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The Effect of Sudan Grass on the Mixed Sowing Chemical Composition of Annual Forage Crops

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Abstract: The experimental results show that the use of Sudan grass in mixed sowing with high-protein annual forage crops for production of green feed made it possible to get herbage with the required nutritional value. Sudan grass having high sugar content in its chemical composition is an attractive crop for animals but has a disadvantage of not having sufficiently high protein content. In order to increase the consumption of herbage and to improve the quality of harvested feed (green feed, hay) the best method is to use mixed sowing of high-protein annual crops (fodder mall, Spring rape and Spring vetch) with Sudan grass. The results of the researches the following conclusion can be drawn: crops used in the experiment have proved to be effective and efficient by having increased the digestible protein content in the feed (herbage) obtained from the mixed sowings. By the results of the researches the following conclusion can be drawn: the crops used in the experiment to raise the content of digestible protein in herbage have proved to be effective. The results of research can be successfully used in the formation of diet for high-yielding milking cows, beef cattle and other types of farm animals and poultry.

Key words: Sudan grass, Spring rape, Spring vetch, fodder mallow, single-crop sowing, mixed sowing

INTRODUCTION

Green forage, obtained from annual grasses, sometimes does not meet the requirements, including quality indexes. A serious problem is the content of the digestible protein (Makartsev, 2007). Researches of many Russian and Foreign scientists show the advantage of annual forage crops sowing in a mixture in comparison with single-crop sowing. A special role is played by legume-grass mixtures. They surpass single-crops sowing of cereal crops by protein content, give more nutritious forage and at the same time they are dependent on various factors like variety, level of agrotechnics, weather conditions, composition of herbage mixtures and etc., (Khamidullin, 2007; Kuznetsov *et al*., 2014).

Based on the research results state that in order to form a stable feeding base and fully meeting the requirements of farm animals in high-quality feeds, it is necessary to improve the structure of annual forage crops by increasing the planting of legume-grass mixed sowing. They give more stable yields with a decrease in the yield of one crop, the compensation takes place at the expense of the other one. At the same time, the quality of feeding mass improves the vital factors (nutrients, humidity, light, etc.) are used optimally. The use of mixed sowing is an environmentally friendly method of increasing the efficiency and stability of forage production. The component composition makes an impact on the yield, the botanical composition of the feed mixture, the content of DP (Digestible Protein), the yield of feed units and energy efficiency. The use of mixtures is one of the agricultural production elements on a biogeocenotical basis. First of all, this is a rejection of single-crop that is low-resistant to diseases and pests and also, deprived of its natural partners like other plants, microflora and insects (Kuznetsov *et al*., 2014).

Sudan grass is an annual plant of grass family-Poaceae Barnh, genus Sorghum (sorghum pens). The botanical name is *Sorghum Sudanense* (piper) Staht. This crop is one of the most valuable forage grasses of the grass family. Its drought resistance, ability to grow after mowing or gazing on high yield of herbage allows rapidly expanding the sowing and introducing this crop

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into production (Kuznetsov *et al*., 2014; Kokonov, 2011). Sudan grass is becoming more common in China, Saudi Arabia and Turkey (Awad *et al*, 2013; Budak and Aydemir, 2017).

The optimal components for forming mixtures with Sudan grass are leguminous plants (Spring vetch and hairy vetch, grass pea, field pea, soybean, planting pea, yellow lupine), cabbage (Spring rape and bird rape). The use of the bean component with Sudan grass in the plant formation allows changing the feeds obtained from mixed sowing by increasing their nutritional value and digestibility (Zhang *et al*., 2018). Attraction of Spring vetch in the diet is pointed out in Huang, Gao, Nan and Zhang's studies (Ismail *et al*., 2018). High-protein forage crop-fodder mallow is of particular interest in recent years. When cultivating mallow with cereal crops their yield does not always exceed single-crops, however, the protein content in herbage increases because of mallow (Diachenko and Dronov, 2003).

The uniqueness of the mallow as a fodder plant is pointed out in studies by Villa and Hurtado (Huang *et al*., 2017). According to the results of the research, Kabi and Bareeba concluded that small farmers in Uganda can effectively use fodder mallow in diets to increase the dairy cattle productivity.

