, NARC Hybrid-2, NARC Hybrid-3, NARC Hybrid-4, NARC Hybrid-5, NARC Hybrid-6, NARC Hybrid-7, NARC Hybrid-8, NARC Hybrid-9, NARC Hybrid-10, NARC Hybrid-11, NARC Hybrid-12, NARC Hybrid-13, NARC Hybrid-14) and one check (Pak-Sudax) was conducted during spring 2009. Using randomized complete block design (RCBD) with 3 replications, the trial was planted at NARC during April, 2009. Seed rate of 30 kg ha^{-1} was hand drilled keeping plot size of 1.2 m x 5.0 m and row spacing of 30 cm. Plot-to-plot distance was 60 cm. Fertilizer dose of 60-60-00 NPK kg ha^{-1} was applied at sowing and 60 kg ha^{-1} N after each cut with irrigation. A net plot size of 0.6m x 5.0m was harvested at flowering initiation at each cutting for green fodder estimation. A total of four cuttings were obtained during the whole growing period, from June 2009 to September 2009. At the time of harvesting, 500 g samples of green fodder were drawn at random from each plot and replication in all the cuttings, chopped and dried in oven at 60 ^{o}C for 72 hours to determine dry matter yield and forage quality. The collected data were statistically analyzed using analysis of variance technique and Duncan's New Multiple Range Test at 5 percent probability to compare the hybrid means.

Results and Discussion

Analysis of variance for green fodder and dry matter yields is presented in Table 1. Significant differences among different S. S. hybrids were observed for both characters. Average green fodder yield and dry matter yield of different S. S. hybrids are presented in Tables 2 and 3.

Table 1. Source of variation (SOV), Degree of freedom (DF) and Mean squares (MS) for Green fodder yield (GFY) and Dry matter yields (DMY)

SOV	DF	Mean Squares	
		GFY	DMY
Replications	2	501.36	11.29
S. S. Hybrids	14	2013.60**	87.06**
Error	28	73.67	0.29
Total	44		

Table 2. Mean green fodder yields (t ha^{-1} and total of 4 cuts) and increase or decrease over check of various S. S. hybrids

Serial #	S. S. Hybrids	Mean green fodder yield	Increase (+) or Decrease (–) over check (%)
1.	NARC Hybrid-1	126.97	15.91
2.	NARC Hybrid-2	143.23	30.75
3.	NARC Hybrid-3	152.95	39.63
4.	NARC Hybrid-4	134.14	22.45
5.	NARC Hybrid-5	153.13	39.79
6.	NARC Hybrid-6	114.44	4.47
7.	NARC Hybrid-7	127.05	15.98
8.	NARC Hybrid-8	66.75	- 39.06
9.	NARC Hybrid-9	134.29	22.59
10.	NARC Hybrid-10	130.40	19.04
11.	NARC Hybrid-11	121.14	10.59
12.	Pak-Sudax (Check)	109.54	-
13.	NARC Hybrid-12	140.99	28.71
14.	NARC Hybrid-13	88.77	– 18.97
15.	NARC Hybrid-14	78.43	– 28.40
LSD (0.05) SE ±		14.34 2.22	

Table 3. Mean dry matter yields (t ha^{-1} and total of 4 cuts) and increase or decrease over check of various S. S. hybrids

Serial #	S. S. Hybrids	Mean dry matter yield	Increase (+) or Decrease (-) over check (%)
1.	NARC Hybrid-1	26.05	33.72
2.	NARC Hybrid-2	26.64	36.75
3.	NARC Hybrid-3	30.70	57.59
4.	NARC Hybrid-4	25.53	31.05
5.	NARC Hybrid-5	29.00	48.87
6.	NARC Hybrid-6	23.15	18.83
7.	NARC Hybrid-7	24.09	23.66
8.	NARC Hybrid-8	12.50	- 35.83
9.	NARC Hybrid-9	25.81	32.49
10.	NARC Hybrid-10	25.57	31.26
11.	NARC Hybrid-11	23.39	20.07
12.	Pak-Sudax (Check)	19.48	-
13.	NARC Hybrid-12	25.32	29.98
14.	NARC Hybrid-13	15.06	- 22.69
15.	NARC Hybrid-14	14.34	- 26.29
LSD (0.05) SE ±		0.99 0.185	

Green fodder yield

The differences among various S. S. hybrids for green fodder yield were found statistically highly significant. NARC Hybrid-5, NARC Hybrid-3, NARC Hybrid-2 and NARC Hybrid-12 recorded the highest and similar green fodder yields of 153.13, 152.95, 143.23 and 140.99 t ha^{-1}, respectively. S. S. hybrids NARC Hybrid-9, NARC Hybrid-4 and NARC Hybrid-10 (134.29, 134.14 and 130.40 t ha^{-1}, respectively) were at par with each other but were found different from NARC Hybrid-5 and NARC Hybrid-3 in green fodder production. The lowest and at par green fodder yields (66.76 and 78.43 t ha^{-1}, respectively) were observed in NARC Hybrid-8 and NARC Hybrid-15. The check (Pak-Sudax) recorded the green fodder yield of 109.54 t ha^{-1}. In this way, 11 hybrids had the potential to produce 4 to 40 percent increased green fodder yield over the check. These results are in accordance with those of Zahid et al. (2002), Kadam et al. (2000), Hussain et al. (1996) and Sarhan et al. (1996).

