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BREEDING OF THE FIRST BULGARIAN VARIETY OF SWEET SORGHUM `SHUMEN SWEET`

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Abstract

On the background of the increased interest in the organic plant production in in the Agricultural Institute - Shumen was created the first for the last 50 years Bulgarian variety of sweet sorghum. Shume Sweet is developped after many years studies of local populations from the North-Eastern region of Bulgaria. Assessment and selection of perspective progenies were carried out for consolidation of stabilized population with high productivity of stem mass in technical maturity as a row material for extraction of juice with 11-15% of sugars - sucrose, fructose and glucose. The preliminary tests in comparative variety trials confirm the high and stable productive potential for extraction of juice with optimal qualities for production of concentrated sweet syrops. After tests in the system of IASAS the Shoumen Sweet variety has been certified by the agency in 2020.

Key words*: sweet sorghum, variety, breeding, selection.*

INTRODUCTION

The production potential of sweet sorghum have been discussed by many scientists (Houze 1995; Mukabane et al., 2014). The crop offers great potential for multi-purpose uses, mainly for syrop, forage and ethanol production. Plant breeders in the United States, India and China have developed high - brix cultivars to increase the potential of this crop for syrup production (Abdalbagi and Mohammed, 2020). Sweet sorghum is known to be one of the most efficient temperate crops for biomass accumulation under conditions of extreme drought and global warming (Rooney, 2000).
The sweet sorghum, also known in Bulgaria as sugar broom and reed, has been used here for more than a century to extract sweet syrups by pressing (Iliev 1921; Pavlov, 1938).
Despite its displacement by crystal sugar, it continues to be grown on small areas for own use (Kostov et al., 1950; Stefanov, 1991). Due to the favorable ratio of sucrose and monosaccharides such as fructose and glucose, its increased demand as a healthy food and for feeding bees (Varbanov and Hristova, 1996) is noted.
All cultivated forms of sweet sorghum are subspecies of sorghum bicolor. To this day, many of the varieties are local populations obtained as a result of the natural and artificial selection (Bantalian et al., 2004). Modern forms of sweet sorghum include various hybrids with Sudan grass, technical and grain forms of sorghum. They have a highly pronounced heterosis effect and an optimal combination of high productivity, multiple undergrowth, carbohydrate, protein and cellulose content and are used for fodder production (Smith and Frederiksen, 2000). The selection with the classical methods of hybridization and selection for height, duration of vegetation, qualities of the raw material, is combined with heterosis and use of cytoplasmic male sterility (Stack and Pedersen, 2003).
The publication demonstrates the results of the selection and productivity testing of sugar sorghum populations from the Breeding Program of Agricultural Institute-Shumen. After selection of a stabilized population and testing, the Shumensko Sladko variety was recognized by the State Variety Trials Commission in 2020, and in 2021 a certificate was issued by the Bulgarian Patent Bureau.

MATERIALS AND METHODS

The study was conducted in Experimental fields of Agriculture Institute - Shumen,

Bulgaria in the period 2010-2020. The soil is carbonate chernozem, on a flat terrain. The period is characterized by frequent deviations from the agro-climatic norms for north-eastern Bulgaria. The sowing was carried out at a soil temperature of 10-12°C, which is usual for the area after 20-th of April. Test trials were made by the long plot method, with 3 replicates. The experimental plot of 12.6 sq m is three-row with 0.7 m inter-row spacing and a seeding density of 20 plants per sq m. Sowing material was not treated with pesticides and fertilizing.

The individual progenies tested were selected after evaluation from local populations. As a result of recurrent selection, 5 prospective stabilized populations were consolidated - SZT, SZW, SZM, SZA, SZC. The sweet sorghum varieties Yantar, Stavropolskaya, Galia, Endje and Super Sweet, which are hybrids of sweet sorghum and Sudan grass, were used in the comparative trials.

The plants of plots were cut and counted, the panicles and leaves were removed and the cane was recorded and then passed through hand driven two-roller mill. The juice quantity was recorded and kept in closed plastic bottles for analysis.

The following juice quality traits were made:

Brix (%) - total soluble solids were recorded using refractometer.

Pol (%) - sucrose percentage of the juice was estimated following dry lead acetate clarification method using polarimeter.

