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COMPREHENSIVE ASSESSMENT OF NEW VARIETIES AND HYBRIDS SUGAR SORGHUM IN THE CONDITIONS OF SOUTH RUSSIA

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Abstract:

The duration of the sprouting-sprouting period for mid-early varieties (Knyazhna and A-3615 lines) was 62-64 days, for medium-ripening (Zersta 38A, Korichnevozernoye 11S, Viktoriya and No. 7812) - 66-68 days. In the late-ripe hybrid Yarik, it lasted 98 days. The most significant initial plant growth rates were found in the Yarik hybrid and its paternal form, variety Galiya (43 cm). The maximum height of plants had hybrids Yarik (306 cm), Alga (269 cm) and the new variety Guzel (272 cm). The heterosis of plant height at seed ripening at Yarik was 42.8%. According to the combination of the length of the panicle (20.5-30.0 cm) and its protrusion from the bell of the upper sheet (12.0-22.0 cm), the best indicators were found in Yarik, Alga, Knyazhna, Guzel and Galiya. On average for 2016-2018 the maximum yield of green and dry mass was obtained from the Yarik hybrid - 103.3 t ha^{-1} and 27.9 t ha^{-1}. For other options, it was 69.7 and 19.7 t ha^{-1}, respectively, for Alga, 70.6 and 19.1 t ha^{-1} for Guzel and for the Galiya standard 49.9 and 14.2 t ha^{-1}. The true heterosis of green mass yield in the Yarik hybrid had values of 71.4 t ha^{-1} (69.1%). The highest sugar content in the juice of the stems was recorded for variants No. 7812 (18.4%), No. 8611 (18.3%). Higher than the standard Galiya (14.2%) sugar content was also obtained from the Larets line (15.2%), varieties Victoria (16.6%) and Guzel (16.8%). In the Alga and Yarik hybrids, this trait had values of 13.7% and 13.8%.

Keywords: *line, variety, hybrid, heterosis, sugar sorghum, yield, plant height, sugar content*

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1. INTRODUCTION:

Sugargrass [Sorghum bicolor] is used for green fodder, hay, grazing, silage, haylage, briquettes, grass meal (Kapustin et al 2012a; Kapustin et al 2012b; Kapustin et al 2017b; Volodin et al 2017a). Plant stems contain 14–18% or more sugar (Kapustin et al 2017a; Volodin et al 2015; Volodin et al 2017b). The juice of this culture contains sucrose, glucose, fructose, amino acids, vitamins and trace elements. (Kapustin et al 2018c; Kapustin et al 2018d). It is suitable for the production of syrup for food purposes, as well as it is processed to produce ethanol, bioplastics, chemicals, etc. (Eggleston & Lima 2015; Lyumugabe et al 2015). Sugar accumulation begins in the flowering phase, but harvesting is optimal when the grain reaches its physiological maturity at the stage of solid dough. (Ratnavathi et al 2016; Zegada-Lizarazu & Monti 2015).

Some authors believe that the quantity and quality of sugar in the juice largely determine the time of sowing, climatic conditions and genetic characteristics of varieties and hybrids (Arora et al 2017; Reddy et al 2014). Tang et al (2015) found that the amount of juice, soil composition has a greater impact than the amount of precipitation. It is indicated that this feature is highly dependent on plant density and the amount of nitrogen fertilizers used in the cultivation of sorghum. (Prajapati et al 2016; Sanjana Reddy et al 2011).

Increased sugar content occurs during plant heterosis (Tariq et al 2014). The magnitude of this feature is greater in parental forms with distant genetic differences (Kapustin et al 2018a; Mindaye et al 2016; Wang et al 2013). Values of true heterosis are determined by the average or best indicator of parental forms (Pal et al 2017). In plants of sugar sorghum increases the height, diameter of the stem (Pfeiffer et al 2010; Ringo et al 2015), panicle size, mass of 1000 grains (Kibalnik 2017), chlorophyll content (More et al 2016). Pfeiffer et al (2010) believe that male sterility can affect the distribution of photosynthesis between parts of plants, creating the potential to increase the sugar content in the stems, by eliminating seeds as a consumer of light and nutrients. Pneumatic removal of leaves and panicles with a rotating disc separator allows you to extract 97.3-99.7% of soluble solids. (Tobias et al 2018). At the same time it is necessary to 19.1% less raw materials. Removal of panicles after flowering reduces starch and phenolic compounds in juice (Silva et al 2016). Studies conducted in the United States (Chen et al 2015) indicate that the glucose content in sorghum stems was from 0.6 to 12%, and from 0.3 to 1.7% in leaves. The levels of sucrose in the stems and leaves had values respectively from 0.3 to 17% and from 0 to 3.1%.

