Productivity of sudan grass and sorghum-sudangrass hybrids depending on seeding rates and planting methods in the steppe dryland zone of the Kabardino-Balkarian Republic

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Abstract. The article contains the results of three-year field research in the steppe dryland zone of the republic, the best options of grass sorghum cultivation, which increase the gross yield of green forage and hay were developed. Optimum planting standards for dry steppe conditions, planting and harvesting methods of Sudan grass and sorghum-Sudangrass hybrids were identified to produce a high, more energy-intensive green and dry forage of the studied crops. The quality and feed qualities of fodder for production and direct feeding to animals are determined. The crop growing time after hay harvest and quantity for feeding after harvesting are given.

1 Introduction

Feed production is the most labor-intensive and complex process of the agrarian economy. The most important challenge in the intensification of agricultural production in the dryland zone of the Kabardino-Balkarian Republic is the development of a sustainable feed base. Expanding the range of feed crops adapted to specific soil and climatic conditions will better meet the needs of animals for high-quality feed, improve land management and also significantly reduce the adverse climate effects.

In the zone of unstable humidification of the republic, research on promising varieties and hybrids of sorghum crops to identify signs of drought resistance, prematurity, high feed productivity and productive longevity to take full advantage of the favorable bioclimatic potential of local conditions for the production of selected feed products was carried out.

The studied varieties and hybrids have a number of valuable qualities: they grow quickly after cutting or feeding, contrary to other annual feed grasses, which allows them to be more widely used in a green conveyor; with increased yields, they produce high-quality hay, which is superior in protein and fat content to other feed crops, second only to legumes.

The development of the proposed agronomic practices is motivated by the importance of growing feed crops that increase the productivity of the arable land of the dry steppe zone,

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and by the implementation of feed technology that stabilizes the gross yield in different weather years.

The goal of the research is to improve the elements of grass sorghum cultivation technology by applying optimal timing and seeding rates, planting techniques and the use of varieties and hybrids with different indicators of the biochemical composition of green forage used for the preparation of high-quality and varied feeds.

The task of the field research is to study the growth and development of Sudan grass and sorghum-Sudangrass hybrids with different seeding rates and techniques, to estimate their economic characteristics, and to develop some techniques for the cultivation of Sudan grass and sorghum-Sudangrass hybrids for green forage and hay; to study the varietal differences and chemical composition of studied grasses to identify the most productive varieties and hybrids for production in the unstable humidification zone.

The novelty of the research is that for the first time in the dryland steppe zone of the republic the possibility of obtaining high yields of green and dry forage of grass sorghum with different technological direction of preparation of quality feed is identified. For the first time, on the chernozem soils of the dry steppe zone of the Kabardino-Balkarian Republic, a comprehensive study of various grass sorghum hybrids was performed and their reaction to the implementation of various seeding rates and planting methods, cutting and use regimes were identified.

The research provides science and production with a range of Sudan grass and sorghum-Sudangrass hybrids, optimally selected to the specific soil and climate zone that produces high-quality feeds with high productivity and nutritional value.

The research results were tested and implemented in various farms in the steppe zone of the republic on an area of 85 ha.

2 Materials and methods

The research was conducted for three years (2015-2017) at the experimental site of the laboratory of technology for the cultivation of field crops of the Institute of Agriculture of the Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences, Tersky district, village Opytnoye Soils are Ciscaucasian carbonate chernozem. The predecessor is winter wheat (2015), grain maize (2016), peas (2017). The humus content in the soil is 3.5%; soil solution reaction is neutral: ph - 6.5-7.1; labile phosphorus content - 2.0-2.5; exchange potassium - 30-40 mg/100g of soil, average annual precipitation is 435 mm with fluctuations from 320 to 545 mm over the studied years, the thickness of the humus horizon is 30-35 cm. Over the years of research, precipitation fell: 2015 - 335.5 mm; 2016 - 545.7 mm; 2017 - 430.5 mm, of which in the autumn-winter months, respectively: 142.5 mm; 170.4 mm; 164.0 mm. Over three years of the experiments, the growing season of 2016 was the wettest - 545.7 mm, compared to 435 mm of average long-term indicators. Meteorological observations over the years of the study are shown in Table No. 1. The choice of the site, the size and location of the plots, the replicates were formed according to the "Methodology of field experiment", Dospekhov B.A. M.: 1979; the scheme of the field experiment, seeding rate, planting methods are presented in Table No. 2.

