Bangladesh J. Bot. **50**(2): 245-251, 2021 (June)

DEVELOPMENT OF DUAL PURPOSE SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH] HYBRID FOR *KHARIF* SEASON HAVING HIGHER GRAIN AND FODDER YIELD OF SPH 1641

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Keywords: *Kharif* sorghum hybrid, Grain yield, Fodder yield, Grain mold tolerance

Abstract

Due to variable use, drought hardiness, stability of yield and adoptability over wide range of climate, sorghum has maintained its importance and dependability. Dual purpose *kharif* sorghum hybrid SPH1641 line was developed by using new CMS line PMS71A having wide adoptability across season (*kharif* and *rabi*) and high yielding restorer line KR196 at Sorghum Research Station, Parbhani. On the basis of 5 years testing (*kharif* 2009-14) SPH 1641 recorded the advantage of 13.38 and 16.06 % for grain and 11.52 and 21.57% for fodder yield, over checks CSH 25 and CSH 16 in Maharashtra State Multi location Varietal cum Hybrid Trials. Grain (crude protein 9.8%) and stover quality (IVOMD 43.5%) parameters of this hybrid were comparable with checks. SPH 1641 is moderately tolerant to grain mold (FGMR 3.95 and TGMR 3.00), shoot fly and stem borer as well. Hence the hybrid is released for commercial cultivation in *kharif* sorghum growing areas of Maharashtra State in 2015.

Introduction

Agricultural crops and livestock play an important role to fulfill the basic necessities of life to the people (Tahir *et al.* 2005). Sorghum is the major source of food for millions of people in the semi arid tropics and its grains is also used as feed for live stocks and poultry. The importance of sorghum as a fodder crop is growing in Maharashtra due to its high productivity and ability to utilize water efficiently even under drought conditions. Owing to its multiple uses, every farmer in Maharashtra grows sorghum to meet the demand of his family and live stock requirement. In recent years, the yield levels of hybrids/varieties have gone down due to heavy attack of shoot fly, stem borer, and midge in the region (Sonalkar *et al.* 2005). The grain quality of these varieties was also affected due to heavy attack of grain mold in the region. Unfortunately all these hybrids were producing low quality fodder due to their dwarf stature and susceptible to pests and diseases (Borikar and Chopade 1981). Sorghum has good genetic variability that allows the breeding and development of new cultivars adapted to different agro-ecological regions around the globe (Zhang *et al.* 2010).

It is therefore of paramount importance that technological developments are extended to increase the productivity and sustainability of sorghum production. Considering the immediate need of farmers, effort were initiated at Sorghum Research Station, Parbhani to develop a dual purpose sorghum hybrid having higher grain and fodder yield with synchronous flowering of female and male lines facilitating commercial hybrid seed production during *kharif* as well as *rabi* season. As a result, a new *kharif* sorghum hybrid SPH 1641 was developed by using new CMS line PMS 71A having wide adoptability across season (*kharif* and *rabi*) and high yielding restorer line KR 196. Due to its high grain and fodder yields besides other desirable traits, this hybrid has been released as SPH 1641 for cultivation in *kharif* sorghum growing areas of Maharashtra, India.

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DOI: https://doi.org/10.3329/bjb.v50i2.54079

