

PHULE MADHUR (RSSGV-46): A SWEET GRAIN RABI SORGHUM VARIETY FOR TENDER GRAIN PROCESSING

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Abstract: RSSGV 46 a new *rabi* sorghum genotype for *hurda* developed from the cross RSSGV 6 x Gulbhendi at Rahuri through pedigree selection was found superior in high *hurda* yield at dough stage over the checks Phule utara, Surthi and Gulbhendi. Average of thirteen tests, it gave 3393 kg/ha *hurda* yield as against 2190 kg/ha of Phule utara, 2510 kg/ha of Surthi and 2082 kg/ha of Gulbhendi, thus amounting to 54.2, 35.2 and 63.0 % increase over the checks respectively. As regards fodder yield, it had recorded 6746 kg/ha dry fodder yield over Phule Utara (6187 kg/ha), Surthi (4989 kg/ha) and Gulbhendi (6387 kg/ha), thus amounting 9.0, 35.2 and 5.6 % increase than the checks, respectively. In respect of nutritional composition of *Hurda* on wet basis it had recorded higher total sugars (5.09 %) over the check surthi (4.82 %) and comparable with Phule Utara (5.37 %) and Gulbhendi (5.22 %). The sensory evaluation studies indicated that, it had recorded better organolyptic properties *viz.*, grain separation (Treshability %), grain shape, color of grain, texture and taste. Beside, being the higher *hurda* yield RSSGV 46 is characterized as Non-Tan plant pigment. Flowers in 77 days and 97 days required for dough stage (*hurda* stage), mid tall plant stature (213 cm), the *hurda* yield and its contributing characters was also higher in this genotype *viz.*, tender grain yield (49.0 g/plant), Easy threshable grain (95.3%), Tender Grain Harvest index (69.4%), Tender grain number per panicle (1976) and 1000 tender grain weight (43.2 g). It had semi-compact oval shape panicle with green colour grains at dough and white flat grains at maturity. It had higher degree of tolerance to shoot fly (32.6 % Dead Heart), stem borer (7.1 % Dead Heart), Charcoal rot (18.8 %). This genotype was observed to be drought tolerant (higher in LAI, RLWC, Photosynthetic rate, PAR, SPAD, stomatal conductance , ear head exertion, root traits and lower in stomatal frequency, leaf temperature and transpiration rate).

Keywords: Rabi sorghum, *Hurda* and Dough stage.

Introduction

Sorghum grown in rabi season is characterized by excellent grain quality, exclusively used for human consumption and hence, fetches high price in the market. Sorghum has nutritional composition similar or better than rice and wheat in some aspects. The grain content high fiber and non starchy polysaccharides and starch with some unique characters. Protein quality

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and essential amino acid profile of sorghum is better than many of the cereals and millets. Sorghum in general is a rich source of fiber and B complex vitamin (Gopal *et al.*, 2000 and Patil *et al.*, 2010). Grain sorghum rich in fiber and minerals apart from having a sufficient quantity of carbohydrates (72%), protein (11.6 %) and fat (1.9%). Starch is the major constituent of the grain. Rabi sorghum grown are consumed in the various ways, like mature grain floor for roti and other recipes mature grain after roasting are pops and tender grains (harvested at milky grain stage) after roasting as *hurda*. The special purpose sorghum can provide choice to the end users in food enterprises. Sorghum *hurda* is one among the special sorghum and it is ready to eat snacks. *Hurda* made from sorghum is known for delicious taste. There is a need for popularize sorghum food as sorghum with its high minerals and fiber content and with low or slow starch digestibility makes an ideal food for diabetic and obese population in the urban as well as rural society. It was therefore felt to develop and identify the genotype for *hurda* purpose which will give benefit to the farmers and consumers too. Now a day's agro-tourism business is increasing in the rural areas and in the contest supplying sorghum *hurda* as a niche product get the more profit to the farmers and producers. This project has developed the variety Phule Uttara during the year 2004-05 for the *hurda* purpose. But this variety has not popularized among the farmers due to difficult in threshability at dough stage. The farmers/commercial growers are demanding the variety having easy threshability with sweet *hurda* grain. At present farmers used the local cultivar Surthi for *hurda* purpose for commercial purpose. These cultivar is having better threshability with less sweetness and poor grain and fodder yield potential. Considering this constraint, this project initiated breeding programme during the year 1999-2000 for alternate uses like *hurda* (Sweet grain genotype). The objective of this paper is to describe the development and characteristics of new *rabi* sorghum genotype for *hurda* purpose.