The purpose of the research is to study in competitive variety testing of yield indicators of sterile lines, new varieties and hybrids, their correlation with the content of sugars in the juice of the stems.

2.MATERIALS AND METHODS:

In 2016-2018 on the experimental field of the Federal State Budgetary Scientific Institution "North-Caucasian Federal Scientific Agrarian Center" (Mikhailovsk, Stavropol Territory). Investigated 4 sterile lines (Knyazhna, Zersta 38A, Korichnevozernoye 11S, A-3615), the fertile line Larets, new varieties Viktoriya, Guzel, No. 7812, No. 8611 (Kapustin et al 2018b). The standard in the experiment was a grade Galiya. The inheritance of economically valuable traits was studied in Yarik (Zersta 38A x Galiya) and Alga (Knyazhna x Galiya) new sorghum hybrids.

The soil cover of the experimental field is black soil with a humus layer depth of 120 cm. The average annual rainfall is 550 mm, including 329 mm for May-September. The average daily air temperature in May-September in 2016 was 19.5 °C, in 2017 - 20.1 °C, in 2018 - 21.0 °C at a rate of 18.4 °C. The amount of precipitation during this period was 385 mm, 305 mm and 131 mm, respectively.

The counts, observations and measurements were carried out in accordance with the method of state crop testing of crops (Fedin 1985). Mathematical processing of crop data of green mass and grain was carried out according to the method of B.A. Dospekhov (1985). Soil cultivation, planting care was carried out according to the “Cultivation of sorghum and annual forage crops for seeds” (Kulintsev et al 2019). Sowing was carried out in the first decade of May, repeated three times, the accounting area of the plots was 25 m^2, and the accommodation was reclosed. Yield green mass was calculated at 70% humidity. The sugar content in the stem juice was measured with a PAL-1 instrument.

3. RESULTS AND DISCUSSION:

According to the data of Table 1, on average for three years, the duration of the sprouting-sweeping period for medium-early varieties was 62-64 days (lines Knyazhna and A-3615, standard grade Galiya).

Table 1: The duration of the period of sprouting-sprouting, height of plants and their foliage (average for 2016-2018)

Line, variety, hybrid	*The period of the shoots-sweeping out, days*	*Plant height, cm*		*Leaf length, cm*	*Leaf content in green mass,%*
		on the 30th day of the growing season	*when seeds mature*		
Knyazhna	63	37	176	69	16.8
Zersta 38A	67	39	115	68	19.1
Korichnevozernoye 11S	68	36	130	66	18.6
A-3615	64	38	106	66	17.2
Larets	76	38	243	68	15.8
Galiya, St	62	43	235	65	15.5
Yarik	98	43	306	86	17.6
Alga	72	37	269	83	16.8
No. 7812	68	35	244	71	14.9
No. 8611	76	34	249	65	14.8
Viktoriya	66	33	232	63	17.9
Guzel	77	38	272	77	14.3

Mid-ripening (66-68 days) lines of Zersta 38A, Korichnevozernoye 11S, Viktoriya varieties and No. 7812 were established. Middle late varieties Guzel, No. 8611, Alga hybrid and fertile line reducing agent Larets had a duration of sprouting-sprouting period - 72-77 days. In the late-ripe hybrid Yarik, it lasted 98 days. Similar laws were established in determining the duration of the period of seedlings-ripening seeds. It was minimal for Galiya, Knyazhna and A-3615 (92-98 days), maximum for Yarik (130 days). In general, the period of seedling emergence-ripening in 2017 and 2018 was 12-16 days less than in the more humid 2016. Sorghum seeds of all varieties of experience reached the phase of full ripeness of the grain. The heterosis of the decrease in the period of sprouting-emergence in Alga and Yarik hybrids has not been established.

