

RESEARCH ARTICLE

Influence of Agrotechnical Measures on the Quality of Feed of Legume-Grass Mixtures

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Received: 25.11.2019. Accepted: 09.12.2019

The influence of agrotechnical measures on the quality of feed of legume-grass mixtures has been studied. Based on the results obtained, it has been found that, on average, the content of crude protein in the dry weight of feed has increased from 10,4–12,5 to 14,8–16,7% or by 4,2–4,4 absolute % at LSD₀₅ 0,8% over the years of cultivation in fertilizer-free variants and on the background of N₃₀P₆₀K₆₀ application in legume-cereal grass stands with the inclusion of red clover and creeping alfalfa, as compared to grass swards.

Key words: Legume-grass herbage; Yield; Chemical composition; Feed quality; Fertilizer

Introduction

Insufficient production of high-quality protein feed, which causes a decrease of animal productivity, is one of the urgent problems in the development of animal husbandry. The widespread use of perennial legumes whose dry matter contains from 17 to 22% of protein can solve the problem of providing livestock with feed protein, whose deficiency is more than 30%. The inclusion of legumes as components of meadow phytocenosis will not only increase their productivity but also serve as an effective way of increasing the crude protein content of the feed (Kovtun, 2009; Erashev, 2011).

The ratio of mineral elements in plant mass and feeding stuffs, which is of great importance, depends on the intensity of biological absorption of chemical elements from soils, which is determined by environmental factors, health of plants and species features of herbage. Optimal use of organic nutrients can only be expected when the feed contains a sufficient amount of minerals. Nutritional conditions, yield and intensity of use determine a change in the mineral composition of the feed (Prorochenko, 2016; Tsyhanskyi et al., 2019).

Fertilizer and methods of its introduction with focus on the species composition of grass stand in the preparation of diets for feeding high-performance livestock have the most significant impact on feed quality and, in particular, indicators of biochemical composition (Kovtun, 2016; Kovtun, 2017).

Perennial legumes with 17 to 22% of protein in the dry matter are the main source of increasing protein content in the feed, while in cereals this indicator varies from 8 to 12%. Leguminous grass species raise the nutritional value of feed by increasing the concentration of crude protein, especially in young herbs. As the plants ripen, the amount of crude protein decreases. Perennial cereal grasses provide the bulk of feed output, in particular with sufficient moisture in the forest-steppe zone (Muir, 2011). Legumes and cereals differ not only in crude protein content but also in the rate of its decline throughout the season (Graw, 2004). Therefore, the use of legume-grass mixtures for meadow formation will ensure a uniform accumulation of crude protein during the growing season, and will lead to higher productivity of newly formed meadows (Kovtun, 2017; Butenko et al., 2019).

According to the studies of domestic and foreign scientists, the quality of plant feed depends on the botanical composition. The amount of crude protein in the dry matter of grasses can rise by 2-5% with the increase of the legume constituent in the component composition of agrophytocenosis. The ability of legumes to fix nitrogen from the atmosphere promotes an active formation of protein substances. The development phase in which grass is mowed also has an effect on the chemical composition of feed (Kovtun, 2010; Veklenko, 2015).

Materials and Methods

The studies were conducted on the dark gray podzolic heavy-loam soil on the experimental farm "Peremoha" of Tysmenytsky district, Ivano-Frankivsk region, founded in 2008. The varieties used in the research were of local selection, suitable for growing on dried soils, highly productive and were tested in the conditions of the area. The soil of the experimental plot possesses the following agrochemical parameters: humus content in the arable layer - 2.12%, saline pH - 4.8, alkaline-hydrolyzed nitrogen - 53, mobile phosphorus - 83, mobile potassium - 69 mg/kg soil.

Assessment of weather conditions during the years of research was carried out on the basis of meteorological data obtained from the Ivano-Frankivsk Regional Hydrometeorological Center.

In 2009, the weather conditions were different from long-term indicators and yet favorable for the formation of legume-cereal agrophytocenoses. During the growing season the rainfall was 67.3 mm below normal, and there was an increase in the average daily air temperature by 0.6 ° C as compared to the average multi-year indicators.

A high temperature regime with an average daily temperature of +1.0 ° C above the long-term normal, increased rainfall by 43.2% more than the normal were characteristic of the year 2010. The year 2011 was quite favorable for the formation of agrophytocenosis of legumes and cereals. Plant growth and development was satisfactory. The two-factor scheme provided four levels of fertilization: control (without fertilizers) and with introduction of N₃₀P₆₀K₆₀, P₆₀K₆₀, P₉₀K₁₂₀ (Table 1) 34% ammonium nitrate, 20% granular superphosphate and 56% potassium chloride were used as fertilizers. Strains of root nodule bacteria and fertilizers were introduced at the time of sowing grass mixtures.