One of the serious problems in the mixed sowing cultivation technology study is the ratio of components in the mixture. Vyalkova (Villa and Hurtado, 2016) in her studies conducted at the Altai State University in 2008-2010 has found that the yield of 50% of rapeseed+50% of Sudanese grass variant was herbage of 3.63 t/ha and the variant of 50% of Sudan grass+50% of Spring vetch was 26.1 tons of herbage per ha. At the same time, the issue remains open over other mixing ranges.

Mixed sowing of legume-grass crops allows solving many problems facing modern agriculture. Simultaneous cultivation of Sudan grass and Spring vetch in the Republic of Bashkortostan show a decrease in the crops weed infestation, the soil keeps the fluffy consistency during the vegetation period, water regime and nutrient status of soil are also, improved. High ability to crowd out weedage is also, the advantage of sowing Sudan grass in mixtures (Vialkova, 2012).

One of the most difficult issues in the cultivation of annual forage crops mixtures is the use of mineral fertilizers. Mineral fertilizers primarily nitrogen fertilizers are the main factors that provide an increase in grasses sowing productivity (40-65%). In the fields of grasses and legume-grasses sowing, the share of mineral fertilizers, mainly phosphate-potassium fertilizers in the total yield of dry matter does not exceed 16-21% (Khamidullin and Khamidullina, 2003, Neustroev, 2011). Sudan grass needs many nutrients as it has high regrow capacity. In their experiments Ducsay and Varenyiova point out that in the Spring rape cultivating, the use of nitrogen fertilizers with a dose of 160 kg/ha a different dose of sulfur is effective. At N_{30} P_{30} K_{30} the yield of herbage of mixed sowing was 105.3 c/ha at N_{60} P_{60} K_{60}, it was 133.7 quintals/ha at N_{90} P_{90} K_{90} it was 115.8 quintals per ha and control variant was 87.8 quintals 1 ha (Usanova and Petrova, 2001).

A review of studies on Sudan grass mixed sowing and high-protein annual forage crops shows the need for studies the mixture components with a different percentage of at different levels of mineral nutrition. In that context, the purpose of our research (2015-2017) was to develop the theoretical foundations and agrotechnical methods of highly productive agrophytocenoses formation of single-crops and mixed sowing of annual forage crops based on Sudan grass for herbage in the conditions of the Southern forest-steppe of Bashkortostan Republic.

In accordance with this, a number of tasks were set in the studies, including defining the optimum proportions of components in Sudan grass and high-protein annual forage crops mixtures (Spring vetch, fodder mallow, Spring rape) defining the nutritional value based on the herbage chemical composition in single-crops and mixed sowing.

MATERIALS AND METHODS

Field experience was conducted in the experimental fields of the Plant Cultivation and Agriculture Department of the Bashkir State Agrarian University (Southern Forest-Steppe Zone of the Bashkortostan Republic) in 2015-2017. The soil is heavy clay-loam leached chernozem. Agrotechnics in the experiments was generally accepted for the zone. At first the experiment was conducted with corn. We studied the following options:

- Single-crop sowing (100%) (Sudan grass, Spring rape, fodder mallow, Spring vetch
- Mixtures in the ratio (80+20%) (Sudan grass+Spring rape, Sudan grass+fodder mallow, Sudan grass+Spring vetch)
- Mixtures in the ratio (60+40%) (Sudan grass+Spring rape, Sudan grass+fodder mallow, Sudan gass+Spring vetch)

- Mixtures in the ratio (40+60%) (Sudan grass+Spring rape, Sudan grass+fodder mallow, Sudan grass+Spring vetch)
- Mixtures in the ratio (20+80%) (Sudan grass+Spring rape, Sudan grass+fodder mallow, Sudan grass+Spring vetch)

The field experiment was placed in a systematic way in fourfold replication. Mineral fertilizers were applied to two levels of planned yields-25 tons/ha of herbage (N_{40} P_{48} K_{38} control, background 1) and 35 tons of green mass/ha (N_{56} P_{67} K_{54}, background 2). Fertilization was carried out in Spring before cultivation. The area of the plots was 150 m^2 (declared area is 50 m^2). Surveys, observations and analyzes were carried out in accordance with generally, accepted methods. Sowing standards recommended for the Southern forest-steppe zone of the Republic of Bashkortostan are: 3.0 million pieces of Sudan grass viable seeds/1 ha, -2.5 million pieces of Spring vetch viable seeds per ha, 2.0 million pieces of fodder mallow viable seeds per one ha and 3.0 million pieces of Spring vetch viable seeds per ha.

