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RSSV 313: A Sweet Sorghum Donor for High Biomass

S.V. Nirmal, M.S. Shinde, V.R. Awari*, V.R. Patil, S.R. Gadakh, U.S. Dalvi and U.D. Chavan

All India Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri 413 722 (M.S.), India
**Corresponding author*

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A B S T R A C T

Sweet sorghum is a new generation bio-energy crop with considerable tolerance to drought and salinity and amenable for multiple uses. Sweet sorghum has elicited the interest of breeder due to its capacity to provide renewable energy products, industrial commodities, food and animal feed. The sweet sorghum donor RSSV 313 is developed through a cross NSS223 x NARI 111 at MPKV, Rahuri through pedigree selection as identified and recommended as a donor parent in crop improvement programme based on specific physiological traits *viz*.; leaf area, LAI, plant height, stay green score, HUE, low HI and high biomass, stay green rating, juice brix^0 and high biomass. Eleven sweet sorghum genotypes were evaluated for fresh biomass and physiological parameters at Rahuri from 2013-14 to 2015-16 (3 years). Among them RSSV 313 was observed to be promising for high biomass and physiological traits. The pooled mean of three years revealed that RSSV 313 recorded the highest fresh biomass (67.6 t/ha) as compared with the check CSV19 SS (58.2 t/ha) thus, amounting to 16.2 % increase over check. The physiological studies indicates that the sweet sorghum donor RSSV 313 equipped with great photosynthetic apparatus *viz*., high leaf area (75.9 dm^2), high LAI (6.37), plant height (368 cm) and low HI (16.3%). The donor RSSV 313 was also observed to most efficient in converting the heat into biomass production owing to efficient utilization of solar radiation (0.028 HUE). The genotype RSSV 313 was therefore recommended as donor parent in sweet sorghum crop improvement programme during the Joint Agresco 2016 held at Dr. PDKV, Akola (Maharashtra).

Introduction

Sweet sorghum is a wonder crop from physiological point of view. No any other cereals or even sugarcane can beat sweet sorghum in its productivity. It is also blessed with efficiency in converting cultural energy and capability to accumulate high level of sugar in their stalk. Due to their high biomass production per unit area, sweet sorghum removes more CO_2 from the atmosphere. This unique attribute of sweet sorghum is considered highly favourable for its eventual emergence as a bio-energy crop. Sweet sorghum by virtue of its C_4 photosynthetic system and rapid dry matter accumulation is an excellent bioenergy crop. Therefore, sweet sorghum is expected to gain importance in the coming years in bioenergy farming. At present, there has no anyone technique which can be needed to meet the demand of the energy in world. It is estimated that the total amount of biomass produced by photosynthesis is reaches 1440 to 11800 hundred million tonnes in the whole world every year. Therefore, since the beginning of energy crises, every county in the word has been seeking new energy sources in order to reduce the dependence on the exotic energy source fuel. One of the ways is the development of green energy sources, green plant is the chief collector of solar energy. Development and utilization of biomass, production of ethanol is one of the most important way, while at present it looks that sweet sorghum is the most ideal crop with its high biomass yield. Considering this issue, this project initiated sweet sorghum breeding programme during the year 2000 - 01 for high biomass. The brief paper describes the procedure followed in developing such a donor and an account of the relative performance of sweet sorghum donor when compared to released variety CSV 19 SS.

Materials and Methods

The sweet sorghum donor RSSV 313 is developed through a cross NSS223 x NARI 111 having high biomass yield coupled with better physiological traits. The cross was effected during the year 2000 - 01 and F_1 was grown during the year *rabi* 2001-02 at Rahuri. It was isolated from F_2 population and evaluated for biomass in subsequent generation thereafter at MPKV Rahuri. The F_3 to F_7 progenies were evaluated during the year from 2004 -05. The promising progeny (NSS 223 x NARI -111-8-1-1-1-1) was identified superior in high biomass as compared with check CSV 19SS. The above promising F_7 progeny was evaluated under the number RSSV 313 at Rahuri in station trial during 2009-10 to 2012-13 for biomass. Considering its outstanding performance, it was sponsored for physiological studies from 2013-15 (3 years).