Dry matter yield

Regarding dry matter yield, the differences among various S. S. hybrids were found statistically highly significant. NARC Hybrid-3 produced significantly the highest dry matter yield (30.70 t ha^{-1}). It was followed by NARC Hybrid-5 which yielded dry matter of 29.00 t ha^{-1}. NARC Hybrid-2 (26.64 t ha^{-1}), NARC Hybrid-1 (26.05 t ha^{-1}) and NARC Hybrid-9 (25.81 t ha^{-1}) were similar to each other but significantly lower than NARC Hybrid-3 and NARC Hybrid-5 in dry matter yield. Similarly, NARC Hybrid-1, NARC Hybrid-9, NARC Hybrid-10, NARC Hybrid-4 and NARC Hybrid-12 were at par among each other but different from NARC Hybrid-5 in dry matter production. Also, NARC Hybrid-10, NARC Hybrid-4 and NARC Hybrid-12 were at par with each other and were found different from NARC Hybrid-2. Significantly the lowest dry matter yields of 14.34 and 15.06 t ha^{-1} were observed in NARC Hybrid-14 and NARC Hybrid-13. The check hybrid Pak-Sudax yielded the dry matter yield of 19.48 t ha^{-1}. Eleven hybrids had the potential to produce 19 to 49 percent increased dry matter yield over the check. These results are in accordance with those of Kadam et al. (2000) and Hussain et al. (1996).

Moreover, the significance of harvesting at various dates was to know the quantity of fodder to be produced at different intervals to cover fodder shortage during the season. It was noted that in the first two cuttings similar mean green fodder yields (42.17 and 42.05 t ha^{-1}) were produced. In the third cutting lower mean green fodder yield of 30.83 t ha^{-1} than the early cuttings was recorded. It might be due to slightly unfavorable temperature required for the crop. The minimum mean green fodder yield of 6.88 t ha^{-1} was produced in the last, i.e. fourth cutting at the end of the season (Table 4). The same pattern was observed in dry matter yield (Table 5). This reduction in yield may be due to low temperature at the time of fourth cutting and decrease in its potential of re-growth due to repeated cuttings.

Table 4. Green fodder yields (t ha^{-1}) of different S. S. hybrids under various cuts

Serial #	S. S. Hybrids	Green fodder yield			
		1st Cut	2nd Cut	3rd Cut	4th Cut
1.	NARC Hybrid-1	41.15	42.266	34.22	9.33
2.	NARC Hybrid-2	53.78	47.18	30.60	11.67
3.	NARC Hybrid-3	50.55	49.511	38.11	14.78
4.	NARC Hybrid-4	47.95	45.626	33.96	6.61
5.	NARC Hybrid-5	52.77	53.928	36.55	9.88
6.	NARC Hybrid-6	34.34	39.403	32.93	7.78
7.	NARC Hybrid-7	42.12	47.18	33.71	4.05
8.	NARC Hybrid-8	25.94	22.82	15.04	2.95

Contd…

Concld…

9.	NARC Hybrid-9	43.44	48.734	36.29	5.83
10.	NARC Hybrid-10	40.83	46.403	37.33	5.83
11.	NARC Hybrid-11	40.83	44.331	30.84	5.13
12.	Pak-Sudax (Check)	45.38	35.777	24.11	4.28
13.	NARC Hybrid-12	49.90	47.957	36.29	6.85
14.	NARC Hybrid-13	34.34	32.928	16.84	4.67
15.	NARC Hybrid-14	29.17	26.677	18.93	3.65
	Average	42.17	42.05	30.38	6.88

Table 5. Dry matter yields (t ha^{-1}) of different S. S. hybrids under various cuts

Serial #	S. S. Hybrids	Dry matter yield			
		1st Cut	2nd Cut	3rd Cut	4th Cut
1.	NARC Hybrid-1	8.26	8.12	7.06	2.71
2.	NARC Hybrid-2	10.79	7.67	5.07	3.39
3.	NARC Hybrid-3	10.14	9.25	7.42	4.29
4.	NARC Hybrid-4	9.62	7.28	6.73	1.95
5.	NARC Hybrid-5	10.59	9.30	6.25	2.87
6.	NARC Hybrid-6	6.89	7.19	6.82	2.26
7.	NARC Hybrid-7	8.45	8.02	6.45	1.17
8.	NARC Hybrid-8	5.20	3.72	3.01	0.86
9.	NARC Hybrid-9	8.71	8.57	7.47	1.69
10.	NARC Hybrid-10	8.19	7.27	8.55	1.69
11.	NARC Hybrid-11	8.19	7.87	5.62	1.49
12.	Pak-Sudax (Check)	9.10	5.08	4.01	1.24
13.	NARC Hybrid-12	10.01	7.47	6.09	1.99
14.	NARC Hybrid-13	6.89	4.47	2.57	1.35
15.	NARC Hybrid-14	5.86	4.09	3.31	1.06

