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Productivity of sweet sorghum in conditions of ecological production

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Abstract

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The research has been conducted during 2019-2020, on the experimental field of the AI-Shumen, with the Sweet sorghum variety Shumensko Sladko and Endje. The method of long plots was used, with 4 repetitions, 14 m^2 area of the experimental plot, with sowing rate of 25 plants per sq. meter and variants of organic fertilization with Free N 100, Raim Zolfo, Heliosulfure, as well as with the biodynamic preparations 500 and Fladen. The soil is carbonate chernozem, the crop rotation is wheat-beets-sorghum, without any application of pesticides and mineral fertilizers.

The results for the green mass productivity from two swaths in brooming stage, a swath in wax stage and the yield of juice from the stems, confirm the potential of the treatment with organic preparations to decrease the negative effect of the extreme deviations from the agro-climatic norms.

The use of sweet sorghum as a forage and as a raw material for production of sweet syrups is an alternative for the increase of the ecological production part.

Keywords: sweet sorghum; green mass; wax stage; syrup; organic; biodynamic

Introduction

Sustainable agriculture is an important priority in the policy for the development of agriculture in Bulgaria. Biological (organic) agriculture is emerging as a popular form in the world. A significant increase in organic production on world markets is noted (Bozhanska et al., 2017).

Integrated and judicious use of inorganic and organic sources of fertilizers is essential in modern crop production. Organic farming strengthens agro-ecosystems, preserves biodiversity, promotes healthy food production and creates more employment in rural areas. The production of food free from chemical contamination becomes fundamental for the health status of the population (Balezentiene & Sampietro, 2009). The regulation of life processes of crops, without the use of chemical preparations is the way to achieve this goal (Kerin & Berova, 2001). A number of companies appeared, offering various ecological fertilizers and bio-stimulants. The experimental study of the complex use of organic preparations provides valuable information to agricultural producers of organic products (Dochev et al., 2019).

Humus content is the main indicator of soil fertility. The excessive use of pesticides in Bulgaria dangerously deteriorates natural fertility, pollutes groundwater and the environment, increases acidification of usable areas (Yakimov, 2013). Biodynamic agriculture, as a form of organic farming, aims to revive soil fertility. Based on many years of experiments, the effect of biodynamic preparations on soil and plants is reported, stimulating the content of humus and biological activity (Shauman, 1987; Raupp, 2001).

The increased demand for organic products is reviving interest in sweet sorghum for the prduction of green mass for fodder, and as a raw material for obtaining sweet syrups by pressing the stems (Enchev & Kikindonov, 2015). Another advantage is its diverse use as feed and energy crop (Rooney, 2000). Sugar sorghum is known to be one of the crops in

the temperate zone with the highest biomass accumulation efficiency under conditions of extreme droughts and global warming.

For the last 30 years, at the Agricultural Institute – Shumen, local populations have been tested and maintained, hybrid forms have been selected for green mass as juicy feed and for silage production (Kikindonov & Slanev, 2006; Enchev, 2011).

The aim of the present research was to study the productive potential of sweet sorghum in the coditions of ecological production in the region of North-Eastern Bulgaria.

Materials and Methods

The experimental study was conducted in 2019-2020, at the Agricultural Institute – Shumen, North-Eastern Bulgaria. The experimental ecological field had a five-year period of no use of chemical pesticides and mineral fertilizers. The soil type is carbonate chernozem, with a wheat/sorghum-beet crop rotation scheme. The field experiment was based on the method of fractional plots with a four-fold repeatability of the variants, with an area of the harvest plot of 14 m^2. Sowing was done at the end of April, at 70 cm row spacing, and with a seeding density of 25 plants/m^2.

The options include the varieties Endje and Shumensko sladko from the selection of the Agricultural Institute, registered in the Varietal List of the Republic of Bulgaria, a control, without treatment, fertilization with biodynamic and biological preparations.

The biodynamic treatment was with the simultaneous use of preparations 500 and Fladen, applied in phase 5-6th leave with a 1.5% solution. As a biological complex treatment, Free N 100 and Reim Zolfo were imported. The first one, applied in a dose of 0.05 l/ha, enriched the soil and helped absorb atmospheric nitrogen; and the second preparation, in addition to being a fungicide, also acted as a plant growth stimulator, applied in a dose of 250 ml/in 100 l. water. Late in the spring, the biological fungicide Heliosulphur was applied at a dose of 500 ml/day.