Materials and Methods

Breeding efforts were initiated at Sorghum Research Station, VNMKV, Parbhani to develop dual purpose sorghum hybrid with higher grain and fodder yield with synchronous flowering of female and male line. Several, cross combinations were affected by using diverse male sterile and restorer lines developed at Sorghum research Station, VNMKV, Parbhani to evolve hybrids which can produce increased grain and fodder yields than existing hybrids and improved varieties. Among these combinations, a cross combination of CMS 71 A × KR 196 R was found to be very much promising in all respects. MS line PMS 71 A is having wide adoptability across season and 'R' line KR 196 has high yield potential. Initially, it was tested in station trials from the year 2006 to 2007 along with the checks CSH 25 and CSH 16. Having been found promising, it was tested in Maharashtra State Co-ordinated trials during *kharif* 2009 - 2014 in *kharif* sorghum growing areas of Maharashtra. Meanwhile the hybrid was nominated in All India Coordinated Sorghum Improvement Project and evaluated at different locations across country during *kharif* 2008 - 09, 2010 - 11 and 2011 - 12 in the name of SPH 1641 along with Checks CSH 16 and CSH 23. The Adaptive Trials were conducted on the farmers' fields during *kharif* 2013 - 14 and 2014 - 15. Screening was done against important pests during station and All India Coordinated trials following standard procedures (Taneja and Leushner 1985, Anahosur 1987). The grain and stover samples were analyzed for their quality parameters at different locations during 2010 - 11 and 2011 - 12. Samples were also analyzed at ICRISAT for grain and fodder quality parameters in 2015 following standard procedures.

Results and Discussion

Sorghum hybrid SPH 1641, a cross between PMS 71A and KR 196 is a dual purpose hybrid that matures in 115 - 118 days and takes 73 - 75 days to attain 50 per cent flowering. It is a medium tall growing hybrid and grows to a height of 220 - 230 cm. Like many other improved sorghum hybrids, it has a plant with tan color foliage. The new hybrid has a test weight of 29.9 g, seeds are round, white in color and lustrous, borne on medium cylindrical and semi-compact earheads (Table 1).

Table 1. Ancillary characters of hybrid SPH 1641 and parents in station trial (SRS, Parbhani).

Traits	Sorghum hybrid	Female parent	Male parent
	SPH 1641	PMS 71A	KR 196
Days to 50% flowering	73 - 75	74 - 75	74 - 75
Days to maturity	115 - 118	110 - 12	178 - 182
Plant height	220 - 230	162 - 165	162 - 165
Test weight	2.9	24.74	25.65
Pigmentation	Tan	Tan	Tan
Panicle	Semi compact	Semi loose	Semi loose
Seed shape & color	Round, white, lustrous	Round, white	Round, elliptical
Grain yield (q/ha)	41	-	-
Dry fodder yield (q/ha)	139	-	-
Staggering	No staggering required	-	-

Hybrid SPH 1641 differs significantly both for grain and fodder yield in station trial conducted at Parbhani during 2005 - 06 and 2006 - 07. On the basis of 2 years of testing hybrid has significantly out yielded CSH 25 and CSH 16 with 46.59 q/ha grain yield as against 39.73 q/ha

of CSH 25 and 37.32 q/ha of CSH 16 indicating 14.72 and 19.90 per cent superiority over checks, respectively. The fodder level of SPH 1641 registered 169 q/ha as against 149 and 140 q/ha of CSH 25 and CSH 16 with an advantage of 13.42 and 20.71 per cent over checks, respectively (Table 2).

Table 2. Grain and fodder yield of sorghum hybrid SPH- 1641 in Station Trial (SRS, Parbhani).

Year	SPH 1641	CSH 25	CSH 16	CD at 5 %	SPH 1641	CSH 25	CSH 16	CD at 5 %
2006-07	45.61	39.21 (14.03)	38.23 (16.18)	3.21	171	152 (12.50)	142 (20.42)	43.22
2007-08	47.56	40.25 (15.37)	36.41 (23.44)	2.24	167	146 (14.38)	138 (21.01)	37.21
Average	46.59	39.73 (14.72)	37.32 (19.90)	-	169	149 (13.42)	140 (20.71)	-

Table 3 indicated that this hybrid recorded grain yield of 38.31 q/ha when evaluated in State Multilocation Hybrid Trials from 2009 - 10 to 2014 - 15, which were 13.38 and 16.06 percent increase over CSH 25 and CSH 16, respectively. It also registered dry fodder yield of 147.67 q/ha, while checks CSH 25 and CSH 16 recorded 130.66 and 123.05 q/ha respectively, indicating the advantage of 11.52 and 21.57 per cent over these checks, respectively.

Table 3. Mean performance of sorghum hybrid SPH 1641 for grain and fodder yield in State Multilocation Hybrid Trial.