The following seeds were used in the research

Sudan grass, Shirokolistnaya variety, originator is the Institute of Agriculture of the Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences

Sorghum-Sudangrass hybrid Navigator, originator is Stavropol NAC

Sorghum-Sudangrass hybrids, originator is Agroplasma LLC, Krasnodar

Sorghum-Sudangrass hybrid Solaris, Agroplasma LLC, Krasnodar

Soil preparation technology: autumn plowing at 25-27 cm with application of the main mineral fertilizer - P20K90, presowing cultivation on depth of 8-10 cm; 6-8 days before

seeding introduce soil herbicide Doual, Avangard - 1,5 l/ha. Solid planting was carried out with C3-3.6 seed, raw planting in 70 cm with SUNP-8 seed with selection of seeding plates - 2 mm. During the growing season, 2-3 intercultivations were carried out with a cultivator with the introduction of nitrogen fertilization - 60 kg of active agent/ha. The plantings were carried out according to the years of research April 24, 2015, May 02, 2016, May 08, 2017.

Phenological observations were made in terms of age of incineration, tillering tube exit, ear formation, dairy and wax ripeness. Green forage accounting was carried out during the heading of panicles phase of sorghum-Sudan hybrids, and the aftergrass was counted as the maximum crop growth.

Table 1. Meteorological data in research years (data of the Kuyan agricultural and meteorological post, village Opytny village, Tersky district of the Kabardino-Balkarian Republic).

No.	Month decade		Rainfall, mm						max, min		
			2015		2016		2017		2015	2016	2017
			by decades	total	by decades	total	by decades	total	max min	max min	max min
1	January	1	8.8	12.9	6.9	48.4	7.5	23.8	7.5	11.50	7.5
		2	0		41.1		-20.5		-25.0	-21.0	-20.5
		3	4.1		30.4						
2	February	1	4.3	12.2	4.1	19.6	21.0	1.3	13.5	21.0	21.0
		2	7.7		15.5		-21.0		-8.0	-6.5	-21.0
		3	0.2		0						
3	March	1	13.7	41.7	4.1	33.4	22.9	18.3	16.0	18.0	22.9
		2	4.7		10.7		-4.0		-5.0	-5.0	-4.0
		3	23.3		18.6						
4	April	1	5.1	14.2	1.2	65.2	26.5	40.5	29.5	29.0	26.5
		2	3.9		35.9		-3.5		0.5	2.0	-3.5
		3	5.2		28.1						
5	May	1	35.8	104.5	27.9	81.3	27.5	79.5	32.0	28.0	27.5
		2	34.7		4.7		6.5		7.5	8.0	6.5
		3	14.0		48.7						
6	June	1	26.8	61.3	139.2	151.9	35.0	69.6	35.0	33.5	35.0
		2	5.2		10.4		12.0		11.0	10.5	12.0
		3	29.3		2.3						
7	July	1	0.5	19.8	77.8	136.2	40.5	34.3	40.0	35.0	40.5
		2	3.5		33.1		13.5		14.0	13.5	13.5
		3	15.8		25.3						
8	August	1	19.4	37.9	2.2	6.7	41.5	23.6	41.0	38.5	41.5
		2	4.5		4.5		16.0		11.5	16.0	16.0
		3	14.0		0						
9	September	1	0	0	8.5	44.9	35.5	13.7	37.5	32.0	35.5
		2	0		2.2		-1.0		7.0	6.0	-1.0
		3	0		34.2						
10	October	1	21.3	37.5	4.2	67.1	23.5	41.2	27.5	25.0	23.5
		2	15.8		21.2		-2.5		-2.0	-1.5	-2.5
		3	0.5		41.7						
11	November	1	0	14.1	0.3	9.1	14.0	13.6	18.5	19.5	14.0
		2	14.1		8.5		-5.0		-3.0	-7.5	-5.0
		3	0		0.3						
12	December	1	5.4	26.8	5.3	23.9	13.0	40.7	16.0	10.0	13.0
		2	0.8		18.6		-7.5		-10.0	-16.0	-7.5
		3	20.6		0						

Table 2. Field experience scheme, seeding rates, planting methods for grass sorghum

No.	Experimental option	Planting methods and seeding rates	
		solid planting 15 cm thousand pcs./ha	band planting 70 cm thousand pcs./ha
1	Sudan grass, Shirokolistnaya variety	1400	800
2	Sorghum-Sudangrass Navigator hybrid	1200	650
3	Sorghum-Sudangrass Sabantuy hybrid	1200	650
4	Sorghum-Sudangrass Solaris hybrid	1200	650

Scientific research on the study of these crops is carried out in a four-pole crop rotation, the location of plots in the experiment is systematic, and the placement of three tiers is by freights (Table. 2). The experiment is one-factor, the area of the plots is 36 m2, the repetition is three-fold.

