Bulgarian Journal of Agricultural Science, 24 (Suppl. 2) 2018,
Agricultural Academy

EFFECT OF THE HYBRIDIZATION ON THE GREEN MASS PRODUCTIVITY IN MILKY-WAX STAGE OF SORGHUM x SUDANGRASS HYBRIDS++

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Abstract

Enchev S., K. Slanev, G. Kikindonov and Tz. Kikindonov, 2018. Effect of the hybridization on the green mass productivity in milky-wax stage of sorghum x sudangrass hybrids++. *Bulg. J. Agric. Sci.*, 24 (Suppl. 2):68-72

In recent years Sorghum x Sudangrass hybrids are becoming a promising forage crop for production of green mass especially in conditions of extreme drought during vegetation. The results from tests for productivity heterosis in Sorghum x Sudangrass hybrids in the period 2015-2016 are presented. The registered heterosis effects towards pollinators and the standard varieties enables the selection of hybrids with high green mass yield potential. Perspective hybrids have been selected with proven higher green and dry mass productivity than the standard commercial varieties.

Key words: Sorghum, Sudangrass, hybrids, heterosis effect

Introduction

The implementation of Sorghum and Sudangrass in practice widens the possibilities for the design of schemes for sustainable agriculture. These crops are popular with their resistance to droughts, especially for regions with high summer temperatures and lower and unevenly distributed rainfalls during the vegetation (Fribourg et al., 1995; Moyer et al., 2004; Kertikov, 2007; Marinov-Serafimov and Golubinova, 2015). The CMS application in Sorghum has given the possibility for use of sterile lines as maternal components (House, 1995) and lines and varieties of Sudangrass as pollinators for the receipt of F1 hybrids. Thus the breeding potential of the hybrids is seriously increased. The hybrids between Sorghum (Sorghum bicolor (L) Moench) and Sudangrass (Sorghum sudanense (Piper) Stapf) distinguish themselves with high green mass yield for the production of high quality silages. The productivity of these hybrids is affected by the agro-climatic factors and the conditions of growth, but they are extremely plastic, adaptive, and manifest their high productive potential even in the warmest and dry summer months (Uzun et al., 2009; Golubinova et al., 2016; Golubinova and Marinov-Serafimov, 2016). They differ with big stems and leaves and satisfactory yield of forage with twofold or multifold cutting in flowering stage, but are most useful with a single cutting in late milky-wax maturity phase for silage production (Snyman and Youbert, 1996). The breeding of new hybrid varieties is focused on productivity, dry matter content, crude protein, fibers, low content of durine, resistance to falling down and foliar diseases (Kalton, 1988).

The aim of the present study is, on the basis of two-year test results, to analyze the heterosis performances of Sorghum x Sudangrass hybrids of our breeding program regarding their green mass productivity in milky-wax stage.

Material and Methods

The study is carried out in the experimental fields of the Agricultural Institute – Shumen during 2015-2016. The soil type of the region is a carbonate black-earth with a good mechanical structure and weakly alkaline reaction of the soil solution. The forerunner crop is beet. The mechanized sowing is made on 25-30th of April, at 45 cm space between the rows, with a high sowing rate – 300000 seeds per ha. The long parcels method has been used for randomization of the

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field tests, with 4 repetitions for each variant, the area of the experimental plot is 10.8 m2, and of the harvest plot – 5.4 m^2. The Group Standard includes the used in practice Sudangrass varieties Vercor (France) and Yantar (a sweet form from Russia). F1 Sorghum x Sudangrass hybrids have been tested, of two selected Sudangrass pollinators with eight male sterile (MS) grain sorghum lines of the AI-Shumen breeding program. The pollinator SV is an elite typical Sudangrass origin, while the SZ pollinator is a stabilized population from the hybridization of Sudangrass with Sweet Sorghum.

The meteorological conditions (vegetation rainfalls, relative air humidity and daily temperatures) during the first year of the test are favorable for the plants' development, while 2016 could be characterized with a too lately coming spring and the insufficient quantities of the vegetation rainfalls. The cutting of the experimental plots is made when the plants have reached milky-wax stage – in 2015 – on 20-22nd of August, and at the end of the same month in 2016. The green mass yield for silage production has been registered. The effect of heterosis is calculated according Abramova (1985) – the real heterosis (HP) is the exceedance in the green mass yield of the hybrids towards the yield of the pollinators (the more productive parents), and the competitive heterosis is the exceedance of the green mass yield of the hybrids towards that of the Standard varieties. The dispersion analysis of the obtained results is according to Lidanski (1988).