Fodder quality

Crude protein contents of different S. S. hybrids are presented in Table 6. S. S. hybrids (NARC Hybrid-5, NARC Hybrid-4, NARC Hybrid-11, NARC Hybrid-13, NARC Hybrid-10 and NARC Hybrid-2) produced maximum and similar crude protein contents (12.50, 12.05, 12.04, 11.97, 11.88 and 11.38 %) while check hybrid "Pak-Sudax" recorded crude protein contents of 10.94 percent. The above findings are similar in accordance with Mohammad et al. 1993; Hussain et al. 1995; Sarhan et al., 1996; and Gupta et al., 2002.

Table 6. Crude protein contents of different S. S. hybrids

Serial #	Name of S. S. hybrid	Crude protein content (%)
1.	NARC Hybrid-1	9.31
2.	NARC Hybrid-2	11.38
3.	NARC Hybrid-3	10.41
4.	NARC Hybrid-4	12.05

Contd…

Concld…

5.	**NARC Hybrid-5**	**12.50**
6.	**NARC Hybrid-6**	**9.02**
7.	**NARC Hybrid-7**	**10.02**
8.	**NARC Hybrid-8**	**10.74**
9.	**NARC Hybrid-9**	**10.20**
10.	**NARC Hybrid-10**	**11.88**
11.	**NARC Hybrid-11**	**12.04**
12.	**Pak-Sudax (Check)**	**10.95**
13.	**NARC Hybrid-12**	**10.64**
14.	**NARC Hybrid-13**	**11.97**
15.	**NARC Hybrid-14**	**10.94**

Conclusion

It can be concluded that NARC Hybrid-3, NARC Hybrid-5 and NARC Hybrid-2 have shown a great potential by producing 31 to 40 percent increased green fodder yield and 37 to 49 percent dry matter yield with better crude protein contents against standard S. S. hybrid (Pak-Sudax). These hybrids are at par with imported hybrids in yield potential and other characters. So, with the production of S. S. hybrid seed on commercial scale locally, import pressure of hybrid sorghum seed worth Rs. 397 million can be reduced considerably.

References

Garcia, O.G.S. 2000. Forage production and quality evaluation of four sorghum forage hybrids. Yield potential. *Rev. Fac. Agron. (LUZ),* 17(5): 413-423.

Gupta, S.K., M.L. Verma and R.S. Jaiswal. 2002. Nutritional evaluation of multicut sorghum strains. *Indian J. Animal Nut.,* 19(2):129-134.

Hussain, A., D. Muhammad, S. Riaz, M.B. Bhatti and Sartaj. 1995. Forage yield potential and quality differences among various sorghum genotypes under rainfed conditions. *Sarhad J. Agri.,* 11(3): 291-295.

Hussain, A., M.U. Mufti, S. Khan and M.B. Bhatti. 1996. Hybrid seed and fodder production in sorghum. Fodder Production in Pakistan. *Proceedings of the National Conference on "Improvement, Production and Utilization of Fodder Crops in Pakistan"* ISBN: 969-8288-03-1, 150-165.

Kadam, D.E., F.B. Patil, T.J. Bhor and P.N. Harer. 2000. Line x tester analysis in sweet sorghum hybrids. *J. Maharashtra Agric. Univ.,* 25(3): 318-319.

Mohammad, D., P.B. Cox, G.L. Posler, M.B. Kirkham, A. Hussain and S. Khan. 1993. Genotype x environment interaction and its implications in sorghum (*Sorghum bicolor*) breeding programme. *Indian J. Agric. Sci.,* 63(3): 153-156.

Pahuja, S.K., R.P.S. Grewal, N. Singh, Y. Jindal and S.R. Pundir. 2002. Evaluation of forage sorghum hybrids for yield and morphological traits. *Int. Sorghum and Millets Newsletter,* 43:42-45.

Sarhan, G.M.A., H.S. Oushi and H.E. El-Selemy. 1996. Evaluation of some new sorghum-sudangrass hybrids for forage yield and quality under different environmental conditions in Egypt. *Annals Agric. Sci. Moshtohor,* 34(3): 789-798.

Zahid, M.S., M.U. Mufti, S. Shafeeq, I.A. Qamar and A.M. Haqqani. 2002. Performance of sorghum sudan grass hybrids. *Pak. J. Agric. Res.,* 17: 255-260.