Biometric measurements and inventories identified the following characteristics: plant height, tilling capacity, number of plants per square meter, percentage of leaves and stems in total mass. All measurements were made before the green forage of each bite was harvested. There were two hay harvest during the growing season. The first hay harvest of Sudan grass and sorghum-Sudangrass hybrids was carried out on 55-60 days after the sprouting, or 5-6 days before the start of the ear formation, and the second was carried out 40-45 days after the first hay harvest. From each plot, two test sheaves of 5 kg were selected to determine the yield of hay, the structure of the crop (percentage of leaves and stems) and the energy content of green and dry forage.

The Sudan grass Shirokolistnaya variety was used as the standard. Statistical processing of experimental data was performed according to B.A. Dospekhov (1985).

3 Research results

One of the most significant indicators giving an initial estimate of the studied hybrids is their morphological characteristics. The plant height varies considerably from year to year due to different water availability and growing medium temperature (Table. 3).

Table 3. Analysis of the height of plants studied in the experiment, cm

No.	Experimental option	Hay harvests	Years of research							
			2015		2016		2017		Three-year average	
			Solid planting	Band planting	Solid planting	Band planting	Solid planting	Band planting	Solid planting	Band planting
1	Sudan grass Shirokolistnaya (standard)	1	135	142	215	235	186	205	178	194
		2	95	102	185	195	156	146	145	147
2	Sorghum-Sudangrass Navigator hybrid	1	144	170	265	278	242	255	217	234
		2	123	134	202	226	189	194	172	185
3	Sorghum-Sudangrass Sabantuy hybrid	1	152	174	275	284	246	264	224	240
		2	128	132	215	235	200	210	181	192
4	Sorghum-Sudangrass Solaris hybrid	1	148	166	270	276	232	247	216	229
		2	121	134	225	227	204	193	183	185

On average, in three years of research, plant heights in solid planting in the second hay harvest ranged from 95 to 185cm in the Sudan grass population, with the highest being the sorghum-Sudan Sabantuy hybrid in band planting - 174-284 cm.

One of the significant characteristics of plants is tilling capacity. Comparing the number of stems, it should be noted that before the second hay harvest in all variants, this number is greater than in the first harvest (Table.4).

Table 4. Analysis of tilling capacity depending on the hay harvest and planting method, (pcs/plant) by years of research

No.	Experimental option	Hay harvests	Years of research							
			2015		2016		2017		Three-year average	
			Solid planting	Band planting	Solid planting	Band planting	Solid planting	Band planting	Solid planting	Band planting
1	Sudan grass Shirokolistnaya (standard)	1	3.2	4.8	5.4	6.2	4.4	4.9	4.4	5.3
		2	4.6	6.3	6.2	7.0	5.1	5.0	5.3	6.1
2	Sorghum-Sudangrass Navigator hybrid	1	4.3	5.1	7.2	8.8	6.0	6.9	5.8	6.9
		2	4.9	5.9	7.8	7.3	6.3	6.5	6.3	6.6
3	Sorghum-Sudangrass Sabantuy hybrid	1	4.1	5.6	7.9	9.3	6.0	6.8	6.0	7.2
		2	4.6	6.1	9.3	10.1	6.5	6.1	6.8	7.4
4	Sorghum-Sudangrass Solaris hybrid	1	3.8	4.9	7.6	9.1	6.9	7.3	6.1	7.1
		2	4.4	5.1	8.8	10.0	6.4	6.8	6.5	7.3

As can be seen from Table 4, over the years of research, the tilling capacity of the investigated plants varies from year to year and from harvest to harvest. Compared to the Sudan grass Shirokolistnaya variety (standard), sorghum-Sudangrass hybrids have a larger tilling capacity of 1.5-2 times, while after the second harvest, according to this indicator the sorghum-Sudangrass Solaris and Sabantuy hybrids can be distinguished - 10.0-10.1 respectively.