Results and Discussion

In the years of tests the typical Sudangrass forms fall down the sweet forms of Sudangrass. The Sudangrass variety Verkor forms significantly lower green mass yield in milky-wax stage than the yield of the sweet form Yantar. The same is valid for the Sudangrass pollinators in the study. The Sudangrass population SV falls significantly down the stabilized population from the hybridization of Sudangrass with Sweet Sorghum SZ. In 2015 (Table 1) the average green mass yield of the tested hybrids of SV is 81.8 t/ha (144.2% of the Standard), and the yield of the SZ hybrids is 84.2 t/ha (148.5% of the Standard). The real heterosis of the SV hybrids is with significantly higher values than the hybridization effect of the SZ hybrids. The SV hybrids realize 143.4% of the pollinator's green mass yield, while the SZ hybrids' yield is on average of 103.3% of the SZ pollinator's yield. The majority of the SV hybrids exceed the green mass yield of the SV pollinator with proved differences. Only the hybrid combination S8 x SV has a negative value of HP, i.e. it forms a lower green mass yield than the yield of the relevant pollinator..At the same time the hybrid of the same MS line (S8) with the SZ pollinator in 2015 forms the highest green mass yield in milky-wax stage – 102.2 t/ha, and is the only one hybrid in the group of SZ hybrids with a proved real heterosis value. All the other tested hybrids of SZ don't show a proved real heterosis, either falling down, or exceeding insignificantly the green mass yield of the productive pollinator SZ. The heterosis effect towards the parents could not give an exact idea about the breeding value of the hybrids. The competitive heterosis (CHE) is the real measurement of the hybrid's value. And the 2015 test results show really high values of CHE for almost all of the Sorghum x Sudangrass hybrids. The exceptions are the hybrids S15 x SZ (with proved negative value of CHE) and the hybrid S8 x SV. By the way, both of these hybrids fall back the relevant pollinator in their green mass productivity. The highest CHE is calculated for the hybrid of the MS line S10 with the Sudangrass pollinator SV (with a green mass yield of 120 t/ha, which is more than double the Standard's yield). The majority of the hybrids with the pollinator SZ also have proved CHE. The results of the tests in 2015 show very good effect of the hybridization of Grain Sorghum lines with Sudangrass pollinators regarding the yield of green mass in milky-wax stage. We could outline the MS lines SC, SA, S9, S10, S13 and S14, which show a very good combining ability with both pollinator types.

The late spring in 2016 brought to low intensity of the initial growth of the plants in the experiment. This, together with the insufficient vegetation rainfalls in the same year were preconditions for the lower green mass productivity of the Sudangrass pollinators and their hybrids with Grain Sorghum MS lines. The presented results of the productivity test and the calculated effects of heterosis (Table 2) show that the yield of SV is 32.6 t/ha (24.4 t/ha lower than the yield of the same pollinator in 2015), and the yield of the SZ pollinator is 52.6 t/ha (28.9 t/ha lower than the yield it formed in 2015). Almost the same is the situation with the tested Sorghum x Sudangrass hybrids – the average yield of the SV hybrids is 61.9 t/ha, and of the SZ hybrids – 64.7 t/ha – significantly lower than the yields they formed in the previous year. But such unfavorable for the crops meteorological conditions are welcome for breeders, who could take the advantage to receive a better idea of the materials they test. In conditions of water deficiency the Sudangrass pollinator SZ again forms much higher yield of green mass than the typical sudangrass population SV. The highest green mass yield forms its hybrid with the SA male-sterile grain sorghum line. – 90.3 t/ha (153.3% of the Standard's yield). The hybrids S14 x SV, SA x SV and S13 x SZ also show very good green mass productivity. The results of the test confirm that higher HP values should be expected for the hybrids of pollinators with lower green

mass productivity. The positive effect of the hybridization is much better expressed for the hybrids of SV – all of them exceed the pollinator's yield with proved differences, i.e. the hybrids of SV have proved HP values. And this is normal if the average green mass yield of the SV hybrids is 189.9% of the pollinator SV's yield. Such a proved heterosis is shown by the hybrids of SZ with the MS lines SA and S13. The highest competitive heterosis effect is shown by the hybrid SA x SZ (+53.3 - proved positive CHE value) and S13 x SZ. The hybrids of the MS lines SA and S14 with the pollinator SV are also with high positive values of CHE.