Years of testing	No. of location	Proposed hybrid SPH -1641	Check		No. of location	Proposed hybrid SPH 1641	Check	
			CSH-25	CSH 16			CSH-25	CSH 16
2009 - 10	10	40.12	35.46	-	8	140.00	125.75	-
2011 - 12	8	39.15	38.56	39.41	8	164.90	147.30	133.00
2012 - 13	8	38.39	34.74	34.88	8	155.55	139.31	138.97
2013 - 14	6	34.68	29.00	23.99	6	148.70	127.46	122.88
2014 - 15	8	39.23	31.20	32.19	8	129.20	113.46	97.34
Overall average	40	38.31	33.79	32.62	38	147.67	130.66	123.05
% increase over the checks	40		13.38	16.06	38		11.52	21.57

Hybrid SPH 1641 was evaluated in AICRIP trials during 2008 - 09, 2009 - 10 and 2011 - 12 in grain sorghum category (Table 4). On the basis of three years of testing in AICSIP trials this has recorded 41.64 q/ha grain yield as against 39.08 q/ha of CSH 23 showing 6.55 per cent advantage. For dry fodder yield SPH 1641 showed significant superiority over both the checks *viz*., CSH 16 and CSH 23, registering 19.64 and 32.21 per cent superiority over these checks with 150.22 q/ha of dry fodder yield.

The per cent starch, fat and protein are the three major constituents of grain affecting the quality in sorghum. Starch, fat and protein were determined in the randomly collected replicated grain samples from entries during 2010 and 2011 at different AICRIP locations. Grain quality of Sorghum Hybrid SPH 1641 in AICRIP and ICRISAT trials given in Table 5 revealed that there

was no significant difference for starch content among the test hybrid and two check hybrids. The hybrid SPH 1641 showed higher starch content. SPH 1641 showed 9.80 per cent protein, higher than CSH 16 but at par with CSH 25. Furthermore, fat content of SPH 1641 is also comparative with the checks.

Table 4. Mean performance of sorghum hybrid SPH 1641 for grain and fodder yield in AICRIP trials.

Years of testing	No. of trials	Proposed hybrid SPH -1641	Check CSH 23	No. of trials	Proposed hybrid SPH 1641	Checks	
						CSH 16	CSH 23
2008 - 09	12	37.47	34.34	12	160.21	120.14	109.83
% increase over check(s)	12		9.11	12		33.35	45.87
2010 - 11	17	43.09	37.54	16	149.88	143.55	130.51
% increase over check(s)	17		14.78	16		4.41	14.84
2011 - 12	17	43.45	44.60	19	150.81	135.66	122.26
% increase over check(s)	17		–2.58	19		11.16	23.35
Overall average	46	41.64	39.08	47	150.22	125.56	113.62
% increase over check(s)	46		6.55	47		19.64	32.21

Table 5. Grain quality of sorghum hybrid SPH 1641 in AICRIP and ICRISAT trials.

		AICSIP trials					ICRISAT, Hyderabad (*kharif* 2014-15)		
Traits	Years of testing	No. of locations	SPH -1641	Checks		Traits	SPH 1641	Checks	
				CSH 16	CSH 25			CSH-16	CSH - 25
Starch (%)	2010 - 11	3	66.1	65.6	64.2	Protein (%)	14.30	12.71	14.07
	2011 - 12	2	66.28	65.25	66.02				
	Average	5	66.2	65.4	64.9				
Protein (%)	2010 - 11	3	9.89	9.99	9.89	Fat (%)	3.38	3.31	2.61
	2011 - 12	2	9.65	9.60	9.46				
	Average	5	9.80	9.84	9.72				
Fat (%)	2010 - 11	3	2.54	2.72	2.71	Starch (%)	62.79	60.13	65.02

CP = Crude protein, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, IVOMD = *In vitro* organic matter digestibility.