The quality of the green and dry forage of plants depends on the size of the leaves in total mass and on the genotype of the variety or hybrid, as well as on the weather conditions of plant development. In years with the abundant precipitation, the leafiness of sorghum-Sudangrass hybrids and Sudan grass (in percentage terms) will be lower than in dryland years. In humid years, the plant height reaches 2.5-2.8m, in dryland years - 130-170cm, therefore internodes are longer and the number of leaves per plant is equal. Accordingly, the percentage of stems in the total plant mass in a wet year will be higher and leaves will be lower (Table. 5).

As can be seen from Table 5, the lowest green forage yield in years of the research was obtained in 2015 due to soil and air drought, which hindered normal plant development.

It should be noted that the yields of sorghum-Sudangrass hybrids exceed the standard for years of the research and for hat harvests. On average over the years of research, there is an advantage of first hay harvest in all experiments, due to the high temperatures in mid-summer and lack of moisture to fully develop the second hay harvest (Table. 6).

Table 5. Appearance of plants of Sudanese grass and sorghum-Sudanese hybrids, depending on sowing and stingray, %, Leafiness of Sudan grass and sorghum-Sudangrass hybrids, depending on the planting and hay harvest method, %

No.	Experimental option	Hay harvests	Years of research							
			2015		2016		2017		Three-year average	
			Solid planting	Band planting	Solid planting	Band planting	Solid planting	Band planting	Solid planting	Band planting
1	Sudan grass Shirokolistnaya (standard)	1	34.2	38.3	31.6	33.8	33.6	34.5	33.1	35.5
		2	38.3	41.1	34.5	34.6	36.2	35.8	36.3	37.1
2	Sorghum-Sudangrass Navigator hybrid	1	43.1	51.3	35.8	38.2	40.2	41.8	39.7	43.7
		2	46.2	53.2	37.6	41.6	41.6	43.6	41.8	46.1
3	Sorghum-Sudangrass Sabantuy hybrid	1	46.1	53.6	37.3	39.6	43.1	44.6	42.1	45.9
		2	49.5	54.2	39.8	42.3	45.3	45.2	44.8	47.2
4	Sorghum-Sudangrass Solaris hybrid	1	44.5	48.3	36.8	39.9	4.01	43.2	40.4	43.8
		2	45.2	51.3	38.6	43.6	42.3	45.6	42.0	46.8

Table 6. Yield of green forage of Sudan grass and sorghum-Sudangrass hybrids by year and harvests, dt/ha

No.	**Variants option**	**Hay harvests**	**Years of research**						**Yield of green forage, average for three years, dt/ha**		**Yield of air-dry forage, average for three years, dt/ha**	
			2015		**2016**		**2017**					
			Solid planting	**Band planting**	**Solid planting**	**Band planting**	**Solid planting**	**Band planting**	**Solid planting**	**Band planting**	**Solid planting**	**Band planting**
1	Sudan grass Shirokolistnaya(standard)	1	70.3	78.6	232.3	258.1	139.6	155.8	147.4	161.4	36.8	41.0
		2	63.8	69.8	215.6	240.6	122.3	141.2	133.9	150.4	33.5	37.6
	For 2 hay harvests		134.1	148.4	447.9	498.7	261.9	297.0	281.3	311.8	70.3	78.6
2	Sorghum-Sudangrass Navigator Navigator hybrid	1	92.3	116.6	261.9	278.9	142.5	166.3	165.6	187.3	41.4	46.8
		2	83.6	107.0	245.8	256.3	131.2	151.2	153.5	171.5	38.3	42.8
	For 2 hay harvests		176.8	223.6	507.7	353.2	273.7	317.5	319.1	358.8	79.7	89.6
3	Sorghum-Sudangrass Navigator Sabantuy hybrid	1	96.3	124.3	268.3	286.8	153.6	169.8	172.7	193.6	43.1	48.4
		2	83.8	112.5	251.6	263.9	141.2	152.3	158.8	176.2	39.7	44.0
	For 2 hay harvests		180.1	236.8	519.9	550.7	845.5	322.1	331.5	369.8	82.8	92.4

Table 6. Continued.