According to agroclimatic zoning, the area of the experimental field belongs to a relatively warm, average humidity region. Climatic conditions can be characterized as continental with dry air and high level of solar energy. Sharp weather and air temperature fluctuations are also, observed.

The Southern forest-steppe refers to the zone of insufficient humidification. The sum of the effective temperatures is 2110-2310°C. The annual amount of precipitation is 476-578 mm. Distribution of precipitation is extremely uneven. The hydrothermal coefficient is 1.05-1.25. The supply of photosynthetically active radiation varies from 1920-2880 kcal/ha.

The studies were carried out with the Sudan grass of the *Chishminskaya Rannya* variety, Spring vetch of the Omichka 3 variety, mallow of the mila variety and the mila variety and Spring rape of the yubileyny variety on heave clay-loam leached chernozem by field experiments. The thickness of the humus-accumulated horizon was 44-49 cm, the total humidity reserves in the soil meter-deep layer reached 310-345 mm. The humus content in the top soil was 8.1-9.2% in average, total nitrogen was 0.49%, phosphorus 0.19% and potassium 0.18%.

According to conventional methods the following studies were conducted: crop density, phenological observations, soil temperature regime, soil water and nutrient regime, structure and botanical composition of the plant formation, linear growth of plants dynamics, leaf surface, photosynthetic potential, yield of herbage, dry matter, chemical composition of plants, etc., using state testing techniques.

RESULTS AND DISCUSSION

For an objective idea of any feed nutritional status, its variability due to various factors, it is necessary to know the content of nutrients (basic) and BAS (Biologically Active Substances) in feeds. A chemical analysis of the herbage of single-crop and mixed crop sowing showed that in 2015 during experiments the content of crude protein at the level of N_{40} P_{48} K_{38} was 8.91-19.13% /1 kg of ADM (Absolutely Dry Matter) in 2016 8.32-17.12% in per kg of ADM and in 2017 8.43-18.07%.

For 2015-2017 in average the yield of crude protein in single-crop and mixed crop sowing of annual gasses was 8.56-18.68%/kg of ADM. The highest content of crude protein (depending on the crop and its share participation) on the N_{40} P_{48} K_{38} background was observed in mallow single-crops sowing (100%) 17.95% in 1 kg of ADM and Spring vetch (100) 18.03% in per kg ADM in mixed sowing of Sudan grass+Spring vetch (20+80%) 16.38% in 1 kg of ADM which significantly exceeded the control variant value in HCP_{05} of factor A main effects 2.29% (Table 1 and 2). With an increase in the mineral nutrition level, the greatest accumulation of crude protein of 18.68% in 1 kg of ADM was obtained in the Spring vetch variant (100%) at the second level of mineral nutrition (background 2) which is significantly higher than at the N_{40} P_{48} K_{38} level.

During the experiments Melnichenko *et al*. (2003) noted the positive effect of mineral fertilizers on herbage quality of Sudan grass mixed crops sowing. The specific gravity of gain varieties in mixtures increased with increasing doses of mineral fertilizers due to a decrease in the leguminous component. In our experiments of strong inhibition, the Spring vetch as a leguminous component did not occur (Melnichenko *et al*., 2003; Kamovskaia, 2006).

There was no strong inhibition of Spring rape wheat with mallow which is associated with a positive allelopathy of these crops with Sudan grass and the calculation of mineral fertilizers for the planned yield in the conditions of the experimental field.

It should be noted that with the increase of mineral nutrition level the fodder mallow was able to

Table 1: Chemical composition of single-crops and mixed crops sowing herbage of annual grass depending on the mineral nutrition level and mixture components share participation (% on absolute dry matter, background 1, for 2015-2017)

