

The effectiveness of surface improvement of sloping mountain meadows of the Carpathians

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Goal. To determine peculiarities of formation of phytocenoses, productivity, chemical composition, nutritive value, and energy content of grass forages depending on the options for surface improvement of slope meadows of the mountain forest belt of the Carpathians at different modes of use. **Methods.** General scientific methods (hypotheses, induction and deduction, analogy, generalization) — to select the work program, and special (field, laboratory, mathematical-statistical, calculation) — to conduct researches and their generalization. **Results.** Surface improvement of cereals and grasses (with 28% share of low-value in feed terms *Nardus stricta*) low-productive (1.39 t/ha of dry weight) slope grasslands of mountain forest belt of the Carpathians improves their species composition and chemical composition of feed increases the productivity of the land. Share of sowed cereals or legumes increases to 34 – 46%. Under the hay regime the highest efficiency as to the output from 1 ha of dry mass was fixed for reseeding mixtures of grasses on the background of N60P30K60 (4.33 t), for the multi-mow regime — reseeding of white clover on the background of P30K60 (3,71 t), that was, respectively, by 14 and 106% more than in the variants without reseeding, and by 146 and 167% more than in the variants without improvement. Among measures of surface improvement influencing forage quality by chemical composition, increasing the content of crude protein, was the introduction of N60P30K60 or 15 t/ha of manure at multi-mow use, and reseeding of white clover — on the background P30K60. Regardless of the measures of surface improvement the highest content of crude protein, the best energy content, and nutritional value of grass fodder were fixed for multi-mow (simulated pasture) mode of use than for hay-mowing. **Conclusions.** Surface improvement of meadows of the mountain forest belt of the Carpathians with natural grass by operating factors of the improvement of species composition and quality of grass fodder, as well as an increase of their productivity, is the annual entering of N60P30K60 or 15 t/ha of manure, or N60P30K60 + reseeding of grass mixture (*Lolium pratense* and *Phleum pratense*) for hay use, or P30K60 + reseeding of white clover for multi-mow use. The best positive effect ensures the application of mineral fertilizers in combination with the reseeding of perennial grasses.

Key words: *protein, energy, feed, fodder units, reseeding of grasses, nutritional value, natural pasture, floristic richness, fertilizers.*

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Today, livestock in Ukraine is insufficiently provided with high-quality high-protein feeds, which is primarily due to low yields of forage crops and their imbalance in protein. Due to the imbalance of feed and a significant deficit of protein in the diet of animals, overconsumption of feed reaches 35%, and the cost of production increases by 1.3-1.5 times. The supply of feed unit with digestible protein is often only 80-85 g instead of the scientifically substantiated 105-115 g [1].

Hayfields and pastures are a source of high quality and cheap feed for livestock. Hay remains one of the main feeds in the diets of animals, as it promotes the normal functioning of the stomach and intestines. It is the only roughage that contains vitamin D, which regulates mineral metabolism in animals [2].

To increase the productivity of natural forage lands and provide livestock with high-quality feed, measures of their surface improvement are widely carried out. Scientific research and production experience show that with a relatively small investment of material and financial resources, fodder production on pastures and meadows can be doubled. Improving natural grasslands by applying fertilizers makes it possible to form highly productive, with improved feed quality and long-term use of agrocenosis [3-6].

World experience convincingly proves that the second most important factor for agricultural production is fertilizers. The introduction of scientifically sound standards of mineral and organic fertilizers can ensure a deficit-free balance of nutrients and humus [7].

In addition to increasing yields, onion growers face no less important task — obtaining high quality feed. One of the main criteria for assessing the nutritional value of feed is the content of digestible protein, the lack of which in the diet reduces the productive effect of other nutrients [8].

The content of organic and mineral substances that reflect the nutritional value of feed depends on the phenological phase of growth and development of plants. Perennial herbs are most nutritious in the early stages of the growing season, because during this period they contain not only complete protein, vitamins, but in small quantities and more acceptable to animals fiber, where there is little lignin, so it is well digested [9].

Types of meadow phytocenosis grasses have an important influence on the quality of fodder, therefore the selection of grasses for creation of new agrophytocenoses plays a crucial role in ensuring high quality. Herbaceous plants, which include more leafy lower grasses or upper grasses with surface foliage, contain 19 - 38% more leaves, are better supplied with nutrients and have higher energy saturation. Unequal content of nutrients was found in some plant organs [10, 11].