4	Sorghum-Sudangrass Navigator Solaris hybrid	1 2	94.6	118.6	245.6	273.8	149.3	164.3	163.2	185.6	40.8	46.4
			82.8	108.3	230.1	252.7	138.7	149.8	150.5	170.2	37.6	42.5
	For 2 hay harvests		177.4	226.9	475.7	526.5	288.0	314.1	313.7	355.8	78	88.9

Table 7. Productivity and nutritional value of Sudan grass and sorghum hybrids (average for 2015-2017)

No.	**Variants option**	**Crop yield, dt/ha**				**Digestible protein kg/ha**				**Feed units dt/ha**				**Carotene dt/ha**			
		green forage		**dry forage**		**green forage**		**dry forage**		**green forage**		**dry forage**		**green forage**		**dry forage**	
		15 cm	**70 cm**	**15 cm**	**70 cm**	**15 cm**	**70 cm**	**15 cm**	**70 cm**	**15 cm**	**70 cm**	**15 cm**	**70 cm**	**15 cm**	**70 cm**	**15 cm**	**70 cm**
1	Sudan grass Shirokolistnaya (standard)	281.3	311.8	70.3	78.6	78.7	87.3	45.7	51.1	73.2	81.1	36.5	40.8	16.9	18.7	1.49	1.57
2	Sorghum-Sudangrass Navigator hybrid	319.1	358.8	79.7	89.6	63.8	71.7	51.8	58.8	82.9	93.3	41.4	46.6	19.1	21.5	1.59	1.79
3	Sorghum-Sudangrass Sabantuy hybrid	331.5	369.8	82.8	92.4	66.3	74.0	53.8	60.1	86.9	96.1	43.0	48.1	19.9	22.2	1.66	1.85
4	Sorghum-Sudangrass Solaris hybrid	313.7	355.8	78.4	88.9	62.7	71.6	51.0	57.8	81.5	95.5	40.7	46.2	18.8	21.3	1.57	1.78

Alyzing the productivity of the investigated options over all years of research, sorghum-Sudangrass hybrids are above the standard for all investigated indicators and can be recommended for cultivation in the dry steppe zone for green forage and hay (Table 7).

The largest share in the structure of the cost of livestock products is the feed cost. Consequently, the cultivation of sorghum-Sudanicgrass hybrids with lower mass cost is one way of reducing production costs (Table 8).

Table 8. Cost-effectiveness of green forage sorghum-Sudangrass hybrid production Navigator, Sabantuy and Solaris

No.	Indicators	Variety, hybrid			
		Sudan grass Shirokolistnaya (standard)	**Sorghum-Sudangrass Navigator**	**Sorghum-Sudangrass Navigator Sabantuy hybrid**	**Sorghum-Sudangrass Navigator Solaris hybrid**
1	Crop yield feed units dt/ha	81.1	93.3	96.1	95.5
2	Prime cost 1 dt. feed unit/ ha (rubles)	148.80	129.34	125.57	126.36
3	Cost 1 dt. feed unit/ ha (rubles)	210.00	210.00	210.00	210.00
4	Cost cost feed units (rubles)	17.031	19.593	20.181	20055
5	Expenses Per 1 ha (rubles)	12.068	12.068	12068	12068
6	Net operating income	4963	7525	8113	7987
7	Profitability level, %	1.41	1.62	1.67	1.66

According to the information in Table 8, it can be concluded that sorghum-Sudangrass hybrids exceed the standard in terms of gross green forage charge. The cost of feed units for sorghum-Sudangrass hybrids is lower - 125.59-129.34 rubles. compared to the standard - 148.80 rubles. The profitability of Sudan grass is 1.41%, while that of sorghum-Sudangrass hybrids is 1.62-1.67%. At the same cost, the net profit increases almost twofold.

4 Conclusion

The research carried out in 2015 - 2017 on the productivity of sorghum-Sudangrass hybrids at the experimental site of the Institute of Agriculture of the Kabardino-Balkarian Scientific Center of the Russian Academy of Science in the dry-steppe zone of the Kabardino-Balkarian Republic leads to the following conclusions:

1. In the unstable moisture zone, the studied sorghum-Sudangrass hybrids Navigator, Sabantuy and Solaris have proved promising, capable of producing high yields of green and air-dry forage, well-eaten by livestock animals.

2. It is recommended to carry out crops in a band manner (60-70 cm), which makes it possible to combat weed vegetation, to apply mineral fertilizers in the form of a feed during intercropping, and to irrigate on raws.

3. Recommended planting standards for sorghum-Sudangrass hybrids Navigator, Sabantuy and Solaris for band planting - 600-700 thousand pcs. /ha, with solid planting - 1100-1200 thousand pcs./ha.

In order to obtain stable yields of 30-35 t/ha of silage in steppe areas with sufficient moisture, it is recommended to apply mineral fertilizers at a dose of N90P120K60 kg/ha of fractions: phosphorus potassium for plowing, nitrogen for feeding.

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