EVALUATION OF THE QUALITY OF SWEET SORGHUM FODDER

S.I. Kapustin[1,2] A.B. Volodin[1] A.S. Kapustin[3,4] N.V. Samokish[2]
Assist. Prof. Researcher Lecturer Lecturer
[1] North Caucasus Federal Agrarian Research Centre, Mikhailovsk, Russian Federation
[2] Stavropol State Agrarian University, Stavropol, Russian Federation
[3] North Caucasus Federal University, Stavropol, Russian Federation
[4] E-mail: hpplus@bk.ru

ABSTRACT

According to the obtained data in 2019-2020, a plant height of the earliest variety Galiya was 201 cm, mid-season L-7897 and Tandem were 218 cm, late ripening Yarik was 282 cm. The maximum yield was obtained from the hybrid Yarik 77.0 t ha^{-1} of green matter and 21.5 t ha^{-1} of dry matter. A significant yield of green and dry matter was provided by L-7897 and Tandem. The data of the dry matter analysis show that the combinations Tandem and Yarik exceed the rates of the best standard Silosnoe 88 in terms of crude protein content and have high rates of metabolic energy. The crude fat content was similar to the standard rates. It was also found to be significant in the varieties Tandem and L-7897. The presence of crude fiber was low. The lowest rate was obtained in the hybrid Yarik. In comparison to the replaceable amino acids, the essential amino acids in the dry matter of sweet sorghum, which was cut in the milk-wax stage of ripeness, have a lower content. The average presence of essential amino acids was found in valine, phenylalanine, and argirine. Leucine had a significant rate. The maximum rates were found in the new combinations of Yarik and Tandem. Among the replaceable amino acids, the highest content had glutamic, aspartic acids, proline, alanine.

Key words: sweet sorghum, protein, metabolic energy, amino acids, dry matter

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تقييم جودة علف السموم الحلو

كابوستين إس [2،1] فولودين [1] كابوستين[3,4] ساموكيش [2]
استاذ مساعد باحث محاضر محاضر
مركز البحوث الزراعية الفيدرالي بشمال القوقاز ، ميخائيلوفسك ، روسيا[1]
جامعة ستافروبول الحكومية الزراعية ، ستافروبول ، روسي[2] جامعة شمال القوقاز الفيدرالية ، ستافروبول ، روسيا[3]

المستخلص

وفقًا للبيانات التي تم الحصول عليها في 2020–2019 ، كان ارتفاع النبات من أقرب صنف Galiya 201 سم ، منتصف الموسم L–7897 و Tandem كان 218 سم ، وكان النضج المتأخر Yarik 282 سم .تم الحصول على أقصى إنتاجية من الهجين Yarik – 77.0 طن / هكتار من المادة الخضراء و 21.5 طن / هكتار من المادة الجافة .تم توفير محصول كبير من المادة الخضراء والجافة بواسطة L–7897 و .Tandem تظهر بيانات تحليل المادة الجافة أن التوليفات Tandem و Yarik تتجاوز معدلات أفضل معيار Silosnoe 88 من حيث محتوى البروتين الخام ولديها معدلات عالية من الطاقة الأيضية .كان محتوى الدهون الخام مشابهًا للمعدلات القياسية .كما وجد أنه مهم في الأصناف Tandem و .L–7897 كان وجود الألياف الخام منخفضًا .تم الحصول على أقل معدل في الهجين .Yarik بالمقارنة مع الأحماض الأمينية القابلة للاستبدال ، فإن الأحماض الأمينية الأساسية في المادة الجافة للذرة الرفيعة الحلوة ، والتي تم قطعها في مرحلة نضج شمع الحليب ، تحتوي على محتوى أقل .تم العثور على متوسط وجود الأحماض الأمينية الأساسية في فالين ، فينيل ألانين ، والأرجرين .كان لوسين معدل كبير .تم العثور على المعدلات القصوى في التوليفات الجديدة من Yarik و .Tandem من بين الأحماض الأمينية القابلة للاستبدال ، كان أعلى محتوى يحتوي على الجلوتاميك، أحماض الأسبارتيك، البرولين، الألانين.