In recent years, work on surface improvement of pastures has virtually stopped. But there are significant reserves that increase the productivity of grasslands by 1.5-2.0 times, as well as improve the quality of feed. No matter how extreme the soil and climatic conditions of the Carpathian region, there are reserves for increasing farm productivity. Thus, the content in the grass mixture of 50% of creeping clover completely solves the protein problem, and 20% of carbohydrates in fenugreek fenugreek (instead of 8% in the prey) replace expensive carbohydrate feeds (corn, beets, molasses and partially concentrates) [12]. Studies by foreign and domestic scientists have shown that the use of various methods of surface improvement of old meadows (systematic fertilization with mineral fertilizers, rejuvenation of grass by disking turf) productivity of pasture grasslands increases by an average of 2.2-2.5 times or , 6 to 5.6-6.5 t/ha of dry mass. Sowing of perennial legumes in turf provides an increase in the share of legume components in the crop to 43 and 47% and increase productivity by 1.5-1.8 times [13, 11]. The introduction of moderate doses of nitrogen fertilizers on cereals increases the dry matter content of crude protein by 2-3% [14], while on legumes or legumes - does not increase its content [15].

The purpose of the work. To establish the peculiarities of phytocenosis formation, productivity, as well as chemical composition, nutritional value and energy consumption of grass fodder depending on the options of surface improvement of slope meadows of the Carpathian mountain-forest belt on different modes of use.

Materials and methods of research. Experimental studies to study the methods of surface improvement of floodplain meadows of the Carpathian mountain-forest belt with natural grass cover under different modes of use were performed during 2017–2019 on sod-brown soil (deep) soils in the farm of Martyschuk V.F. (Krasnyk village, Verkhovyna district, Ivano-Frankivsk region). The size of sown areas — 10 m², accounting — 8 m². The experiment was repeated four times. Mineral fertilizers in all doses were applied in the spring at the same time. The scheme of the experiment included five options for surface improvement in two modes of use: haymaking with two slopes and multi-mowing (imitation of pasture use).

The research was performed according to the methodology of the Institute of Feed NAAS [16]. Crop accounting was performed by the weight method, by weighing, followed by recalculations of the yield of 1 ha of green mass, dry mass, feed units, crude protein, metabolic and gross energy; dry matter content (dry mass) — thermostat-weight method at a temperature of 105°C. The chemical composition of the feed was determined in plant samples taken during harvest, air-dried and ground. The dry matter of vegetable mass was determined by the content of crude protein, protein, crude fat, crude fiber, phosphorus, potassium and digestibility of feed dry matter in vitro — by infrared spectroscopy, the content of nitrogen-free extractives (BER) — by calculation. The content of feed units, gross and metabolic energy in feeds was determined by a calculation method using the coefficients of digestibility of dry matter of feed and the content of crude protein, crude fat, crude fiber, BER [17]. Mathematical processing of research results was performed by methods of analysis of variance and variation statistics according to Dospekhov B.A. [18].

Research results. The results of our research on the impact of surface improvement measures of sloping meadow lands with natural grass cover of the river on the second terrace of the Black Cheremosh river valley of the Carpathian mountain forest belt showed that the initial grass cover for improvement was grass-grass with a content of wild grasses 56-63% I — 26-30% and unsown legumes 6-9%. The share of low-value in terms of fodder compressed whitewash reached 28%, and productivity did not exceed 1.3 t/ha of fodder units.

With the application of a set of surface improvement measures, their species composition has improved, productivity has increased and the chemical composition of feeds has improved. At the same time, the floristic saturation of the meadow phytocenosis decreased. In the third year of use for sowing at the beginning of the study of a mixture of cereals on the background of N₆₀P₃₀K₆₀ for hay use compared to the option without improvement, the total number of species decreased from 32 to 20, and for sowing creeping clover for multiple use on the background of P₃₀K₆₀ — from 41 to 29. More the floristic saturation of the phytocenosis in all variants of surface improvement was more diversified than haymaking.

On average for 2017-2019 with the introduction of N₆₀P₃₀K₆₀ the content of unsown cereals increased by 6-9% (Table 1). With hay use for sowing in the first year in the spring in the turf mixture of cereals from meadow thyme and meadow fire against the background of N₆₀P₃₀K₆₀ application, their total share increased to 46%, and for multi-use and for sowing creeping clover against the background of P₃₀K₆₀ application, the total 39% or 31%, including meadow clover up to 34%.

1. Botanical composition of grassy slope meadows depending on the options for surface improvement (average for 2017-2019)

Options for surface improvement	Cereals of everything	including			Beans all	including creeping clover	Variety
		by components		unsown			
		1st	2nd				
Haymaking use							
Без добрив	67	5	3	62	5	-	28
P ₃₀ K ₆₀	66	8	3	55	7	-	27
N ₆₀ P ₃₀ K ₆₀	75	9	4	62	2	-	23

N ₆₀ P ₃₀ K ₆₀ + sowing of cereal mixture *	80	22	24	34	1	-	19
Manure, 15 т/га	74	9	4	61	3	-	23
Multi-use							
Без добрив	67	5	3	59	7	-	26
P ₃₀ K ₆₀	66	5	3	58	8	-	26
P ₃₀ K ₆₀ + Sowing of creeping clover	41	4	6	31	39	34	20
N ₆₀ P ₃₀ K ₆₀	72	6	4	62	2	-	26
Manure, 15 т/га	72	6	4	62	3	-	25
* components of the mixture: 1) meadow thyme, 6 kg / ha +2) meadow fireweed, 10 kg / ha. In other variants of surface improvement, meadow thyme and meadow fireweed with a share of 3-9% were present in the natural grassland.							