The results of our two years tests confirm the green mass productivity potential of the Sorghum x Sudangrass hybrids, established in our previous studies. We could add also the yield components as a great advantage of the hybrids as a source for high quality silages.. The hybrids are with much higher part of the broom in the total green mass yield during the milky-wax stage, which is of great effect for the fermentation processes during the silage production.

Table 1. Heterosis effect in Sorghum x Sudangrass hybrids in milky-wax stage, 2015

Origin	t/ha	Отн.%	HP (F1 – P)	CHE (F1 – St)
Verkor	45.0	79.4		
Yantar	68.3	120.6		
Standard	56.7	100.0		
SV (P1)	57.0	100.5		
SA x SV	71.1	125.4	24.9	25.4
SC x SV	94.8	167.2	66.7	67.2
S8 x SV	48.1	84.8	- 15.7	- 15.2
S9 x SV	87.4	154.1	53.6	54.1
S10 x SV	120.0	211.6	111.1	111.6
S13 x SV	69.6	121.0	20.5	21.0
S14 x SV	83.7	147.6	47.1	47.6
S15 x SV	79.3	139.9	39.4	39.9
SZ(P2)	81.5	143.7		
SA x SZ	74.4	131.2	- 12.5	31.2
SC x SZ	85.9	151.5	7.8	51.5
S8 x SZ	102.2	180.2	36.5	80.2
S9 x SZ	85.9	151.5	7.8	51.5
S10 x SZ	69.6	122.8	- 20.9	22.8
S13 x SZ	91.1	160.7	17.0	60.7
S14 x SZ	88.9	156.8	13.1	56.8
S15 x SZ	75.6	133.3	- 10.4	-33.3
GD 1%	16.6	24.5		
P%	6.32			

Table 2. Heterosis effect in Sorghum x Sudangrass hybrids in milky-wax stage, 2016

Origin	t/ha	Отн.%	HP (F1 – P)	CHE (F1 – St)
Verkor	42.2	71.6		
Yantar	75.6	128.4		
Standard	58.9	100.0		
SV (P1)	32.6	55.3		
SA x SV	77.7	131.9	76.6	31.9
SC x SV	57.8	98.1	42.8	- 1.9
S8 x SV	59.3	100.7	45.4	0.7
S9 x SV	60.0	101.9	46.6	1.9
S10 x SV	58.5	99.3	44.0	- 0.7
S13 x SV	40.7	69.1	13.8	- 30.9
S14 x SV	77.8	132.1	76.8	32.1
S15 x SV	63.7	108.1	52.8	8.1
SZ(P2)	52.6	89.3		
SA x SZ	90.3	153.3	64.0	53.3
SC x SZ	64.4	109.3	20.0	9.3
S8 x SZ	46.7	79.3	- 10.0	- 20.7
S9 x SZ	54.1	91.9	2.6	- 8.1
S10 x SZ	66.7	113.2	23.9	13.2
S13 x SZ	74.8	127.0	37.7	27.0
S14 x SZ	66.7	113.2	23.9	13.2
S15 x SZ	54.1	91.9	2.6	- 8.1
GD 1%	19.7	33.4		
P%	6.27			

Conclusions

The differences of the characteristics of the pollinators used in hybridization and in the vegetation rainfalls quantities determine different manifestations of heterosis in the green mass productivity of Sorghum x Sudangrass hybrids. In conditions of normal vegetation rainfalls quantities significant part of the tested Sorghum x Sudangrass hybrids exceed the Standard Sudangrass varieties in their yield of green mass in milky-wax stage.

The hybrids SA x SV, S14 x SV, SA x SZ and S13 x SZ have the highest competitive heterosis values in the two years of tests. They could be suggested for testing in the system of State Variety Trials.

Aknowledgements

The publishing of the present scientific paper is co-financed by "Scientific Researches" Fund Contract №01/31 from 17.08.2017.

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