Materials and Methods

The *rabi* sorghum genotype RSSGV 46 is developed through a cross RSSGV 6 x Gulbhendi having very easy threshable and high *hurda* yield (tender grain yield) potential with tolerance to shootfly and charcoal rot. The cross was effected during the year 1999-2000 and F₁ was grown during the year 2000-01 at Rahuri. It was isolated from F₂ population in 2001-02 season and evaluated for *hurda* yield in subsequent generation thereafter at MPKV, Rahuri. The F₃ to F₁₁ progenies was evaluated during the year from 2002-03 to 2010-11. The promising progeny (RSSGV 6 X Gulbhendi-1-1-1-1-1) was identified superior in easy threshability with high *hurda* yield at dough stage. The varietal trials were conducted as per

the norms and recommended procedure as per university programme (Anonymous. 2011). The genotype RSSGV 46 was tested in station trials during the year 2011-12. This genotype further evaluated in University Multilocation trials during 2012-13 at Rahuri Karad and Solapur, during 2013-14 at Rahuri, Solapur, Jalgaon, Mohol, Karad and during 2014-15 at Rahuri, Solapur, Chas, Jalgaon for *hurda* and fodder yield potential. The observations were recorded *viz.*, *hurda*, fodder, shootfly, charcoal rot, phenological and morphological data as per the standard procedure.

The sorghum *hurda* prepared were subjected for the sensory evaluation to a panel of ten semi trained judges during the 2011-12 to 2014-15. The parameter evaluated by the judges included colour and appearance, texture, aroma/ flavor, taste and overall acceptability. For the sensory evaluation sorghum *hurda*, hedonic scale one to nine point (like extremely (Excellent): 9, like very much (Very good): 8, like moderately (Good): 7, like slightly : 6, neither like nor dislike : 5, Dislike slightly : 4, Dislike moderately : 3, Dislike very much : 2, Dislike extremely : 1) was used, (Amerine *et al.* 1965). Visual observation and sensory parameters of sorghum *hurda* of different varieties prepared were compared and recorded. The chemical analysis (moisture, total sugars, soluble protein, brix and phenolics) of the roasted grain were done according to the standard method of AOAC, 1990.

During the year 2013-14, the variety RSSGV 46 (Phule Madhur) with the checks Phule Uttara were evaluated for *hurda* and fodder yield in 30 adaptive trials in Maharashtra comprising the 14 districts *viz.*, Ahmednagar, Solapur, Pune, Sangali, Satara, Kolhapur, Nashik, Nadurbar, Dhule, Jalgaon, Aurangabad, Parbhani, Bid and Nanded. The statistical analysis was done as per the methods of Panse and Sukhatme (1985).

Results and Discussion

The genotype RSSGV 46 was tested for *hurda* and fodder yield with checks Phule Uttara, Surthi and Gulbhendi in station trials at Rahuri during 2011-12, University Multilocation Trials during 2012-13 at Rahuri, Karad, Solapur, during 2013-14 at Rahuri, Solapur, Jalgaon, Mohol, Karad and during 2014-15 at Rahuri, Solapur, Chas and Jalgaon and results of *hurda* and fodder yield are presented in Table 1& 2, respectively. Based on overall performance for the four years, i.e. from 2011-12 to 2014-15 over 13 tests, RSSGV 46 produced high mean *hurda* yield (3393 kg/ha) as against Phule Uttara (2190 kg/ha), Surthi (2510 kg/ha) and Gulbhendi (2082 kg/ha) which amounted to 54.9, 35.2 and 63.0 % increase in *hurda* yield over the checks Phule Uttara, Surthi and Gulbhendi, respectively.