The productivity of slope meadows with natural grass cover, depending on the options of surface improvement on average for three years of research on the yield of 1 ha of dry mass for hay use ranged from 1.76 to 4.33 tons, and multi-slope — 1.39 to 7.71 tons (Table 2).

Thus, productivity was 10–16% higher for haymaking than for multi-mowing use. While the yield of 1 ha of feed units and crude protein had a certain advantage (by 5-6%) in all variants had a multi-slope mode of use.

2. Productivity of meadows on the slope depending on the options of surface improvement, t/ha (2017-2019)

Options for surface improvement	Dry weight by years of use			Average for 2017–2019			
	2017	2018	2019	dry weight	of feed un	raw protein	metabolic energy, GJ / ha
Haymaking use							
Without improvement	1,21	1,90	2,18	1,76	1,14	0,19	15,3
P ₃₀ K ₆₀	1,52	2,25	2,49	2,09	1,38	0,24	18,2
N ₆₀ P ₃₀ K ₆₀	3,20	3,94	4,25	3,79	2,53	0,51	33,4
N ₆₀ P ₃₀ K ₆₀ + sowing of cereals	3,67	4,56	4,78	4,33	2,86	0,59	38,1
Manure, 15 т/га	2,92	3,78	3,92	3,54	2,37	0,47	31,2
HIP ₀₅ , т/ ha	0,11	0,14	0,15	0,13			
Multi-use							
Without improvement	1,00	1,73	1,45	1,39	1,08	0,21	13,3
P ₃₀ K ₆₀	1,25	1,95	2,21	1,80	1,42	0,27	17,3
P ₃₀ K ₆₀ + creeping clover sowing	3,16	3,80	4,18	3,71	3,04	0,70	36,7
N ₆₀ P ₃₀ K ₆₀	2,93	3,43	3,95	3,44	2,72	0,61	33,0
Manure, 15 т/га	2,57	3,22	3,53	3,11	2,45	0,55	29,9
HIP ₀₅ , т/ ha	0,10	0,12	0,14	0,12			

In the haymaking mode, the highest productivity was for sowing a mixture of cereals on the background of N₆₀P₃₀K₆₀, and in the case of multi-mowing - sowing of creeping clover on the background of P₃₀K₆₀, which is 14 and 106% more compared to non-sowing and 146 and 167% — compared to option without fertilizer. Additional application of N₆₀ on the background of P₃₀K₆₀ in both modes of use increased productivity after yield from 1 ha of dry mass by 81-91%, and in comparison with the option without application of fertilizers — by 115

and 147%. Manure application at a dose of 15 t/ha compared to the option without fertilizer application increased it by 101 and 123%, respectively.

Regularities of productivity at the rate of 1 ha of dry mass, depending on the studied options for surface improvement and modes of use, which were on average for 2017-2019, have been preserved over the years of research. For haymaking, two slopes with a share of 60-70 and 30-40%, respectively, were obtained, and for multi-mowing (pasture imitation) — three. In multi-slope use, the most uniform distribution of yield by slopes was in the variants with the introduction of P₃₀K₆₀ + sowing of creeping clover with a share of 1st slope 39%, 2nd — 33 and 3rd — 28% and unevenness, which is expressed by the coefficient of variation — 18%. Less uniform distribution of the crop on the slopes was in the variants without fertilizers and on the application of P₃₀K₆₀ with the share of the 1st mowing 46–49%, the second — 32-34% and the 3rd 19–20% and the unevenness — 42%. Variants with the application of N₆₀P₃₀K₆₀ or 15 t/ha of manure on the slopes occupied an intermediate position compared to the above options.

Analysis of indicators of organic matter content in feed and its digestibility in floodplain meadows depending on surface improvement measures showed that these indicators were most influenced by the mode of use. The best quality of feed was in the multi-mode mode of use (Table 3). With multi-use, compared to hay in all variants, the content of crude protein in the dry mass increased by 3.9-4.3% and protein — by 2.4-3.8% and decreased the content of crude fiber by 2.9-3.2% and nitrogen-free extractives by 2.5–2.6%. At the same time, the digestibility of dry feed in vitro increased by 9-11%.