Chlorophyll concentration was assessed using chlorophyll meter (SPAD-502 Plus, Minolta). Measurements were taken at three points (upper, middle and lower parts). Average of these three readings was considered as SPAD reading of the leaf. The mean SCMR reading was taken out in the end and presented at average SPAD value. The leaf area (dm^2) of the plant was calculated by taking maximum length and width at the broadest point of the green leaves and multiplying by the factor 0.747 (Stickler *et al.*, 1961). Leaf area index (LAI) is the ratio of total leaf area per unit ground area or land area, both expressed in the same units. It was calculated by the formula given by Watson (1947). The total heat unit required from seed germination to physiological maturity was worked out by total summation of the degree days above the base temperature with the help of formula suggested by Iwata (1984). Base temperature was being taken as 10^0C (Klages, 1958). Heat unit efficiency was computed for fresh biomass at maturity as per the formula given by Rajput (1980). The days to flowering, physiological maturity and stay green rating score was done as per the standard procedure. The brix value of juice was recorded with help of hand refractometer at physiological maturity stage. The plant height (cm) and fresh biomass was recorded at physiological maturity stage. The harvest index was calculated by the formula given by Donald (1962). The statistical analysis was done as per procedure given by Panse and Sukhatme (1985).

Results and Discussion

Sweet sorghum possesses genetic diversity for high biomass production. In the present investigation, total fresh biomass differed significantly among the sweet sorghum genotypes (Table 1). The genotype RSSV 313 recorded significantly high total fresh biomass (67.6 q/ha) at physiological maturity. The genotype RSSV 313 established maximum leaf area (75.9 dm^2 and LAI 6.37) at flowering stage indicated that a RSSV 313 was equipped with a photosynthesizing structure of great potential. The higher plant height of this genotype (368 cm) indicates more biomass accumulation which has been reflected in higher fresh biomass. It is inferred that the total fresh biomass in RSSV 313 mainly due to higher plant height, leaf area and LAI. These results are in line with the earlier results of Patil *et al*., Mutkule (2010) and Repe (2012) (Table 2).

The SPAD can quickly and reliably asses the nitrogen status indicator of the photosynthetically active light transmittance of the light. In this study, the genotype RSSV 409 (59.1) and RSSV 313 (56.0) recorded the highest SPAD value at the flowering stage (Table 3). The higher SPAD value in RSSV 313 indicating importance of this trait in governing productivity through growth parameters like plant height and leaf area.

The higher stay green score in RSSV 313 (3-4) help in intercepting more solar energy, enhancing their photosynthetic area for longer duration which ultimately resulted in high biomass production (Table 4).

Growth is expressed as height and leaf area. Leaf area plays an important role in biomass production and photosynthesis. Correlation between leaf area and yield suggests its importance in determining the yield. In the present studies, there was significant variation in leaf area at 50% flowering. The genotype RSSV 313 at 50% flowering produced significantly higher leaf area (75.9 dm^2) and LAI (6.37). Higher leaf area and LAI might have intercepted more light enhancing their photosynthetic rate which is ultimately resulted in higher fresh biomass. These findings corroborate the results reported by Mutkule (2010) and Repe (2012).

The significant genetic difference was found with respect to plant height at maturity. The genotype RSSV 313 (368 cm) recorded the highest plant height followed by RSSV 432 (362 cm). The higher plant height indicate more biomass accumulation which has been reflected in higher fresh biomass (67.6 t/ha). These results were in accordance to Repe (2012). Crop productivity mainly depends upon the climatic requirement of a crop. Each genotype needs an accumulation of certain amount of heat to complete its life cycle. In the present studies, the genotype RSSV-313 accumulated the highest heat unit (2344) among the genotypes. Due to slow accumulation of heat unit the flowering was delayed in the genotype RSSV-313.

Crop productivity inhibited at temperature higher than optimum, Heat unit efficiency could be used as a measure of crop efficiency for temperature utilization. The efficiency of temperature utilization of heat unit is a function of production efficiency of a crop. It varies depending upon the genotypes and environment. The variation in efficiency of heat unit due to various sweet sorghum genotypes was significant for total fresh biomass and grain yield. The genotype RSSV-313 was observed to be most efficient in converting the heat into fresh biomass owing to efficient utilization of solar radiation. The genotype RSSV-313 (0.028) was found to be most efficient in converting the heat into fresh biomass. Similar results were reported by Mutkule *et al*., (2012) in sweet sorghum. Harvest index (HI) reflects the physiological capacity of crop varieties to mobilize or translocate photosynthates to plant part having economic value. Differences among the sweet sorghum genotype were significant. The high yielding biomass ability in RSSV 313 (67.6 t/ha) was mainly attributed to poor translocation (16.3 % HI) of assimilates from stem (source) to sink (grain). The result was similar line of report of Mutkule (2010).