It also yielded 6746 kg/ha fodder yield as against Phule Uttara (6487 kg/ha), Surthi (4989 kg/ha) and Gulbhendi (6387 kg/ha), which amounted to 9.0, 35.2 and 5.6 per cent increase over the check Phule Uttara, Surthi and Gulbhendi, respectively.

The data on 30 adaptive trials on farmers field (Table 3) indicated that the genotype RSSGV 46 yielded the higher *hurda* yield (1355 kg/ha) over Phule Uttara (1011 kg/ha) amounting to 34.0 % increase over the check. Where as its mean fodder yield was 3761 kg/ha as against 3069 kg/ha of Phule Uttara amounting to increase of 22.5 per cent over the check.

The sensory evaluation of roasted sorghum *hurda* revealed that (Table 5), the genotype RSSGV 46 were easily threshable (free threshability) than Phule Uttara and Gulbhendi but comparable with Surthi. The grain shape of all the *hurda* genotype is oval/oblong and colour of grain is medium green. The texture of the RSSGV 46, Phule Uttara and Surthi is soft while the Surthi is medium. The genotype RSSGV was found very good having more than 8.6 overall acceptability scale for sorghum *hurda*.

Studies on morphological and *hurda* yield contributing traits (Table 6) indicated that, the genotype flowered in 77 days, required 97 days for dough stage and matured in 121 days. It grows to the height of 213 cm. As regards *hurda* yield and its contributing traits, revealed that, the genotype RSSGV 46 produced high *hurda* (49 g/plant) as compared to the checks viz., Phule Uttara (31.9 g/plant), Surthi (36.5 g/plant) and Gulbhendi (31.5 g/plant). The high *hurda* yield of RSSGV 46 was mainly due to higher threshability (95.3%), tender grain harvest index (69.4 %), tender grain number (1976) and 1000 tender grain weight (43.2 g).

The study on nutritional composition of sorghum on wet basis was undertaken at Rahuri during 2011-12 to 2014-15. It had recorded more moisture (57.26 %) as compared to Phule Uttara (56.19%), Surthi (50.87 %) and Gulbhendi (55.57%), comparable total sugars (5.09%) and brix (17.5 %) at dough stage, more soluble proteins (1.42%) and lower phenolics (0.38%) as compared to checks.

The nutritional composition of fodder at dough stage (Table 7) revealed that, the genotype RSSGV 46 recorded higher protein (6.56%), IVDMD (58.4%) and comparable crude fiber (31.7%), NDF (60.4%) and ADF (39.1%) as compared to the check Phule Uttara, Gulbhendi and Surthi. The variety RSSGV 46 (Table 8) had tolerant to shootfly (32.6 % Dead Heart), stem borer (7.9 % Dead Heart) and charcoal rot (18.8 %) as compared to checks.

The drought tolerant studies (Table 9) indicated that, the genotype RSSGV 6 found to be drought tolerant. The drought tolerance of this variety was mainly attributes to high LAI (4.01), RLWC (78%), SPAD (51), photosynthetic rate (33.8 μ moles $\text{CO}_2/\text{m}^2/\text{sec}$), stomatal

conductance (28.4 m moles /m²/sec), ear head exertion (87%) and root traits , while lower leaf temperature (-5.5⁰C), transpiration rate (1.42 m moles H₂O/m²/sec) and stomatal frequency at addax (140) and abax (168).