Redusing sugar (%) - invert sugars were estimated using dinitro-salicid acid method.

Acids, Vitamin C and Poliphenols were estimated in standard analysis method using spectroscopy analysis with the use of limon, follic and gallic acids standard.

The data collected were subjected to analysis of variance ANOVA following the standard procedure of analyzing GD design for productivity and least significant differences LSD procedure for juice quality analysis using GenStat statistical package (2009).

RESULTS AND DISCUSSIONS

In the period 2011-2015, a selection of elite plants was conducted in local populations with testing of their offspring for productivity at technical maturity stage of the seeds (Table 1).

Table 1. Shows the results of the distribution of the tested offspring in terms of productivity to a group standard - an average of three standard varieties - Endje, Super sweet and Yantar

Variants	Endje, t/ha	Yantar, t/ha	Super Sweet, t/ha	Distribution of individual progenies towards the group Standard		
				< 90 %	90-110%	110% <
2011	40.69	47.14	43.57	29	64	7
2012	53.04	55.18	55.89	21	56	12
2013	55.36	73.23	56.44	20	69	11
2014	56.90	56.62	55.17	36	56	8
2015	52.00	68.28	64.15	9	48	5

For each selection cycle, plants are selected from the progenies with values above 110% of the standard.

In 2015, the seeds from the five offspring with over 110% of the standard were harvested to form 5 populations - SZT, SZW, SZM, SZA, SZC. They were tested in 2016 and 2017 in comparative trials together with the standard varieties Yantar, Stavropolskaya, Galia, Enje and Super Sweet.

In the phase of technical maturity of the grain, the weight and dry content of the plants and the proportion of stems were measured. The results are shown in Table 2.

Table 2. Results for productivity dry matter content and part of stems of varieties and elite populations of sweet sorghum for 2016-2017

Variants	2016			2017		
	Yield, t/ha	Dry matter, %	Stems part, %	Yield, t/ha	Dry matter, %	Part of the stems, %
Endje	63.7	60.3	74.9	72.4	57.0	87.4
Super Sweet	57.1	59.0	79.6	63.6	53.8	75.4
Yantar	53.6	66.3	78.1	73.8	52.1	84.5
Stavropolska	55.9	65.5	84.5	70.0	52.9	85.8
Galiya	55,2	65,5	84,5	59,3	56,5	89,9
SZT	64.0	62.1	87.3	74.9	55.1	87.4
SZM	55.2	61.8	88.4	67.1	51.7	78.8
SZW	58.6	63.3	85.7	70.5	49.4	73.8
SZA	61.0	64.1	89.5	72.9	58.7	78.5
SZC	51.1	63.2	86.1	68.6	58.8	86.0
Mean	57.3	63.4	81.6	70.5	53.7	82.2
GD 1%	8.72			11.2		
P %	3.16			3.62		

The productivity in 2016 varied from 51.1 to 64 tons per hectare with an average of 57.3 t/ha. For 2017, as a result of the greater ammount of precipitation, the productivity is higher - varying from 63.6 to 74.9 t/ha with an average of 70.5 t/ha. In both years, the SZT population had the highest yield. The dry matter content of the tested variants varied little between years, with the two year averages

differing by almost 10% depending on the wetter meteorological conditions in 2017.
The average values for the share of the stems in the total productivity in both years are practically equal, and the values of the tested variants vary slightly from 73.5-89%.
As a result of the preliminary tests, the SZT population was selected as promising for inclusion as a candidate for a new variety. The average results of a three-year competition test for productivity and qualities of the raw material are indicated in Table 3.
The values for the total productivity and that of the stems correspond to the preliminary tests. The Shumensko Sladko variety exceeds Endje and Super Sweet in terms of productivity and is equal to Yantar, Stavropolska and Galia. The share of stems determining the yield of juice for the new variety has been stable over the years of testing and with 52.9 t/ha is falling back only to Stavropolska.
The most important economic parameter for sweet sorghum is the yield of juice pressed from the stems. It strongly depends on the harvesting period and the genotype of the variety. As seed ripening progresses, the dry content of the vegetative mass increases and the amount of sap in the stems decreases. But the later pressed juice has a higher sugar content, which makes it necessary to calculate the most suitable period of mowing. The average results for the yield of pressed juice and the content of soluble substances, determined refractometrically, demonstrate the high qualities of the new variety when compared to the varieties used in Bulgaria.