During the browning phase, two swaths were carried out to obtain green mass and one mowing – in the waxy maturity phase of the grain, to obtain stalks for juice pressing. According to the green mass and stems yield indicator, the weight of each harvest plot of each variant was measured, the juice was obtained by pressing the stems on a roller press, the dry content of the stems was determined by weight, and the juice – refractometrically (method source). The results were processed statistically with the XLSTAT program for provenance and accuracy of the experiments.

Include table, describe bio preparations, application methods, concentrations, dosage.

Variety „Endje 1“, is a stabilized population from hybridization of Sudangrass with sweet sorghum. „Shumensko sladko“ is a new sweet sorghum cultivar.

Results and Discussion

Agrometeorological conditions in 2019 at the beginning of the vegetation season were characterized as favorable. A good moistering of the soil, combined with a sufficiently high temperature was noted, which contributed to the normal germination of the sweet sorghum and the formation of gar-

Table 1. Agrometeorological conditions for the vegetation period in 2019–2020

Year/Month	Rainfalls, mm					Temperature, °C Average for the month
	Decades			Sum	Norm	
	I	II	III			
2019, IV	7.7	45.9	–	53.6	41.0	10.1
V	24.8	16.0	8.4	49.2	64.0	16.7
VI	28.8	10.6	31.2	70.6	75.0	22.2
VII	8.0	24.5	9.1	41.6	60.0	21.9
VIII	22.1	3.7	1.6	27.4	42.0	22.9
IX	–	4.2	11.9	16.1	28.0	18.7
X	16.2	–	7.1	23.3	53.0	13.3
2020, IV	0.0	0.6	1.0	1.6	41.0	12.0
V	12.3	0.0	14.1	26.4	64.0	16.8
VI	4.9	71.1	2.4	78.4	75.0	21.4
VII	0.5	1.1	13.2	14.8	60.0	24.7
VIII	0.0	21.1	0.3	21.4	42.0	24.4
IX	21.7	0.0	9.4	31.1	28.0	21.1
X	17.7	18.9	11.3	47.9	53.0	15.6

Table 2. Effect of treatment with organic preparations on the green mass productivity from 2 swaths in brooming phase and 1 swath in waxy maturity phase of sweet sorghum varieties Endje and Shumensko Sladko, 2019–2020

Variants / Variety – fertilization	I swath in brooming phase		II swath in brooming phase		Swath in waxy maturity phase	
	t/ha	Rel. to control, %	t/ha	Rel. to control, %	t/ha	Rel. to control, %
2019						
Endje – control	27.9	100.0	18.1	100.0	42.9	100.0
Endje – biodynamical fertilization	28.8	103.2	18.6	102.8	50.0	117.9
Endje – biological fertilization	31.0	111.1	20.7	114.4	51.5	120.0
Shumensko Sladko – control	28.9	100.0	13.8	100.0	47.9	100.0
Shumensko Sladko – biodynamical fertilization	30.5	105.5	14.3	103.6	57.5	120.0
Shumensko Sladko – biological fertilization	34.5	119.4	16.0	115.9	59.5	124.2
2020						
Endje – control	26.2	100.0	11.8	100.0	30.5	100.0
Endje – biodynamical fertilization	29.5	112.6	13.8	115.9	33.3	109.2
Endje – biological fertilization	30.0	114.5	15.1	127.5	38.6	126.6
Shumensko Sladko – control	23.6	100.0	9.05	100.0	31.4	100.0
Shumensko Sladko – biodynamical fertilization	25.1	106.4	9.52	105.2	34.3	109.2
Shumensko Sladko – biological fertilization	26.4	111.9	10.4	114.9	36.9	117.5
GD 1%	3.27	5.21	2.24	4.33	5.43	6.24
P %	4.72		5.85		4.33	

nished crops. The rains that fell in July, created an opportunity for the intensive development of the cultivation. From the middle of August to the end of October, a drought followed, which reduced the accumulation of biomass. The following year of testing was defined as extremely unfavorable, with record values of water deficit. Winter precipitations were in half of normal. In the months of March and April, no rainfall was recorded, but in the whole month of May, the amount of precipitation was one third of the norm. The subsequent prolonged extreme drought in the months of July and August irreversibly affected the record low levels of productivity.