		Content in 1 kg of Absolute Dry Matter (ADM) (%)						
Crops	Share participation (%)	Crude protein	Crude fat	Crude fiber	Crude BAS	Ash	Calcium	Phosphorus
Sudan grass	100	8.56	1.77	24.67	57.17	7.07	0.53	0.18
Spring rape		16.58	4.04	25.13	40.37	11.07	2.54	0.20
Fodder mallow		17.95	3.59	24.76	37.03	13.91	2.44	0.25
Spring vetch		18.03	3.64	25.01	42.11	9.37	1.50	0.29
Sudan grass+Spring rape	80+20	9.79	2.31	24.71	53.92	8.13	0.88	0.19
Sudan grass+mallow		10.22	2.17	24.78	53.00	8.67	0.87	0.21
Sudan grass+Spring vetch		10.40	2.25	24.78	53.72	7.85	0.72	0.21
Sudan grass+Spring rape	60+40	11.67	2.73	24.76	50.26	8.85	1.48	0.18
Sudan grass+mallow		11.98	2.55	24.67	49.52	9.74	1.29	0.18
Sudan grass+Spring vetch		12.31	2.56	24.80	50.51	8.41	1.15	0.18
Sudan grass+Spring rape	40+60	13.29	3.19	25.02	47.28	9.18	1.78	0.19
Sudan grass+mallow		13.94	2.89	25.00	45.13	10.99	1.79	0.19
Sudan grass+Spring vetch		14.18	2.89	25.00	47.70	8.68	1.25	0.23
Sudan grass+Spring rape	20+80	14.89	3.57	25.12	44.06	10.03	2.06	0.20
Sudan grass+mallow		16.15	3.26	24.91	41.30	12.11	1.96	0.24
Sudan grass+Spring vetch		16.38	3.54	25.06	44.31	9.07	1.31	0.25

Table 2: Chemical composition of single-crops and mixed crops sowing herbage of annual grass depending on the mineral nutrition level and mixture components share participation (% on absolute dry matter, background 2, for 2015-2017)

		Content in 1 kg of Absolute Dry Matter (ADM) (%)						
Crops	Share participation (%)	Crude protein	Crude fat	Crude fiber	Crude BAS	Ash	Calcium	Phosphorus
Sudan grass	100	8.93	1.84	24.87	56.25	7.24	0.61	0.19
Spring rape		17.16	4.11	25.18	39.25	11.36	2.64	0.23
Fodder mallow		18.50	3.64	24.79	35.79	14.22	2.71	0.28
Spring vetch		18.68	3.78	25.22	40.01	10.43	1.54	0.27
Sudan grass+Spring rape	80+20	10.07	2.35	24.89	53.33	8.33	0.75	0.21
Sudan grass+mallow		10.84	2.24	24.86	52.27	8.67	0.82	0.23
Sudan grass+Spring vetch		10.78	2.29	24.90	52.58	8.44	0.74	0.23
Sudan grass+Spring rape	60+40	12.13	2.81	24.98	49.28	9.18	1.38	0.17
Sudan grass+mallow		12.44	2.63	24.70	49.13	9.51	1.35	0.17
Sudan grass+Spring vetch		13.01	2.68	25.00	49.20	8.90	0.95	0.19
Sudan grass+Spring rape	40+60	13.50	3.21	25.20	46.90	9.21	1.71	0.20
Sudan grass+mallow		14.55	3.01	24.75	45.23	10.40	1.76	0.23
Sudan grass+Spring vetch		14.73	3.00	25.20	46.57	8.88	1.30	0.25
Sudan grass+Spring rape	20+80	15.34	3.73	25.30	42.78	10.38	2.18	0.22
Sudan grass+mallow		16.64	3.30	24.97	40.26	12.26	2.25	0.25
Sudan grass+Spring vetch		16.43	3.47	25.24	43.51	9.60	1.42	0.26

increase the protein content in the mixtures in contrast to the Spring vetch with a similar ratio of components. The accumulation of protein on the background 2 was significantly higher than that of background 1.

The experiments are consistent with the results of Kamovskaya's investigations where with the use of a high protein component, the herbage protein value is significantly increased. The yield of crude protein was 17.7% in Sudan grass single-crops sowing with crude protein content of 11.28% and in Spring vetch mixed crops sowing at the 2 million of viable seeds rate of sowing+0.8 million of viable seeds (approximately 70+30%)[24]. The advantage of our experiment results is analyzing all the possible ratio variants of the mixture components from 100% of Sudan grass to 100% of vetch with a possible variation in the chemical composition which gives a unique opportunity to use the research results in the feed formation and what is equally important to reduce the cost of feed.