Table 3. Average results for productivity and raw material qualities of sweet sorghum varieties, mean of 2018-2020

Variant	Parameters			
	Total yield t/ha	Stems yield, t/ha	Pressed juice, l/ha	Dry matter of juice, %
1. Shumensko Sladko - SZT	67.8	52.9	10600	17.2
2. Yantar	66.2	51.2	10200	16.5
3. Endje	60.0	48.5	9570	14.6
4. Super Sweet	52.5	45.6	9200	15.6
5. Stavropolska	75.5	53.6	10800	17.2
6. Galia	67.5	45.5	9200	15.8
GD 1%	6.88	3.67	736	
P %	4.21	3.48	4.18	

In 2021, samples of pressed juice of 6 varieties were analyzed for qualities such as soluble substances, reducing sugars, sucrose, acids, vitamin C and polyphenoles (Table 4). The ratio and balance between them determine the calloric and taste qualities of the juice to obtain sweet syrups or for alcohol fermentation. The ratio and balance between them determine the caloric and taste qualities of the juice for obtaining sweet syrups or for alcohol fermentation.
The higher content of invert sugar or glucose and fructose in Super sweet, Galia and Stavropolskaya makes an impression. For Shumensko Sladko at a high level of total sugars, the ratio of reduced sugars and disaccharide sucrose is at an average level for the varieties tested.
The ratio of sugars and acids determines the taste of the juice and for the new variety the acidity index is balanced. The content of vitamin C and polyphenols enhance the beneficial properties of the pressed juice.
Table 4 also shows the qualities of syrup thickened up to a quarter by evaporation from the initial volume of juice from Shumensko Sladko. The content of polyphenoles increases the most, sucrose three times, vitamin C twice and invert sugar and acids by 50% each.

Table 4. Qualities of pressed juice from the stems of sugar sorghum varieties, 2021

Variety	Dry matter, (Re) %	Inverted sugar, (%)	Sugar, (%)	Acids, (%)	Vit. C, (mg %)	Total Poliphenols, (mg %)
Endje	14.6	11.4	17.58	0.68	12.32	74.39
Yantar	16.5	15.4	11.97	0.80	12.32	57.50
Super sweet	15.0	25.6	5,13	0.68	12.32	78.19
Galia	16.5	27.3	7.13	0.68	14.08	42.54
Stavropolska	17.2	35.8	2.00	0.54	10.56	68.61
Shumensko Sladko-	17.2	22.2	10.64	0.68	12.32	51.49
Syrup	61.2	34.8	35.82	0.94	24.64	431.9
LSD (0.05)	2.71	1.42	3.481	0.084	3.688	34.89

The presented results for the productivity and qualities of the raw material from sweet sorghum are comparable with the data from older studies (Stefanov, 1991; Varbanov, Hristova, 1996). and more recent publications from Africa and Asia (Abdalbagi and Mohammed, 2020). Rajvannshi et al. (2006) note that excellent syrup can be made from sweet sorghum when brix of raw juice is greater than 15%. Syrup yelding ranging 800-1900 l/ha have been reported from Mukabane et al (2014). The negative correlation of the

yield and the concentration of the pressed juice with the ripening of the seeds raises the question of the time of harvesting the stems. The simultaneous use of the vegetative mass and the seeds after enzymatic hydrolysis would make the use of the new Shumensko Sladko variety highly efficient for the production of raw material for spirit distillation.

CONCLUSIONS

The new Bulgarian sweet sorghum variety Shumensko Sladko does not fall back the varieties used in practice in terms of productivity and qualities of the pressed juice from the stems. With a yield of 50-55 t/ha of stems in the stage of technical maturity of the seeds, 10,000-12,000 liters of pressed juice are obtained per hectare.

With over 17% soluble substances of the juice and with thickening up to a quarter of the initial volume, up to 2500-3000 l/ha of sweet syrup is obtained, which has a balanced content of reduced sugars and sucrose, acids, vitamin C and polyphenols.

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