In our previous research, the varieties Endje and Shumensko sladko were characterized as highly productive, both in terms of biomass obtained, and the amount of obtained pressed juice (Enchev & Kikindonov, 2015; Enchev et al., 2016). The results of the test of organic preparations on the productivity of the two varieties of sweet sorghum are indicated in Table 2.

Sweet sorghum demonstrated a high degree of adaptability to the conditions of ecological production with a 5-year conversion period, with no use of pesticides and mineral fertilization.

In the relatively more favorable year 2019, the productivity in the brooming phase of both varieties in the control variant, was at levels of 25-29 t/ha for the first swath. The second swath of the Endje variety had a significantly higher regenerative potential, which was due to the hybrid genotype (with Sudangrass in the parental component). The sugar biotype of the Shumensko sladko variety affected the higher yield from swaths in the phase of maturity.

Treatment with biodynamic preparations leads to insignificant statistical increase in the yield of both swaths when brooming, but for the late swaths at wax maturity a significant increase in yield of 17-20% was reported. This is an evidence that the effect of biodynamic preparations is enhanced under less favorable drought conditions in August-September 2019. Treatment at the beginning of the growing season with biological preparations that stimulate nitrogen uptake and growth and with fungicidal action of Heliosulfur, increases by over 15% yield for swaths at brooming stage, and over 30% at waxy maturity stage.

The extreme conditions of water deficit in 2020, reduced productivity more significantly for the Shumensko sladko variety, and also at the end of the vegetation season, when cutting at waxy maturity. It most severely reduced the yield of the second swaths in brooming stage. Treatment with organic preparations under these conditions had a statistically significant increase of yield for both varieties. The effect of biological preparations was higher. A similar trend was found in the researches of Doifode (2021). He investigated the influence of innoculation with bio-fertilizer, i.e. Azotobacter and phosphate soluble bacteria (PSB) alone and in different combinations with the recommended dose of chemical fertilizer (NPK: Nitrogen Phosphorous-Potassium). Significant

Table 3. Assessment of the effectiveness of pressed juice obtainment from sweet sorghum forms in waxy maturity phase, 2020

Variants	Parameters			
	Yield of stems, t/ha	Dry matter content of the stems, %	Pressed juice, l/ha	Dry matter of juice, %
Endje – control	20.4	46.9	9800	17.2
Endje – biodynamical fertilization	24.6	48.1	12050	18.5
Endje – biological fertilization	26.9	47.5	11250	16.6
Shumensko Sladko – control	22.1	31.4	10080	15.6
Shumensko Sladko – biodynamical fertilization	25.8	32.9	12020	17.2
Shumensko Sladko – biological fertilization	28.8	33.2	12250	16.8
GD 1%	3.27	7.54	432	2.34
P %	4.72	2.34	5.33	6.74

improvement in growth characteristics, such as plant height, number of internodes, stem diameter, root system weight, number of functional leaves, plant weight, plant dry weight and feed yield, were higher in the inoculated crop compared to the control.

In 2020, the yield and dry content of the stems at waxy maturity, the yield and the dry matter content of the pressed juice were measured.

In conditions of extreme drought, the differences between the two varieties in the yield of stems were reduced, with the highest yield observed in the variant with biological fertilization for Shumensko sladko – 28.8 t/ha. Treatment with organic preparations increased juice yield through the effect of biomass yield, not accounting for significant differences in juice quality.

The yield of 12250 l/ha of pressed juice obtained from the Shumensko sladko variety in the variant with the complexly imported Free N 100, Reim Zolfo and Heliosulfur and the dry matter content in the juice from the Endje variety in the variant with the biodynamic preparations 500 and Fladen, make an impression. The higher dry matter content of the earlier variety Endje reduced the yield of pressed juice. The results found are in agreement with the published results of Antonopoulou et al. (2008) and Mosali et al. (2010).

Conclusions

The correct application of bio-fertilizers reduces the need for conventional fertilization, thus reducing the cost of production and, on the other hand, minimizing soil stress.

The results of the test under the conditions of ecological production, without the use of pesticides and mineral fertilizers demonstrate the adaptive potential of sweet sorghum.

The realized yields of green mass expand the raw material base for the production of organic feed and for the production of organic sweet syrups.

Treatment with organic biological and biodynamic preparations has a significant effect on the increase of yield and largely compensates for unfavorable agrometeorological conditions.

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