Table 1. Chart of field experience.

Factor A - types of grasses and their seeding rates, kg/ha	Factor B – fertilizers
1. Red clover, 10+awnless brome, 12+Italian ryegrass, 12+red fescue grass, 10	Without fertilizers N ₃₀ P ₆₀ K ₆₀
2. Creeping alfalfa 10+awnless brome, 12+Italian ryegrass, 12+red fescue grass, 10	N ₃₀ P ₆₀ K ₆₀ +strain P ₆₀ K ₆₀
3. Awnless brome, 12+Italian ryegrass, 12+red fescue grass, 10	P ₆₀ K ₆₀ +strain P ₉₀ K ₁₂₀ P ₉₀ K ₁₂₀ +strain

Recognized and promising varieties of legume and cereal grasses such as red clover - Darunok, creeping alfalfa - Andi, awnless brome – Kozarovyts'kyi, Italian ryegrass - Peredhirna, red fescue grass- Menchul'ska were sown.

Conventional methods (Dospikhov, 1985) and "Methods of conducting experiments on fodder production" (Babych, 1998) were used.

Results

Studies have shown that inclusion in the grass mixtures of cereals, such as awnless brome, Italian ryegrass, red fescue grass and legumes, such as red clover and creeping alfalfa considerably improves the quality of feed, enlarges the content of crude protein and protein, increases digestibility of dry matter, and at the same time, decreases the content of nitrogen-free extractives, crude fat and crude fiber. Thus, the content of crude protein in legume-grass herbage with the inclusion of the above mentioned legumes increased from 10.4-12.5 to 14.8-16.7% or by 4.2–4.4 absolute% at LSD₀₅ 0.8% in variants without fertilizers and on the background of N₃₀P₆₀K₆₀ in comparison with grass sward (Table 2).

Among legume-grass herbage a significantly higher content of crude protein in the dry weight (16.5–17.0%), regardless of the fertilizer, was characteristic of that with inclusion of creeping alfalfa, where the content ranged from 14.8–15.8%, which was due to better conservation and higher content of this legume component in the herbage.

Mineral nitrogen introduced in the grass sward in a dose N₃₀ in combination with P₆₀K₆₀ had a significantly less impact on the crude protein content in the dry mass of the legume-grass herbage. The grass sward composed of awnless brome, Italian ryegrass and red fescue grass showed an increase of crude protein content from 10.4 to 12.5% or by 2.1%. Mineral nitrogen in a dose N₃₀ had an even smaller effect on the crude protein content of the legume-grass herbage giving it a slight increase.

Analysis of the parameters of the crude protein content in the dry weight of food of the legume-grass herbage depending on the combined application of different doses of phosphorus-potassium fertilizers showed that introduction of both P₆₀K₆₀ and P₉₀K₁₂₀ led to a slight increase of this indicator, namely by 0.1-0.6% at LSD₀₅ 0.9%. The application of strains of nitrogen-fixing preparations on both studied legume-grass herbage increased the content of crude protein insignificantly. On different agricultural backgrounds, namely N₃₀P₆₀K₆₀, P₆₀K₆₀ i P₉₀K₁₂₀, its content increased only by 0.1-0.3% at LSD₀₅ 0.9%. The use of symbiotic and mineral nitrogen had the same affect with even less increase of protein in the dry mass. Thus, in fertilizer-free variants and on the background of N₃₀P₆₀K₆₀, the protein content in the dry weight of the feed increased from 7.3–8.8 to 10.4–11.7% or by 2.9 absolute% at LSD₀₅ 0.5%. In legume-grass stands when compared to grass swards. Among legume-grass herbage the grass stand with inclusion of creeping alfalfa had a notably higher content of crude protein in the dry mass than that with red clover. On the same agricultural backgrounds the digestibility of dry mass of the feed in legume-grass herbage increased from 54-55% to 56-58%, or by 2-4% at LSD₀₅ 3% in comparison with grass swards. Nevertheless, the legume components and types of fertilizers hardly changed the digestibility in legume-grass stands. With inclusion of perennial legumes in the fertilizer-free variant the content of nitrogen-free extractives in the dry weight decreased from 49.1 to 45.5-46.2%, and crude fiber content reduced from 28.6 to 25.7-26.4%. However, the legume component did not naturally change the stated indicators.