For 2015-2017 in average the crude fat content in single-crops and mixed sowing of annual gasses was 1.81-4.08% /1 kg of ADM. Depending on the crop and its share participation, the largest accumulation of crude fat was recorded in single-crop sowing of Spring rape crops (100%) 4.11% in 1 kg of ADM in mixed crops of Sudan grass+Spring rape (20+80%) 3.73 % in 1 kg of ADM which significantly exceeded the value of the control variant for HCP_{05} of the 0.6% factor A main effects (Table 3).

Depending on the mineral nutrition level, the greatest accumulation of crude fat 4.11% in 1 kg of ADM was at the second level of mineral nutrition (background 2) which is significantly higher than at the first level (background 1).

Table 3: Crude fat content (absolute dry matter content in 1 kg, % for 2015-2017 in average)

	Mineral nutrition background B		
Crops A	B1	B2	Average A
Sudan grass (100%)	1.77	1.84	1.81
Spring rape (100%)	4.04	4.11	4.08
Fodder mallow (100%)	3.59	3.64	3.62
Spring vetch (100%)	3.64	3.78	3.71
Sudan grass+Spring rape (80+20%)	2.31	2.35	2.33
Sudan grass+mallow (80+20%)	2.17	2.24	2.21
Sudan grass+Spring vetch (80+20%)	2.25	2.29	2.27
Sudan grass+Spring rape (60+40%)	2.73	2.81	2.77
Sudan grass+mallow	2.55	2.63	2.59
Sudan grass+Spring vetch (60+40%)	2.56	2.68	2.62
Sudan grass+Spring rape (40+60%)	3.19	3.21	3.20
Sudan grass+mallow (40+60%)	2.89	3.01	2.95
Sudan grass+Spring vetch (40+60%)	2.89	3.00	2.95
Sudan grass+Spring rape (20+80%)	3.57	3.73	3.65
Sudan grass+mallow (20+80%)	3.26	3.30	3.28
Sudan grass+Spring vetch (20+80%)	3.54	3.47	3.51
Average B	2.93	3.00	
HCP_{05}	Main effects	Sectional differences	
A	0.6	0.8	
B	$F_\phi > F_{05}$		
AB	$F_\phi < F_{05}$		

Table 4: BAS content (content in 1 kg of absolute dry matter, %, for 2015-2017 in average)

	Mineral nutrition Background b		
Crops A	b1	b2	Average A
Sudan grass (100%)	57.17	56.25	56.71
Spring rape (100%)	40.37	39.25	39.81
Fodder mallow (100%)	37.03	35.79	36.41
Spring vetch (100%)	42.11	40.01	41.06
Sudan grass+Spring rape (80+20%)	53.92	53.33	53.63
Sudan grass+mallow (80+20%)	53.00	52.27	52.64
Sudan grass+Spring vetch (80+20%)	53.72	52.58	53.15
Sudan grass+Spring rape (60+40%)	50.26	49.28	49.77
Sudan grass+mallow (60+40%)	49.52	49.13	49.33
Sudan grass+Spring vetch (60+40%)	50.51	49.20	49.86
Sudan grass+Spring rape (40+60%)	47.28	46.90	47.09
Sudan grass+mallow (40+60%)	45.13	45.23	45.18
Sudan grass+Spring vetch (40+60%)	47.70	46.57	47.14
Sudan grass+Spring rape (20+80%)	44.06	42.78	43.42
Sudan grass+mallow (20+80%)	41.30	40.26	40.78
Sudan grass+Spring vetch (20+80%)	44.31	43.51	43.91
Average B	47.33	46.39	
HCP_{05}	Main effects	Sectional differences	
A	3.0	6.4	
B	$F_\phi > F_{05}$		
AB	$F_\phi < F_{05}$		

For 2015-2017 in average the crude fiber content in single-crops and mixed sowing of annual gasses was 24.67-25.30% in 1 kg of ADM. Depending on the crop and its share, the highest crude fiber content was observed in single-crops Spring rape (100%) 25.18% in 1 kg of ADM in mixed crops Sudan grass+Spring rape (20+80%) 25.30 % and of Sudan grass+Spring vetch (20+80%) 25.24% in 1 kg of ADM which significantly exceeded the control variant value for HCP_{05} of factor a main effects 0.3%. Depending on the level of mineral nutrition, the highest content of crude fiber 25.30% in 1 kg of ADM was at the second level of N_{56} P_{67} K_{54} mineral nutrition, which is significantly higher than at the N_{40} P_{48} K_{38} level. It should be noted that during the experiment fodder mallow and Sudan gass was characterized by fiber content at the 24.67-24.87% level and Spring rape with Spring vetch was characterized by a higher content at the 25.01-25.22% level.