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Table 1: Summary *Hurda* grain (Tender grain) yield (kg/ha) performance of proposed variety RSSGV-46 in various trials during 2011-12 to 2014-15

Name of the trials	Year	No. of trial	Proposed variety RSSGV 46	Checks varieties (kg/ha)		
				Phule Uttara	Surthi	Gulbhendi
Station trial	2011-12	1	4167	3241	3439	2976
University MLT	2012-13	3	3347	2181	2211	2201
University MLT	2013-14	5	3505	2458	2760	2232
University MLT	2014-15	4	3095	1599	2191	1582
Over all mean		13	3393	2190	2510	2082
% Inc.Over				54.90	35.2	63.0

Table 2: Summary Fodder yield (kg/ha) performance of proposed variety RSSGV-46 in various trials during 2011-12 to 2014-15

Name of the trials	Year	No. of trial	Proposed variety RSSGV 46	Checks varieties (kg/ha)		
				Phule Uttara	Surthi	Gulbhendi
Station trial	2011-12	1	6800	5255	5344	5179
University MLT	2012-13	3	7014	7355	5280	7261
University MLT	2013-14	5	6390	5436	4737	5563
University MLT	2014-15	3	7055	6282	4999	7290
Over all mean		12	6746	6187	4989	6387
% Inc.Over				9.0	35.2	5.6

Table 3. *Hurda* and fodder yield of rabi sorghum variety RSSGV 46 (Phule Madhur) in adaptive trial on farmers field during the year 2014-15.

Sr. No.	Location of trial at farmers field	No. of trials	<i>Hurda</i> yield (kg/ha)		Fodder yield (kg/ha)	
			Phule Madhur	Phule Uttara	Phule Madhur	Phule Uttara
1.	Ahmednagar	5	1530	1070	3762	3220
2.	Solapur	4	1031	851	4293	3262
3.	Pune	2	1875	1350	5625	4625
4.	Satara	2	1475	1100	3250	2800
5.	Sangali	2	1450	1170	4000	2975
6.	Kolhapur	1	1350	950	3900	3250
7.	Nashik	2	1250	900	3300	2825
8.	Nandurbar	2	1650	1200	3000	3150
9.	Dhule	3	1317	1033	3500	2842
10.	Jalgaon	3	1517	1093	3683	2950
11.	Aurangabad	1	1100	900	3350	2800
12.	Parbhani	1	750	600	1200	1000
13.	Bid	1	1125	950	4500	3850
14.	Nanded	1	650	500	2200	1850
Over all Mean		30	1355	1011	3761	3069
% increase over			-	34.0	-	22.5

Table.4. Morphological and *hurda* yield contributing traits of RSSGV 46 during the year 2011-12 to 2014-15 (Mean of four years)

Sr.No	Phenological traits	No of trials	Proposed variety RSSGV 46	Check varieties		
				P.Uttara	Surthi	Gulbhendi
1	Days to 50 % flowering	13	77	76	74	76
2	Days to dough stage	13	97	97	95	97
3	Days to maturity	13	121	120	118	120
4	Plant Height (cm)	13	213	202	206	205
5	Tender grain yield (gm/plant)	13	49	31.9	36.5	31.5
6	Easy threshable grain %	4	95.3	61.0	90.2	58.2
7	Tender grain harvest index % (TGHI)	4	69.4	43.2	61.9	39.2
8	Tender grain number per panicle	4	19.76	19.25	18.15	17.89
9	1000 tender grain weight (gm)	4	43.2	39.1	37.2	36.7

Table 5. Sensory evaluation of roasted sorghum (sorghum *hurda*) from 2011-12 to 2014-15 (Mean of four years) at MPKV,Rahuri.

Sr. No.	Sample No.	Grain separation from Glum	Grain shape	Colour of grain	Texture	Taste
1.	RSSGV 46	E	O	MG	S	8.6
2	Phule Uttara	H	O	MG	S	8.4
3	Surati	E	O	MG	M	8.0
4	Gulbhendi	H	O	MG	S	8.2

Grain separation	Grain shape	Grain colour	Texture	Taste (Score)
Easy – E	Round – R	Dark green – DG	Soft – S	Like extremely – 9 Like very much – 8
Medium – M	Oval/oblong – O	Medium green – MG	Medium –M	Like moderately– 7 Like slightly – 6
Hard - H	Wrinkle - W	Faint green - FG	Hard - H	Neither like nor dislike – 5 Dislike – 4 Not accepted – 3