The most significant initial plant growth rates (their height on the 30th day of the growing season) were in the Yarik hybrid (43 cm) and its paternal form, Galiya (43 cm). High initial growth rates (38–39 cm) were obtained from Zersta 38A, A-3615 Larets, Guzel. In Alga and Knyazhna, they were 37 cm. The remaining variants had lower plant growth rates on the 30th day of the growing season (33-36 cm). From the tillering stage, the growth of plants of sugar sorghum increased and, depending on the varietal characteristics during the period of seed ripening, the height of the stalk stand varied from 115 cm to 306 cm. The later ripening hybrids Yarik (306 cm), Alga (269 cm) and the new variety Guzel had the greatest height. (272 cm). Paternal forms Galiya and Larets reached values of 243 and 235 cm. The sterile line Zersta 38A has a small plant height (115 cm), but together with Galiya it provides heterosis of height in the Yarik hybrid at 4.7% on the 30th day of vegetation and 42.8% at maturation seeds. In Alga, during this period he was 23.6% (Table 2). In the arid-dry 2018, the height of the plants of the sorghum was 10–16 cm lower than in 2017 and 22–31 cm than in the wet year 2016.

Table 2: The manifestation of the heterosis effect of the main economically valuable traits of the hybrids Alga and Yarik (average for 2016-2018)

Signs	*Alga*			*Yarik*		
	indicators, cm,%, t ha^{-1}	*true heterosis*		*indicators, cm, %, t ha^{-1}*	*true heterosis*	
		cm, %, t ha^{-1}	*%*		*cm, %, t ha^{-1}*	*%*
Period shoots-sweeping out, day	72	+9.5	+13.2	98	+33.5	+34.2
Plant height on the 30th day of vegetation, cm	37	-3	-8,1	43	+2	+4,7
Plant height at seed ripening, cm	269	+63.5	+23.6	306	+131	+42.8
Stem thickness, cm	1.97	+0.6	+30.5	1.98	+0.56	+28.3
Leaf length, cm	83	+16	+19.3	86	+19.5	+22.7
The leaf content of plants, %	16.8	+0.5	+2.9	17.6	+0.4	+2.3
Sugar content,%	13.7	+3.5	+25.5	13.8	+3.4	+24.6
Yield of green mass, t ha^{-1}	69.7	+34.5	+49.5	103.3	+71.4	+69.1
Dry mass yield, t ha^{-1}	19.7	+9.7	+49.3	27.9	+18.7	+67.0
Grain yield, t ha^{-1}	4.11	+1.01	+24.6	2.45	-0.39	-15.9

The stalk thickness was the highest among the tallest combinations Yarik (1.98 cm) and Alga (1.97 cm). The length of the leaf in the Galiya standard was 65 cm. In the Alga and Yarik hybrids, this figure was 83 and 86 cm. At the same time, the true heterosis of increasing the leaf length in the studied hybrids compared to the average leaf length in the parental forms was 16 cm in Alga (19.3%), in Yarik 19.5 cm (22.7%). On average, over three years, the highest leaf content in green mass was obtained from Zersta 38A (19,!%), Korichnevozernoye 11S (18.6%), A-3615 (17.2%), Yarik (17.6%), Alga (16.8%) and Viktoriya (17.9%). The standard Galiya this sign was 15.5%. In the resulting hybrids, the heterosis of the studied indicator was insignificant and ranged from 2.3 to 2.9%.

For an average of 3 years (Table 3), the maximum sugar content in the juice of the stems was found in the new numbers 7812 (18.4%) and 8611 (18.3%). Higher than that of the standard Galiya (14.2%), the sugar content was also obtained from the Larets line (15.2%) and the varieties Viktoriya (16.6%) and Guzel (16.8%).

Table 3: Sugar content and yield of green, dry mass, ripe grain lines, varieties and hybrids of sorghum

Line, variety, hybrid	*Sugar content,%*				*Yield, t ha^{-1}(average for 2016-2018)*		
	2016 year	*2017 year*	*2018 year*	*average*	*green mass*	*dry weight*	*corn*
Knyazhna	5.9	5.9	6.9	6.2	20.4	5.8	3.31
Zersta 38A	6.2	6.1	7.5	6.6	13.9	4.2	2.78
Korichnevozernoye 11S	4.7	4.7	5.1	4.8	15.3	4.4	2.48
A-3615	5.1	5.4	6.8	5.8	12.9	4.1	2.79
Larets	14.2	17.1	14.4	15.2	57.2	15.2	3.02
Galiya – St	12.4	14.0	16.2	14.2	49.9	14.2	2.90
Yarik	12.2	13.5	15.8	13.8	103.3	27.9	2.45
Alga	11.7	14.4	15.1	13.7	69.7	19.7	4.11
№ 7812	16.2	21.6	17.4	18.4	62.9	17.4	3.42
№ 8611	16.6	21.0	17.3	18.3	62.5	16.7	3.15
Viktoriya	15.7	18.0	16.0	16.6	49.9	13.9	2.86
Guzel	14.1	19.1	17.1	16.8	70.6	19.1	3.13
NDS 0.05 t ha^{-1}					**2.7**	**0.8**	**0.17**