The content of nitrogen-free extractives in the dry weight of grass feed under the action of both symbiotic and mineral nitrogen in the dose N₃₀ in combination with the introduction of P₆₀K₆₀ on the grass sward decreased from 49.1 to 46.5% or by 2.6%. Meanwhile, the decrease was insignificant in legume-grass herbage under exposure to N₃₀.

When comparing the chemical composition of the feed with the zootechnical standards of feeding cattle, it was found that most of the quality indicators, by and large, met the latter. However, the crude protein content on the grass sward on backgrounds without fertilizers and with introduction of N₃₀P₆₀K₆₀ was lower than normal (10.4–10.8% in dry weight at standard 14%).

When comparing the chemical composition of feed with DSTU standards 4674, 4684, 4685, 4782, 8528, it was found that the grass as for the content of crude protein and crude fiber meets the requirements of high quality herbal feed in making hay, haylage, silage, green fodder and artificially dried grass feeds. All legume-grass herbage, irrespective of the background of fertilizers, and a grass sward with the N₃₀ introduction on the P₆₀K₆₀ background, are suitable for the production of hay, haylage and green fodder of Class 1 and artificially dried grass fodder of Class 3.

Table 2. Chemical composition of feed and digestibility of legume-grass herbage under different fertilizers, % in dry weight, 2009-2011.

Grass mixture (types of grasses and seed rate, kg/ha)	Fertilizers	Crude protein	Protein	Crude fat	Crude fiber	NFE	Digestibility		
1. Red clover, 10+awnless brome, 12+Italian ryegrass, 12+red fescue grass, 10 (cereals)	Without fertilizers	14.8	10.4	3.3	26.4	46.2	58		
	N ₃₀ P ₆₀ K ₆₀	15.7	11.0	3.4	26.3	45.2	58		
	N ₃₀ P ₆₀ K ₆₀ +strain	15.8	11.1	3.5	26.2	45.1	58		
	P ₆₀ K ₆₀	15.3	10.7	3.4	25.7	46.2	58		
	P ₆₀ K ₆₀ +strain	15.5	10.9	3.5	25.6	46.0	58		
	P ₉₀ K ₁₂₀	15.4	10.8	3.4	25.7	46.0	59		
Creeping alfalfa + cereals	P ₉₀ K ₁₂₀ +strain	15.6	10.9	3.5	25.6	45.8	59		
	Without fertilizers	16.5	11.6	3.2	25.7	45.5	56		
	N ₃₀ P ₆₀ K ₆₀	16.7	11.7	3.3	25.6	45.2	56		
	N ₃₀ P ₆₀ K ₆₀ +strain	17.0	11.9	3.4	25.5	44.9	57		
	P ₆₀ K ₆₀	16.6	11.6	3.3	25.8	45.1	57		
	P ₆₀ K ₆₀ +strain	16.8	11.8	3.4	25.7	44.9	57		
Cereals	P ₉₀ K ₁₂₀	16.7	11.7	3.3	25.8	44.9	58		
	P ₉₀ K ₁₂₀ +strain	16.9	11.8	3.4	25.7	44.7	58		
	Without fertilizers	10.4	7.3	3.6	28.6	49.1	54		
	N ₃₀ P ₆₀ K ₆₀	12.5	8.8	3.7	29.0	46.5	55		
	grass stand fertilizer	0,8	LSD ₀₅ , t/ha by factors:					0.5	3
		0,9						0.6	3
grass stand fertilizer	60	Share of factors, %:					59	61	
	40						41	39	

A grass sward with introduction of N₃₀P₆₀K₆₀ or without fertilizers as for the crude protein and fiber content is suitable for the production of hay, haylage and green fodder of Class 2, however, it is unsuitable for the production of artificially dried grass feeds. It was found that the content of fodder units in the dry mass of different types of herbage ranged from 72 to 78% and the exchange energy content- from 8.5 to 9.0 MJ/kg (Table 3).

The inclusion of perennial legumes, in particular red clover or creeping alfalfa in cereal grass mixtures, has somewhat improved the nutritional value of feed as for the content of feed units and their energy intensity. During 2009-2011 the content of fodder units in the dry mass in these herbage increased on average from 72-73 to 74-77% and the content of the exchange energy - from 8.5 to 8.6-9.0 MJ/kg as compared to cereal grass mixtures.

Table 3. Nutrition and energy value of feed depending on fertilizers and nitrogen-containing preparations of grass mixtures.