Sorghum varieties with improved fodder parameters have a direct impact on animal productivity, a positive influence on the pricing of stover sold as animal feed, thereby contributing to income from both crop and livestock enterprises (Blummel and Rao 2006). Protein content and digestibility (measured as *in vitro* organic matter digestibility, IVOMD) are the important trait for stover quality. The fiber content (ADF and NDF) plays a crucial role in providing roughage as well as in determining digestibility. The sorghum hybrid SPH 1641 was characterized for stover traits and compared with 2 check hybrids (Table 6). Data revealed that the crude protein per cent of SPH 1641 (7.06) was at par with both the check hybrids i.e. CSH 16 (7.25) and CSH 23 (7.26), on the basis of mean of 5 locations across two seasons. Whereas, IVOMD of SPH 1641 registered nonsignificant differences with that of both the hybrid checks indicating comparative significance of SPH 1641 in respect of stover quality with that of checks.

Although high yielding varieties and hybrids have been released in sorghum since 1960s, several biotic and abiotic constraints have affected its productivity. One of the most important biotic stress is the shootfly (*Atherigona soccata* Rond.) causing infestation up to 90 - 100%.

However, expression of resistance to shoot fly damage varies between the rainy and the postrainy seasons (Sharma 2014). Srilaxmi and Paul (2011) also reported severe damage caused by shoot fly in Deccan plateau. Interland fish meal technique was used for screening as suggested by Soto (1974). Reaction of Sorghum hybrid SPH 1641 to pest incidence in AICRIP trials is illustrated in Table 7. This hybrid showed a moderate level of resistance against shootfly and stem borer as the incidences of these pests in the hybrid were found moderate and even lesser than the incidence score of check hybrids *viz*., CSH 16 and CSH 23 and far lesser than the susceptible check (DJ 6514).

Table 6. Stover quality of sorghum hybrid SPH 1641 in AICRIP trials.

Traits (%)	Years of testing	No. of locations	SPH 1641	Checks	
				CSH 16	CSH 23
Ash	2010 - 11	2	10.07	9.93	10.10
	2011 - 12	3	10.85	11.84	11.51
	Average	5	10.54	11.07	10.94
CP	2010 - 11	2	8.53	9.31	8.84
	2011 - 12	3	6.06	5.88	6.19
	Average	5	7.06	7.25	7.26
NDF	2010 - 11	2	61.55	59.95	61.29
	2011 - 12	3	61.60	61.76	60.72
	Average	5	61.6	61.0	60.9
ADF	2010 - 11	2	49.55	47.26	48.71
	2011 - 12	3	4.67	44.55	43.45
	Average	5	46.62	45.63	45.55
IVOMD	2010 - 11	2	40.58	41.79	41.40
	2011 - 12	3	45.42	45.45	47.41
	Average	5	43.48	43.98	45.01

Table 7. Reaction of Sorghum hybrid SPH 1641 to pest incidence in AICRIP trials.

Characters	Year of testing	No. of trials	SPH 1641	CSH 16	CSH 23
Shoot fly dead hearts (%) 28 DAE	2008 - 09	6	63.3	73.6	65.8
	2010 - 11	6	61.0	60.4	59.0
	2011 - 12	8	58.5	62.5	59.1
	Overall Average	20	59.8	63.6	59.8
Shoot fly eggs per 5 plants numbers	2008 - 09	1	8.6	6.0	11.0
	2010 - 11	6	6.8	6.8	7.0
	2011 - 12	3	5.4	5.3	5.4
	Overall Average	10	6.5	6.3	6.9
Stem borer dead hearts (%) 45 DAE	2008 - 09	6	11.0	9.0	16.8
	2010 - 11	5	22.6	17.6	18.5
	2011 - 12	6	13.9	12.0	18.3
	Overall Average	17	15.4	12.6	17.8

DAE = Days after emergence.

Grain mold is complex disease-causing enormous loss in rainy season sorghum in the years of prolonged rainfall at the time of crop maturity. This results in loss in quality of grain leading to poor market value. This is one of the major reasons for the replacement of *kharif* sorghum with

other crops. Developing mold resistant hybrids is the only solution to tackle this problem. Sorghum varieties with semi compact panicles are generally found to be tolerant to grain mould

Table 8. Reaction of Sorghum hybrid SPH 1641 to diseases in AICRIP trials.