الكلمات المفتاحية: الذرة الرفيعة، البروتين، الطاقة الأيضية، الأحماض الأمينية، المادة الجافة

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INTRODUCTION

Sorghum plays a leading role in ensuring food security for more than half a billion people in Asia and Africa. This crop is mainly cultivated as fodder in industrialized countries. In recent decades, it is cultivated as a raw material for the production of bioethanol. Despite a similar nutritional profile to other grain crops, which is even better in terms of health-promoting elements, sorghum is considered a low-value crop, primarily due to the poor digestibility of its proteins. Sorghum varieties with a high protein content, which can be digested, have not been developed yet. These efforts are frustrated due to the strong connection between the characteristics of some easily digestible proteins and the endosperm phenotype. Transgenic sorghum lines with improved protein digestibility have been developed, but they are associated with a phenotypically turbid endosperm. There are indications that this may lead to the development of varieties with easy protein digestibility and vitreous endosperm texture. Protein digestibility variability exists among sorghum germ plasm and can be used to improve characteristics by selection (12). In studies by Tariq, A.S., Akram, Z., et al., (19) the grain quality was improved by genetic variation. The heterosis of sugar, crude protein and crude fat content was established. The proteins show significant differences between the resulting hybrid and its parent forms (1, 4, 11, 13, 14). Fermentation of sorghum grain increases the total content of amino acids. The content of essential amino acids increases their total content (17). At the same time, there is a lack of lysine and threonine in sorghum (10). Thorsoe, K. S., Bak, S., Olsen, C. E., etc. (20) point out the role of glutamic acid, histidine, serine, and arginine, which form hydrogen bonds and stabilize the binding of the sugar donor. The quality of fodder (sugar yield) may depend on the density of the plants and the amount of nitrogen fertilizers (6, 15). The yield of sugar, stems, juice content, and the percentage of sucrose contribute to a change in the ethanol yield (16). The amount of sugar also depends on the sowing period and the plant genotype (2, 5, 7, 18, 22). The accumulation of free amino acids is less in seeds and seedlings with high tannin content (9). The content of sugar and amino acids decreases in sorghum with leaf rust (3). The concentration of sugar and amino acids increases in the roots of plants treated with aluminum (8). The aim of the research is to determine the content of nutrition elements (protein, fat, fiber, nitrogen-free extracts (NFE)), metabolic energy, the level of essential and other amino acids in different varieties and hybrids of sweet sorghum in a completely dry matter.

MATERIAIS AND METHODS

The study of forage quality indicators in new varieties and hybrids of sweet sorghum was carried out in 2019-2020. The research methods were field and laboratory experiments. Measures of Weende analysis and amino acid composition of dry matter were determined in the certified scientific laboratory “Feed and Metabolism” at the Stavropol State Agrarian University. The content of 16 amino acids was studied (21). Field studies were carried out on the experimental field of North Caucasus Federal Agrarian Research Centre, the soil cover of which is represented by typical chernozem with 120 cm of humus horizon depth. The humus content in the plow layer of 0-30 cm is 3.2%. The level of active forms of mineral nutrition in the soil is average.During the years of experiments, insufficient precipitation, high air and soil temperatures in July-September caused drought. 13 numbers of sweet sorghum were studied in the seed field of competitive variety trial. Seeds were sown by wide-row method with 70 cm of space between rows. The number of replications was 4. The number of rows in the working plot was 3. The plant density was 150 thousand ha-1. The sowing time was May 12. Indicators of forage value and the content of amino acids in dry matter were determined in lines, varieties and hybrids of sweet sorghum in North Caucasus Federal Agrarian Research Centre selective breeding. We studied a new late ripening hybrid Yarik, a middle-early variety Galiya, a line L-7897, as well as a new mid-season variety Tandem, which was sent to the state testing of new varieties of agricultural plants in 2020. The standards were the variety Stavropolskoe 36 and the hybrid Silosnoe 88.