Table.1 Mean pooled biomass at physiological maturity and grain yield of donor RSSV 313 in station trial 2013-14 to 2015-16: (Mean of three years)

Sr. No.	Genotype	Total fresh biomass (ton/ha)	Grain yield kg/ha.
1	RSSV 313	67.6	1197
2	RSSV 325	54.1	1564
3	RSSV 333	56.7	1378
4	RSSV 350	60.7	1154
5	RSSV 351	56.7	1459
6	RSSV 369	58.9	1026
7	RSSV 381	47.9	1114
8	RSSV 387	49.3	977
9	RSSV 409	44.0	1193
10	RSSV 432	45.3	1016
11	CSV 19SS ©	58.2	1032
	G. Mean ±	59.5	1275
	SE ±	1.35	166
	CD at 5 %	3.94	484

Table.2 Phenological and ancillary data of donor RSSV 313 in station trial 2013-14 to 2015-16: (Mean of three years)

Sr. No.	Genotype	50 % flowering	Phy. maturity	Plant height (cm)
1	RSSV 313	79	121	368
2	RSSV 325	73	114	353
3	RSSV 333	72	112	346
4	RSSV 350	78	118	367
5	RSSV 351	75	115	360
6	RSSV 369	78	118	358
7	RSSV 381	66	106	331
8	RSSV 387	70	110	363
9	RSSV 409	70	110	329
10	RSSV 432	70	110	362
11	CSV 19SS ©	75	114	357
	G. Mean ±	75	116	356
	SE ±	2.09	2.24	9.90
	CD at 5 %	6.09	6.52	28.78

Table.3 Physiological traits associated with biomass at 50% flowering in RSSV 313 in station trial 2013-14 to 2015-16: (Mean of three years)

Sr. No.	Genotype	SPAD value	Leaf Area (dm^2)	Leaf Area Index
1	RSSV 313	56.0	75.9	6.37
2	RSSV 325	53.1	49.4	4.12
3	RSSV 333	54.4	49.7	4.14
4	RSSV 350	51.1	61.2	5.08
5	RSSV 351	50.2	57.3	4.77
6	RSSV 369	53.4	62.9	5.21
7	RSSV 381	54.0	54.0	4.57
8	RSSV 387	53.1	52.8	4.37
9	RSSV 409	59.1	51.9	4.30
10	RSSV 432	51.7	53.1	4.42
11	CSV 19SS ©	51.5	55.4	4.58
	G. Mean ±	53.4	59.3	4.96
	SE ±	2.62	4.42	0.38
	CD at 5 %	7.60	12.85	1.11

Table.4 Physiological traits associated with biomass at physiological maturity in RSSV 313 in station trial 2013-14 to 2015-16 (Mean of three years)

Sr. No.	Genotype	Total Heat Unit	Heat unit efficiency	Stay Green (1-9)	HI (%)	$Brix^0$ (%)
1	RSSV 313	**2344**	**0.028**	**3-4**	**16.3**	**18.7**
2	RSSV 325	2241	0.022	5-6	21.8	17.0
3	RSSV 333	2193	0.024	5-6	23.9	19.3
4	RSSV 350	2288	0.026	5-6	16.8	19.0
5	RSSV 351	2250	0.023	5-6	23.8	16.3
6	RSSV 369	2313	0.026	3-4	16.4	18.3
7	RSSV 381	2106	0.020	3-4	23.5	19.0
8	RSSV 387	2170	0.020	3-4	21.2	19.0
9	RSSV 409	2175	0.018	5-6	26.5	18.0
10	RSSV 432	2171	0.018	5-6	21.0	18.3
11	CSV 19SS	**2239**	**0.025**	**5-6**	**15.8**	**19.7**
	G. Mean ±	2253	0.024	-	19.52	19
	SE ±	36.8	0.0016	--	2.31	0.71
	CD at 5 %	106.9	0.0047	--	6.71	2.07

The poor translocation of assimilates from source (stalk) to sink (grain) as evidence from lower harvest index in the RSSV 313 (16.3%) which has been reflected in poor grain yield (1197kg/ha). These results are similar line reported as Patil *et al*., (2005).

The genotype RSSV 313 recorded significantly higher fresh biomass (67.6 ton/ha), the higher potentiality of these genotype was mainly due to better physiological traits *viz*. SPAD value (56.0), leaf area (75.9 dm2), LAI (6.37), plant height (368 cm), Heat Unit Efficiency (0.028) and low harvest index (16.3).

Therefore based on physiological traits, the sweet sorghum donor RSSV 313 is recommended as donor in sweet sorghum crop improvement programme by the Joint Agresco 2016 held at Dr. PDKV, Akola (MS) (Anonymous, 2016).

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