Character	Year of testing	No. of trials	SPH 1641	Checks	
				CSH 16	CSH 23
Grain mold field grade	2008 - 09	4	4.1	4.2	4.9
(1 - 9 rating)	2010 - 11	6	4.3	5.4	5.8
	2011 - 12	6	3.5	4.4	4.9
	Overall average	16	3.95	4.73	5.26
Grain mold threshed	2008 - 09	1	2.9	2.4	3.1
grade	2010 - 11	3	4.3	5.7	5.8
(1 to 9 rating)	2011 - 12	3	1.7	2.9	3.5
	Overall average	7	3.00	4.03	4.40
Grain affected %	2008 - 09	1	34.6	34.0	39.0
	2010 - 11	2	37.8	42.1	41.5
	2011 - 12	2	35.5	32.7	34.9
	Overall average	5	32.24	36.70	38.36
Germination %	2008 - 09	1	57.7	53.4	52.5
	2010 - 11	3	57.7	49.3	49.7
	2011 - 12	3	65.4	57.3	55.8
	Overall average	7	61.00	53.30	52.70
Ergot	2008 - 09	1	31.6	16.2	20.5
	2010 - 11	1	8.7	11.0	9.9
	2011 - 12	1	3.0	4.3	3.7
	Overall average	3	14.43	10.50	11.36

(Thakur *et al.* 2006). Semi compact panicles of SHP 1641 confers low incidence of mold as supported by lower values of TGMR (3.95) and FGMR (3.00) as against 4.47 and 5.26 for TGMR and 4.03 and 4.40 for FGMR for checks CSH 16 and CSH 23, respectively in AICRIP trial evaluated at different hot spot locations across country. These results reflected in the higher germination percentage of SPH 1641 (61) (Table 8).

Adaptability of this hybrid was assessed in the farmers' fields under Adaptive Trials conducted during *kharif* seasons of 2013 - 14 and 14 - 15 on 60 farmer's field spread over 8 districts of Marathwada region of Maharashtra State (Table 9). This hybrid registered a mean

Table 9. Mean performance of sorghum hybrid SPH 1641 in adaptive trials (Marathwada region of Maharashtra State).

Year	No. of districts	No. of farmers	Grain yield (q/ha)			Fodder yield (q/ha)		
			SPH 1641	CSH 16	CSH 25	SPH 1641	CSH-16	CSH 25
2013 - 14	07	30	37.13	32.40	32.57	144.80	123.43	125.93
		% increase over		12.75	12.30		14.76	13.03
2014 - 15	08	30	37.20	32.70	33.10	145.33	125.57	126.17
% increase over				12.10	11.02		13.60	13.19
Overall average			37.17	32.55	32.83	145.07	124.50	126.05
% increase over				12.42	11.66		14.18	13.11

grain yield of 37.13 q/ha during *kharif* 2013 - 14 and 37.20 q/ha during *kharif* 2014 - 15 with a yield increase of 12.10 and 11.02 per cent over checks CSH 23 and CSH 25, respectively and 12.10 and 12.42 per cent over the respective checks. The mean stover yields of the hybrid was 37.17 as against 32.55 and 32.83 q/ha over respective checks exhibiting 12.42 and 11.66 per cent increase.

Identification of superior dual-purpose (food and fodder) sorghum hybrids is the need of the farmer as it is the only way to meet the ever-growing food, feed and fodder demands of the country (Blummel and Reddy 2006). All these field experiments proved the superiority of SPH 1641 over check hybrids CSH 25, CSH 16 and CSH 23 for stabilized grain and fodder yield, reaction to shoot fly, stem borer and grain mold. Furthermore, grain and fodder nutritional qualities of SPH 1641 are also found comparable with the checks. Considering all these aspects, SPH 1641 is released as a new *kharif* sorghum hybrid for the *kharif* sorghum growing areas of Maharashtra State.

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(Manuscript received on 28 February, 2019; revised on 8 June, 2020)