RESUITS AND DISCUSSION

According to the data in table 1, the duration of the seed germination-maturation period for standards was 96-97 days. The new mid-season variety Tandem had a similar period of 104 days. This rate of late ripening hybrid Yarik was 139 days. In the dry conditions of 2019-2020, the seeds of all varieties and hybrids reached the firm ripe stage. Sweet sorghum plants are characterized by different rates of initial growth. This rate is also important for improving the productivity of the aftergrowth. On the 30th day of the growing season, the plant height of the standard variety Stavropolskoe 36 was like on the 58 day. L-7897 (67 cm), Galiya (65 cm) and Yarik (76 cm) had the maximum rates of this trait. At later stages of development, the plant height rates changed and depended on the weather conditions, varietal features and high air temperature tolerance. In this regard, at the milk-wax stage of ripeness, the fluctuation in the height of plants on the seed field reached 97 cm (from 185 cm to 282 cm). The plant height of the earliest variety Galiya was 201 cm. The height of the mid-season L-7897 and Tandem – 217-218 cm. The height of late ripening Yarik was 282 cm. Standard varieties reached a height of 185-192 cm.

Table1. Economic and biological characteristics and quality of the dry matter of sweet sorghum (average for 2019-2020)

Variety, line, hybrid	Number of days from germination to seed maturation	Plant height, cm		Sugar content, %	Yield, t ha^{-1}			Weende analysis					
		The 30th day of the growing season	The milk-wax stage of ripeness		green matter	dry matter	ripe grain	crude protein, %	crude fat, %	crude fiber, %	crude ash, %	NFE, %	metabolic energy for sheep, MJ kg^{-1}
Stavropolskoe 36, St	**97**	**58**	**185**	**13.3**	**30.3**	**8.8**	**2.57**	**6.86**	**2.64**	**14.73**	**5.14**	**70.63**	**10.27**
Silosnoe 88, St	**96**	**73**	**192**	**9.9**	**42.4**	**12.8**	**3.14**	**7.24**	**2.37**	**14.89**	**5.99**	**69.51**	**10.17**
Galiya	**99**	**65**	**201**	**14.6**	**32.1**	**9.4**	**2.89**	**6.95**	**2.45**	**14.32**	**6.06**	**70.23**	**10.19**
Tandem	**104**	**59**	**218**	**16.5**	**37.7**	**11.1**	**2.87**	**8.97**	**2.55**	**15.40**	**4.54**	**68.53**	**10.55**
L-7897	**108**	**67**	**217**	**14.4**	**40.5**	**10.9**	**2.91**	**6.76**	**2.54**	**14.22**	**5.15**	**71.32**	**10.30**
Yarik	**139**	**76**	**282**	**12.0**	**77.0**	**21.5**	**3.37**	**8.68**	**2.38**	**14.07**	**4.45**	**70.42**	**10.57**
LSD $_{0.05}$, t ha^{-1}					**2.9**	**0.94**	**0.31**						

Most of the new varieties and hybrids are characterized by a low degree of tillering and branching, similar height of plants, and the simultaneous onset of phenological stage of development. They are not damaged or have low vulnerability to bacteriosis, smut and aphids. The high sugar content in the stems was found in the varieties Tandem (16.5%), Galiya (14.6%) and L-7897 (14.4%). The value of sucrose in sugar in the variety Tandem was 7240%, glucose – 17.33%, fructose – 10.26%. The stable yield of sweet sorghum is an important trait of this crop. Despite the unfavorable weather conditions in the middle and second half of the growing season, the green matter yield varied from 30.3 to 77.0 t ha^{-1}. The maximum yield was obtained from the late ripening hybrid Yarik (77.0 t ha^{-1} of green matter and 21.5 t ha^{-1} of dry matter). This was due to the long growing season, the tallness of the plants and other positive traits. A significant yield of green and dry matter was provided by L-7897 (40.5-10.9 t ha^{-1}) and Tandem (37.7 and 11.1 t ha^{-1}). The quality of the obtained mass was evaluated in air-dry matter. Samples were taken during the cutting of sweet sorghum in the milk-wax stage of ripeness. Crude protein is the total amount of nitrogen-containing substances in the forage. It is evaluated by the Kjeldahl method. The content of crude protein includes proteins and amides. Proteins consist of amino acids which are linked together by peptide bonds. The highest content of crude protein, in the dry matter which was obtained in our studies, was found in the new variety Tandem (8.97%), the hybrid Yarik (8.68%). The best standard Silosnoe 88 had 7.24%. The other varieties had 6.76-6.95% of protein. Nitrogen-free substances of the organic part of the forage include fat, fiber, NFE. Crude fat is a substance that is soluble only in organic solvents and is a source of energy nutrition.