Grass mixture (types of grasses and seed rate, kg/ha)	Fertilizer	Content of feed units, %	Content of exchange energy, MJ/kg	Provision of feed unit with the digestible protein, g
Red clover, 10+awnless brome, 12+Italian ryegrass, 12+red fescue grass, 10(cereals)	Without fertilizers	74	8.6	141
	N ₃₀ P ₆₀ K ₆₀	75	8.7	146
	N ₃₀ P ₆₀ K ₆₀ +strain	76	8.8	146
	P ₆₀ K ₆₀	75	8.7	142
	P ₆₀ K ₆₀ +strain	76	8.8	143
	P ₉₀ K ₁₂₀	75	8.7	143
	P ₉₀ K ₁₂₀ +strain	76	8.8	145
	Without fertilizers	76	8.8	152
	N ₃₀ P ₆₀ K ₆₀	77	8.9	151
	N ₃₀ P ₆₀ K ₆₀ +strain	78	9.0	153
Creeping alfalfa+cereals	P ₆₀ K ₆₀	77	8.9	152
	P ₆₀ K ₆₀ +strain	78	9.0	150
	P ₉₀ K ₁₂₀	77	8.9	153
	P ₉₀ K ₁₂₀ +strain	78	9.0	152
	Without fertilizers	72	8.5	103
Cereals	N ₃₀ P ₆₀ K ₆₀	73	8.5	122

When comparing the obtained parameters of these indicators on legume-grass herbage with different leguminous components, it was found that herbage with creeping alfalfa tended to show rather higher parameters than those with inclusion of red clover. The dry weight of alfalfa contained 2% more feed units and 0.2 MJ/kg more of the exchange energy.

The type of fertilizer had a slight influence on nutrient and energy content parameters. When comparing them with zootechnical standards, it was found that the content of feed units was within the standards. 1 kg of dry weight of feed contained 8.1-8.9 MJ of

exchange energy, which is a little less than the standard of 9–11 MJ. It has been established that, according to the nutrient and energy content parameters, the dry food of the fodder of different variants of the experiment, as a whole, meets the requirements of the current state standards of Ukraine (DSTU 4674, 4684, 4685, 4782, 8528) for the purpose of making hay, haylage, silage, green fodder and artificially dried grass feeds. All legume-grass herbage, irrespective of the background of fertilizers, and a grass sward with introduction of N_{60} on the background $P_{60}K_{60}$, are suitable for the production of hay, haylage and green fodder of the first and second classes. The provision of feed unit with the digestible protein ranged from 103 to 158 g depending on the factors researched. The symbiotic and mineral nitrogen were the most influential in the growth of this indicator. With the inclusion of different types of perennial legumes in cereal grass mixtures, as a source of symbiotic nitrogen, the provision of feed unit with the digestible protein in the fertilizer-free variant and on the background of $N_{30}P_{60}K_{60}$ increased from 103–122 g to 141–152 g or by 30–38 g. However, the introduction of $N_{30}P_{60}K_{60}$ in the grass sward increased this indicator by 19 g as compared to the effect of symbiotic nitrogen. Among legume-grass herbage with different legume components, the alfalfa grass sward had a better provision of the fodder unit with digestive protein than the clover grass sward. It was established that significant changes under the influence of the factors researched occurred in mineral composition of the feed (Table 4). Legume-grass herbage compared to grass swards on the same agricultural backgrounds (variants without fertilizers and with introduction of $N_{30}P_{60}K_{60}$) were characterized by a better mineral feed composition for feeding livestock. These grass stands, irrespective of the agricultural background, accumulated by 0.8–1.1% more of crude ash in the dry mass, namely 9.1–9.4%, while in the grass sward the indicator was 8.3%.

Table 4. Content of crude ash, macronutrients and their ratio in legume-grass herbage depending on the type of fertilizer, % in dry weight.