In the sterile lines that have a half-stem, the sugar content was insignificant - 4.8-6.6%. The heterosis level of sugar content in terms of the average number of parent forms in the Alga hybrid was 3.5% (25.5%), in Yarik - 3.4% (24.6%). Depending on the amount of precipitation and air temperature, the presence of sugar in the juice of the stalks fluctuated over the years and higher was established in arid 2017 and 2018. In the moderately humid and cool 2016, it decreased by 1.1-3.2%.

The main indicator of economically valuable signs of sugar sorghum is the yield of green mass. Among the studied samples, on average for three years the highest yield of green mass (103.3 t ha^{-1}) was obtained from the Yarik hybrid. For other combinations, this indicator was respectively 69.7 t ha^{-1} for Alga, 70.6 t ha^{-1} for Guzel, 62.9 t ha^{-1} for No. 7812, 62.5 t ha^{-1} for No. 8611, 57.2 t ha^{-1} in the line Larets. The productivity of the standard Galiya mattered 49.9 t ha^{-1}. The level of true heterosis of green mass was significant and amounted to Alga 34.5 t ha^{-1} (49.5%). The sterile line Zersta 38A and the variety Galiya fertility restorer are characterized by a high combinational capacity of the green mass yield. Therefore, the heterosis indicators of this trait in the Yarik hybrid reached 71.4 t ha^{-1} (69.1%). The yield of green mass correlated with precipitation and air temperature during the growing season. The averaged data of this trait by experience in 2016 amounted to 54.1 t ha^{-1}, in 2017 - 48.9 t ha^{-1}, in 2018 - 44.1 t ha^{-1}. Similar patterns were obtained for dry matter yield. It is set at its maximum at the Yarik late-ripening hybrid (27.9 t ha^{-1}). For other options, this indicator was lower and amounted to 19.7 t ha^{-1} for Alga; Guzel - 19.1 t ha^{-1}; No. 7812 - 17.4 t ha^{-1}; No. 8611 - 16.7 t ha^{-1}, with the yield of standard Galiya 14.2 t ha^{-1}. The high seed productivity of the sterile Knyazhna line (3.31 t ha^{-1}) and the variety Galiya (2.90 t ha^{-1}) ensured a grain yield at the Alga hybrid of 4.11 t ha^{-1}. The true heterosis of this trait in the hybrid was 1.0 t ha^{-1} (24.6%). According to the analysis of other options, it follows that more than 3.0 t ha^{-1} of grain was obtained from No. 7812 (3.42 t ha^{-1}), No. 8611 (3.15 t ha^{-1}), Guzel (3.13 t ha^{-1}), Larets (3.02 t ha^{-1}). The late-ripening hybrid Yarik had a weak yield of ripe grain - 2.45 t ha^{-1}. Compared to 2016, in arid conditions of 2017, grain yield decreased by 0.26 t ha^{-1}, and in 2018 by 0.68 t ha^{-1}.

4. CONCLUSIONS:

On average for 2016-2018 The maximum yield of green mass was obtained from the Yarik hybrid - 103.3 t ha^{-1}. In other variants, it was 69.7 t ha^{-1} in Alga, 70.6 t ha^{-1} in Guzel, and in the Galiya standard it was 49.9 t ha^{-1}. The true heterosis of green mass yield in the Yarik hybrid is 71.4 t ha^{-1} (69.1%).

The highest sugar content in the juice of the stems was found in options No. 7812 (18.4%), No. 8611 (18.3%). Higher than the standard Galiya (14.2%) sugar content was also obtained from the Larets line (15.2%), Viktoriya varieties (16.6%) and Guzel (16.8%).

The most significant height was observed in Yarik (306 cm), Alga (269 cm) and the new variety Guzel (272 cm) hybrids. The length of the leaf (83-86 cm) was most significant in hybrids Yarik and Alga.

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