The higher the concentration of desaturated fatty acids that come in with the forage, the softer the fat in the milk. The studied varieties have a fat content that is similar to the standard rates. It is high in the variety Tandem (2.55%) and L-7897 (2.54%). Crude fiber determines the degree of forage digestion. Older plants contain more crude fiber with poorer digestibility. The content of crude fiber affects the milk fat synthesis. In our experiment, the total crude fiber content was low and varied in the range of 14.07-15.40%. The lowest rate was obtained in Yarik (14.07%), L-7897 (14.22%) and Galiya (14.32%). NFE (nitrogen-free extracts) are all nitrogen-free substances (starch, sugars, pentosans), except fat and crude fiber. In the obtained data, the NFE was associated with the rates of crude protein. The varieties Tandem and Yarik had 68.53% and 70.4%, where more crude protein was obtained (8.97% and 8.68%). In general, there were no significant differences in the content of NFE between the varieties of the experiment. When determining the amount of metabolic energy in the sheep forage, it turned out that 1 kg of dry matter contained 10.17-10.57 MJ. These rates in the new combinations Tandem and Yarik were 10.55-10.57 MJ. Standards had 10.17-10.27 MJ. The forage crops which are used in animal husbandry differ from each other significantly in the content of the main nutrients. A relatively high content of crude fat, NFE and metabolic energy, as well as low crude fiber content was obtained in the dry matter of sweet sorghum. In feeding, protein cannot be replaced by any other nutrient. Only a plant can form protein from non-protein compounds. About 20 different amino acids are involved in the formation of animal protein. Some of these amino acids must necessarily come with forage (irreplaceable and essential for life). Other amino acids are synthesized in the animal's body directly. The content of essential amino acids in the forage determines its biological value. An optimal ratio of amino acids, which is necessary for different animals, is achieved due to the combination of various feed components. Essential amino acids are valine, threonine, methionine, leucine, isoleucine, lysine, phenylalanine, histidine. The replaceable amino acids, studied in our experiment, are serine, aspartic and glutamic acids, proline, glycine, alanine, tyrosine, and arginine. Table 2 shows the content of 16 amino acids contained in the dry matter of sweet sorghum, cut in the milk-wax stage of ripeness. In comparison to the replaceable amino acids, the essential amino acids in the dry matter of this crop have a lower content. Thus, methionine and histidine are contained in a very small amount (0.11-0.22%). The highest rates for almost all amino acids were obtained in the new varieties Tandem and Yarik. Also, a relatively low content of essential amino acids (0.25-0.35%) was found in threonine, isoleucine and lysine. The average presence of essential amino acids (0.35-0.50%) was found in valine, phenylalanine, and arginine. Only leucine had a significant rate and amounted to 0.85-0.92%. Yarik and Tandem had the maximum rates.