The content of crude BEV in single-crops and mixed crops sowing of annual gasses was 35.79-56.7% /1 kg of ADM (Table 4) for 2015-2017 in average. Depending on the crop and its share, the highest content of crude BAS was recorded in single-crops sowing of grass (control) (100%) 56.71% in 1 kg of ADM in mixed sowing of Sudan grass+Spring rape (80+20%) 53.63% in 1 kg of ADM which was significantly lower than the control variant for HCP_{05} of the factor A 3.0% main effects. Depending on the level of mineral nutrition, the highest content of crude BEV of 57.17% in 1 kg of ADM was at the first level of $N_{40}P_{48}K_{38}$ mineral nutrition which is significantly higher than at the $N_{56}P_{67}K_{54}$ level.

Analysis of the ash content in 1 kg of ADM showed that the Sudan grass with 7.07-7.24% had the lowest content in single-crops sowing; fodder mallow (13.91-14.22%) had the largest for 2015-2017 in average. With an increase in the level of mineral nutrition an increase in this index was noted. All mixed crops exceeded the control variant of Sudan grass (100%) in terms of ash content. Higher values of ash content are noted at a mixing ratio of 20+80%. In the experiments the yield of calcium from 1 kg of ADM was 0.53-2.71%;

Table 5: Herbage nutrient density of single-crop and mixed sowing of annual grass depending on the mineral nutrition level and share of mixture components (absolute dry matter, background 1 for 2015-2017 in average)

		Content in 1 kg of absolute dry matter				
Crops	Share participation (%)	Metabolic energy (mJ)	Goss energy (mJ)	Fodder unit	Digestible protein (g)	Digestible protein concentrarion per 1 fodder unit (g)
Sudan grass	100	7.73	16.10	0.47	45.07	92.91
Spring rape		10.22	18.11	0.84	124.60	147.20
Fodder mallow		9.18	17.38	0.67	138.19	202.18
Spring vetch		9.59	18.29	0.75	138.95	191.23
Sudan grass+Spring rape	80+20	8.34	16.35	0.56	57.45	102.39
Sudan grass+mallow		8.07	16.35	0.52	61.70	116.93
Sudan grass+Spring vetch		8.21	16.49	0.54	63.42	116.08
Sudan grass a+Spring rape	60+40	8.81	16.87	0.62	76.06	120.68
Sudan grass+mallow		8.41	16.58	0.56	79.09	137.70
Sudan grass+Spring vetch		8.50	16.92	0.58	82.46	140.50
Sudan grass+Spring rape	40+60	9.30	17.29	0.69	92.06	132.56
Sudan grass+mallow		8.65	16.92	0.59	98.53	162.36
Sudan grass+Spring vetch		8.81	17.39	0.62	100.90	161.53
Sudan grass+Spring rape	20+80	9.71	17.71	0.76	107.90	141.45
Sudan grass+mallow		9.00	17.39	0.65	120.37	183.00
Sudan grass+Spring vetch		9.61	18.07	0.74	122.68	163.26

Table 6: Herbage nutrient density of single-crop and mixed sowing of annual grass depending on the mineral nutrition level and share of mixture components (absolute dry matter, background 2, for 2015-2017 in average)

		Content in 1 kg of absolute dry matter				
Crops	Share participation (%)	Metabolic energy (mJ)	Gross energy (mJ)	Fodder unit	Digestible protein (g)	Digestible protein concentration per 1 fodder unit (g)
Sudan grass	100	7.80	16.26	0.49	48.86	98.83
Spring rape		10.24	18.16	0.84	130.34	153.88
Fodder mallow		9.18	17.48	0.68	143.61	209.87
Spring vetch		9.61	18.25	0.75	145.46	197.79
Sudan grass+Spring rape	80+20	8.40	16.57	0.57	60.22	105.04
Sudan grass+mallow		8.15	16.55	0.53	67.84	125.64
Sudan grass+Spring vetch		8.28	16.69	0.55	66.88	119.97
Sudan grass+Spring rape	60+40	8.89	17.06	0.63	80.54	125.63
Sudan grass+mallow		8.51	16.72	0.58	83.65	142.23
Sudan grass+Spring vetch		8.63	17.16	0.59	89.32	147.79
Sudan grass+Spring rape	40+60	9.33	17.46	0.70	94.14	133.38
Sudan grass+mallow		8.79	17.03	0.62	104.50	166.36
Sudan grass+Spring vetch		8.94	17.64	0.64	106.28	165.13
Sudan grass+Spring rape	20+80	9.90	17.90	0.78	112.39	141.78
Sudan grass+mallow		9.00	17.47	0.65	125.23	190.47
Sudan grass+Spring vetch		9.44	18.01	0.72	123.18	171.54