Note : 10 semi trained judges were used for the sorghum *hurda* organoleptic/sensory quality evaluation

1. Grain separation from glume: E=Easy,M=Medium,H=Hard
2. Grain shape:R=Round,O=Oval,W=Wrinkled
3. Grain colour:DG=Dark green,MG=Medium Gree.,FG=Faint Green
4. Texture:S=Soft,M=Medium,H=Hard
5. Taste score:9=Like extremely,8=Like very Much,7=Like moderately,6=Like slightly
5=Neither like nor dislike, 4=Dislike,3=Not accepted

Table 6. Nutritional composition of sorghum *hurda* on wet basis (Mean of four years i.e 2011-12 to 2014-15)

Sr.No	Characters	No of trials	RSSGV 46	Check varieties		
				P.Uttara	Surthi	Gulbhendi
1	Moisture (%)	4	57.26	56.19	50.87	55.57
2	Total sugars (%)	4	5.09	5.37	4.82	5.22
3	Soluble proteins (%)	4	1.42	1.34	1.21	1.28
4	Brix of tender grain (%)	4	17.5	20.5	16.5	20.5
5	Phenolics (%)	4	0.38	0.56	0.75	0.67

Table 7. Nutritional constituents of fodder of sorghum varieties at dough stage during 2014-15

Sr.No.	Genotypes	Nutritional constituents of fodder				
		Crude Protein %	Crude fiber %	NDF %	ADF %	IVDMD %
1.	RSSGV 46	6.56	31.7	60.4	39.1	58.4
2.	Phule Uttara	5.25	38.9	67.6	54.0	46.8
3.	Surthi	7.87	32.1	65.2	41.8	56.3
4.	Gulbhendi	6.12	42.1	67.0	43.3	55.2
	SE \pm	0.22	1.96	3.40	1.01	1.73
	CD at 5 %	0.65	6.10	10.20	3.02	5.31

Table 8. Reaction to pest and disease of *hurda* sorghum genotypes (Mean of four years i.e 2011-12 to 2014-15.

Sr. No.	Genotypes	Shootfly pest (% Dead Heart)	Stem borer (% Dead Heart)	Charcoal Rot (%)
1.	RSSVG 46	32.6	7.1	18.8
2.	Phule Uttara	41.8	7.9	22.5
3.	Surthi	40.0	7.6	24.0
4	Gulbhendi	45.7	10.5	20.5

Table 9. Drought tolerant studies of sorghum genotypes under moisture stress from 2012-13 to 2014-15 (Mean of three years)

Sr. No.	Physiological traits	Proposed variety RSSGV 46	Check varieties		
			P. Uttara	Surthi	Gulbhendi
1.	LAI at 50 % flowering	4.13	4.07	3.28	3.78
2.	RLWC (%) at 50 % flowering	78	77.7	75	77.6
3.	SPAD at 50% flowering	51.0	45.4	51.4	50.4
4.	Leaf temperature ($^{\circ}$ C)	-5.5	-4.9	-5.4	-4.9
5.	Photosynthesis rate (μ moles $\text{CO}_2/\text{m}^2/\text{sec}$)	33.8	34.4	30.6	32.2
6.	Stomatal cond. (m moles/ m^2/sec .)	28.4	26.8	23.8	25.3
7.	Transpiration rate (m moles $\text{H}_2\text{O}/\text{m}^2/\text{sec}$)	1.42	1.45	1.52	1.48
8.	PAR (μ moles/ m^2/sec)	508	510	515	437
9.	Stomatal frequency (mm^2) Adax.	140	142	149	146
10.	Stomatal frequency (mm^2) Abax.	168	162	162	158
11.	Earhead exertion (%)	87	83	83.3	83.3
12.	Root number	38	37	39	39
13.	Root length (cm)	55	53	54	52
14.	Root volume (ml)	53	55	48	51
15.	Root mass (g/plant)	58	56	51	54