Table 2. Amino acid content of green matter of sweet sorghum in 2019-2020

Variety, line, hybrid	Amino acids, %															
	Aspartic acids (Asp)	Threonine (Thr)	Serine (Ser)	Glutamic acid (GLu)	Proline (Pro)	Glycine (GLy)	Alanine (Ala)	Valine (Val)	Methionine (Met)	Isoleucine (Lie)	Leucine (Leu)	Tyrosine (Tyr)	Phenylalanine (Phe)	Histidine (His)	Lysine (Lys)	Arginine(Arg)
Stavropolskoe 36, St	**0.51**	**0.23**	**0.31**	**1.44**	**0.53**	**0.24**	**0.58**	**0.35**	**0.11**	**0.29**	**0.85**	**0.31**	**0.39**	**0.15**	**0.21**	**0.27**
Silosnoe 88, St	**0.56**	**0.23**	**0.31**	**1.49**	**0.54**	**0.26**	**0.58**	**0.36**	**0.12**	**0.28**	**0.85**	**0.25**	**0.33**	**0.16**	**0.21**	**0.28**
Galiya	**0.55**	**0.22**	**0.32**	**1.48**	**0.55**	**0.25**	**0.57**	**0.37**	**0.12**	**0.27**	**0.86**	**0.24**	**0.34**	**0.17**	**0.20**	**0.29**
Tandem	**0.91**	**0.32**	**0.40**	**1.56**	**0.76**	**0.33**	**0.60**	**0.43**	**0.14**	**0.35**	**0.92**	**0.38**	**0.44**	**0.22**	**0.31**	**0.35**
L-7897	**0.52**	**0.24**	**0.32**	**1.48**	**0.52**	**0.23**	**0.59**	**0.34**	**0.12**	**0.30**	**0.87**	**0.32**	**0.40**	**0.16**	**0.22**	**0.26**
Yarik	**0.90**	**0.31**	**0.39**	**1.55**	**0.75**	**0.32**	**0.61**	**0.44**	**0.13**	**0.34**	**0.91**	**0.37**	**0.43**	**0.20**	**0.30**	**0.34**

Among these essential amino acids, isoleucine is necessary for wound healing, the formation of hemoglobin. Along with threonine, they strengthen the immune system. Leucine regulates blood sugar level. Phenylalanine is the raw material for insulin. Histidine prevents atherosclerosis, hypertension, heart attacks. Valine helps regulate and prevent neurological disorders. The replaceable amino acids that can be synthesized by the body are aspartic and glutamic acids, serine, proline, glycine, alanine, tyrosine, arginine. Out of this number, the highest content was obtained for glutamic acid (1.44-1.49% for standard samples and 1.55-1.56% for Tandem and Yarik) in the dry matter of sweet sorghum, which was cut in the milk-wax stage of ripeness. A significant presence of replaceable amino acids had aspartic acid (0.51-0.91%), proline (0.53-0.76%), alanine (0.57-0.61%). Serine (0.31-0.40%), tyrosine (0.24-0.38%), arginine (0.26-0.35%), glycine (0.23-0.33%) had lower rates. The replaceable amino acids presented in the studies also play an important role. Thus, aspartic acid is very important for the proper functioning of the nervous and endocrine systems, stimulates the production of testosterone and other hormones. Along with alanine, this acid activates the production of antibodies, which strengthens the immune system. Glutamic acid is found in the brain and spinal cord, the liquid part of the muscles. It stimulates the production of new cells, prevents premature aging. Arginine activates the production of hormones, insulin.

CONCLUSIONS

The studies conducted in 2019-2020 showed that the maximum plant height (218-282 cm) and the yield of green and dry matter of sweet sorghum (37.3; 77.0 t ha^{-1} and 11.1; 21.5 t ha^{-1}, respectively) were obtained from a new hybrid Yarik and the variety Tandem. The Weende analysis data of dry matter indicate that the combinations of Tandem and Yarik exceed the rates of the best standard Silosnoe 88 in terms of protein content by 1.44-1.73% and have high rates of metabolic energy (10.55-10.57 MJ kg-1). The variety Tandem and the hybrid Yarik provide a higher content of amino acids in the dry matter in comparison with other studied samples. The presence of glutamic and aspartic acids, proline, alanine and leucine is especially significant.

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