Grass mixture	Fertilizes	Crude ash	P	K	Ca	Mg	K: (Ca+Mg)	Ca:P
	Without fertilizers	9.3	0.35	2.33	0.56	0.18	3.1	1.6
Red clover, 10+awnless brome, 12+Italian ryegrass, 12+red fescue grass, 10(cereals)	$N_{30}P_{60}K_{60}$	9.4	0.36	2.36	0.55	0.17	3.3	1.5
	$N_{30}P_{60}K_{60}$ +strain	9.4	0.37	2.35	0.56	0.18	3.2	1.5
	$P_{60}K_{60}$	9.4	0.37	2.37	0.59	0.19	3.0	1.6
	$P_{60}K_{60}$ +strain	9.4	0.36	2.36	0.60	0.20	3.0	1.7
	$P_{90}K_{120}$	9.5	0.37	2.49	0.59	0.20	3.2	1.6
	$P_{90}K_{120}$ +strain	9.5	0.36	2.48	0.60	0.21	3.1	1.7
Creeping alfalfa + cereals	Without fertilizers	9.1	0.34	2.33	0.55	0.15	3.3	1.7
	$N_{30}P_{60}K_{60}$	9.2	0.35	2.38	0.53	0.14	3.5	1.5
	$N_{30}P_{60}K_{60}$ +strain	9.2	0.33	2.35	0.54	0.15	3.4	1.6
	$P_{60}K_{60}$	9.2	0.34	2.38	0.57	0.15	3.3	1.7
	$P_{60}K_{60}$ +strain	9.2	0.33	2.37	0.58	0.16	3.2	1.8
	$P_{90}K_{120}$	9.3	0.36	2.47	0.58	0.16	3.3	1.6
Cereals	$P_{90}K_{120}$ + strain	9.3	0.35	2.46	0.59	0.17	3.2	1.7
	Without fertilizers	8.3	0.33	2.59	0.44	0.13	4.5	1.3
	$N_{30}P_{60}K_{60}$	8.3	0.31	2.62	0.42	0.12	4.9	1.4
Zootechnical standard			0.2- 0.35	1.0- 3.0	0.3- 0.6	0.12- 0.26		0.7- 2.5
LSD ₀₅		0.5	0.02	0.10	0.03	0.01		

These legume-grass herbage in comparison with grass swards accumulated more calcium and magnesium and less potassium. On the same backgrounds of fertilizers (without fertilizers and with introduction of $N_{30}P_{60}K_{60}$) the amount of calcium in the dry mass of legume-grass herbage with different legume components accumulated to 0.53–0.56%, while in grass swards this indicator was 0.42–0.44%, which is by 0.11–0.12% more. The content of magnesium in the dry mass of legume-grass herbage was 0.14–0.18% and 0.12–0.13% in grass swards, which is by 0.02–0.05% more. Potassium in the dry weight of legume-grass herbage made up 2.33–2.38%, while in grass swards it came to 2.59–2.62, which is by 0.24–0.26% less. It was found that legume-grass herbage, as compared to grass swards, accumulated phosphorus by 0.03–0.05% more in the dry mass, namely 0.34–0.36% versus 0.31–0.33%. It should be noted that the introduction of phosphate and potassium fertilizers in doses $P_{60}K_{60}$, $P_{90}K_{120}$ and $N_{30}P_{60}K_{60}$, as well as in combination of these fertilizers with nitrogen-fixing preparations, most commonly, insignificantly affected the mineral composition of the feed. However, introduction of $P_{90}K_{120}$ and $P_{90}K_{120}$ + strain increased, within the zootechnical standards, the amount of potassium in the dry mass of legume-grass herbage from 2.33 to 2.46–2.49%, or by 0.13–0.16% at LSD₀₅ 0.10%. The studies showed that changes in the mineral composition of feed from various meadow grass stands lead to significant changes in the ratio of mineral elements, which are so important for cattle feeding. Thus, with inclusion of perennial legumes in legume-grass herbage, on the same agricultural backgrounds (without fertilizers and with introduction of $N_{30}P_{60}K_{60}$), the ratio of potassium to the amount of calcium and magnesium in the dry mass of grass feed decreased from 4.5 to 3.1–3.5, and the ratio of calcium to phosphorus slightly increased from 1.3–1.4 to 1.5–1.8. However, it should be noted that both ratios K: (Ca + Mg) and Ca: P remained within the zootechnical standards for cattle. This leads to the conclusion that the raw material for the production of grass feed from the studied herbage is quite suitable for feeding cattle.

Conclusion

The studies show that effective ways of fertilizers introduction change the chemical composition of dry mass, nutritional value and energy value in different legume-grass herbage. It was also found that legume components determined the content of crude protein, crude fiber, exchange energy, fodder units and the provision of feed unit with the digestible protein. Grass mixtures of red clover, awnless brome, Italian ryegrass and red fescue grass had the highest content of crude protein, exchange energy, fodder units and the provision of feed unit with the digestible protein. The fertilizer in a dose $N_{30}P_{60}K_{60}$ +strain

proved to be the most effective for all grass mixtures as it provided the highest proportion of creeping alfalfa in the phytocenosis as well as the highest food value of the dry weight.

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Citation:

Karbiavska, U. M., Butenko, A. O., Masyk, I. M., Kozhushko, N. S., Dubovyk, V. I., Kriuchko, L. V., Onopriienko, V. P., Onopriienko, I. M., Khomenko, L. M. (2019). Influence of Agrotechnical Measures on the Quality of Feed of Legume-Grass Mixtures. *Ukrainian Journal of Ecology*, 9(4), 547-551.



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