Sudan grass with 0.53-0.61% had the lowest content in single-crops sowing and Spring rape with 2.54% had the largest content on background 1. With an increase in the mineral nutrition level an increase in the calcium content was noted. In mixed crops, its content was 0.72-2.25%, the largest calcium content was observed in the Sudan grass+fodder mallow variant (20+80, background 2).

In the experiment the phosphorus indexes were in the range of 0.17-0.29%. Single-crop sowing had a content of 0.18-0.29% in this case a decrease in the phosphorus content in single-crops sowing of Spring vetch with an increase in the mineral nutrition level was noted. Mixed sowing provided phosphorus yield at the level of 0.17-0.26%. The greatest yield was provided by the variant of Sudan grass+Spring vetch in the ratio of 20+80 (background 2).

The analysis showed that the herbage nutrient density of single-crops sowing and mixed sowing depended on the seeding rates, the mixture ratio and the mineral nutrition level. In experiments, the Metabolic Energy content (ME) and Gross Energy content (GE) in single-crops sowing at the $N_{40}P_{48}K_{38}$ level was the largest in 2017, being 7.87-10.63 MJ and 16.03-18.69 in 1 kg of ADM, respectively.

In mixed sowing the largest content of MB and GE was noted in the Sudan grass+Spring rape variant (20+80%) in 2015 and 2017 (Table 5 and 6). At the level of $N_{56}P_{67}K_{54}$ mineral nutrition, the content of MB and GE in single-crop sowings was in the range of 7.59-10.72 and 16.20-18.63 mJ per 1 kg of ADM, respectively. The greatest content of ME was observed in the single-crop sowing of Spring rape as for GE in single-crop sowing of Spring vetch in 2017. Among the mixed sowing, the largest amount of ME was in the Sudan grass+rapeseed Spring (20+80%) variant in 2017 of GE was in the Sudan grass+Spring vetch variant (20+80%) in 2015.

For 2015-2017 in average the content of metabolic energy at the first level of mineral nutrition was 7.73-10.22 MJ per 1 kg of ADM, the content of GE at $N_{56}P_{67}K_{54}$ level was higher by 0.02-0.07 mJ (Table 4, 5). The content of gross energy at the $N_{40}P_{48}K_{38}$ level was 16.10-18.29 mJ per 1 kg of ADM, the content of GE at the level of N_{56} P_{67} K_{54} was 16.26-18.25 mJ. In average during 3 years of experiments the content of fodder units and digestible protein in 1 kg of ADM in single-crops sowing was 0.47-0.84 control units and 45.07-145.46 g, respectively.

In mixed sowing, the content of fodder units was at the 0.52-0.78 level and the digestible protein at the level of 57.45-125.23 g. One of the important points in determining the forage value of forage crops is the concentration of Digested Protein (DP) per 1 control unit. In experiments the concentration of DP at the $N_{40}P_{48}K_{38}$ level was in the range of 92.91-202.18 g at the $N_{56}P_{67}K_{54}$ level of was in the range of 98.83-209.87 g.

CONCLUSION

By the results of the researches the following conclusion can be made the crops used in the experiment to raise the content of digestible protein in herbage has proved their efficiency. During 3 years of the research in average the concentration of digestible protein per fodder unit in Spring rape was 147.20-153.88 g in Spring vetch 191.23-197.79 g in fodder mallow was 202.18-209.87 g. The usages of these crops in mixed sowing with Sudan grass made it possible to increase the concentration of digestible protein to the level of 102.39-190.47 g with control level of 92.91-98.83 g.

The highest concentration of digestible protein was observed at a ratio of 20+80 at the level of N_{56} P_{67} K_{54} mineral nutrition.

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