Among the options for surface improvement of the experiment with hay use, the most positive effect on the chemical composition of the feed had options with the introduction of N₆₀P₃₀K₆₀, N₆₀P₃₀K₆₀ + sowing of cereals and with the introduction of 15 t/ha of manure. In this case, compared with the variants without fertilizers and with the introduction of P₃₀K₆₀, the content of crude protein increased by 2.0-2.6%, protein — by 1.6-2.2% and decreased the content of BER — by 2.7-3,1%.

In the case of multi-use, the best indicators of chemical composition were characterized by the option with the introduction of P₃₀K₆₀ + sowing of creeping clover, where the content of crude protein and protein in the dry mass was the highest (19.0 and 15.8%, respectively), which is 1.2-1.4 and 1.0–1.2% more than in the variants with N₆₀P₃₀K₆₀ or 15 t/ha of manure and by 4.0-4.1 and 3.3-3.4% more in comparison with the variants without fertilizers and with by making P₃₀K₆₀.

3. The content of organic matter in the feed and its digestibility on sloping meadows depending on surface improvement measures (average for 2017-2019)

Options for surface improvement	Crude protein	Protein	Crude fat	Cheese fiber	BER	Digesti-bility
Haymaking use						
Without improvement	11,0	9,0	3,8	28,9	47,5	59
P ₃₀ K ₆₀	11,3	9,3	3,8	28,7	47,2	60
N ₆₀ P ₃₀ K ₆₀	13,5	11,1	3,9	29,5	44,5	60
N ₆₀ P ₃₀ K ₆₀ + sowing of cereals	13,6	11,2	3,9	29,7	44,3	59
Manure, 15 т/ha	13,3	10,9	3,8	28,8	45,5	60
HIP ₀₅ , т/ ha	0,8	0,7	0,2	1,9	2,3	3
Multi-use						
Without improvement	14,9	12,4	3,7	26,6	44,9	68
P ₃₀ K ₆₀	15,0	12,5	3,7	26,5	44,8	69
P ₃₀ K ₆₀ + creeping clover sowing	19,0	15,8	4,1	25,0	42,1	71
N ₆₀ P ₃₀ K ₆₀	17,8	14,8	3,9	26,8	41,8	69
Manure, 15 т/ha	17,6	14,6	3,9	26,7	42,1	69
HIP ₀₅ , т/ ha	0,9	0,7	0,2	1,8	2,2	3
Zootechnical norm	14-20			25-30		50-70

The nutritional value and energy consumption of dry biomass and the provision of the feed unit with digestible protein by grass grass on the slope were most influenced by the mode of use. The best feed quality was in the multi-cut mode of use, when in all variants of surface improvement the content of feed units in the dry mass of feed ranged from 78-82%, which is 12-16% more than in hay use. The content of metabolic energy in multi-use used ranged from 9.6 to 9.9 MJ/kg of dry weight, which is 0.8-0.9 MJ/kg more than in hay use.

The supply of feed unit with digestible protein in multi-use was in the range of 133-161 g, which is 18-20 g more than in hay use.

There was no significant difference between the surface improvement options in terms of dry matter content of feed units and metabolic energy for both hay and multi-mowing use. In terms of feed unit digestible protein, the options with application of $N_{60}P_{30}K_{60}$, $P_{30}K_{60}$ + sowing of creeping clover or with application of 15 t/ha of manure with rates of 139-144 g for hay use and 157-161 g for multi-crop use, which are 17-27 and 21-28 g more in comparison with the options without fertilizers or with the introduction of $P_{30}K_{60}$.

The content of crude ash, macronutrients and their ratio in the forage grass slope slopes, depending on surface improvement measures are shown in table 4.

4. The content of crude ash, macronutrients and their ratio in the grass of the sloping meadows of the Carpathians, depending on surface improvement measures, % in dry weight (average for 2017-2019)

Options for surface improvement	Raw ash	P	K	Ca	Mg	K: (Ca+Mg)	Ca:P
Haymaking use							
Without improvement	8,8	0,3 9	1,90	0,54	0,14	2,7	1,4
$P_{30}K_{60}$	8,9	0,4 4	2,13	0,55	0,13	3,1	1,3
$N_{60}P_{30}K_{60}$	8,6	0,4 2	2,09	0,53	0,13	3,2	1,3
$N_{60}P_{30}K_{60}$ + sowing of cereals	8,5	0,3 9	2,05	0,52	0,12	3,2	1,3
Manure, 15 t/ha	8,6	0,4 0	2,08	0,53	0,13	3,2	1,3
Multi-use							
Without improvement	9,9	0,3 9	1,97	0,55	0,14	2,9	1,4
$P_{30}K_{60}$	10,0	0,4 4	2,14	0,56	0,13	3,1	1,3
$P_{30}K_{60}$ + creeping clover sowing	9,8	0,4 2	2,04	0,66	0,18	2,4	1,6
$N_{60}P_{30}K_{60}$	9,7	0,4 2	2,09	0,52	0,13	3,2	1,2
Manure, 15 t/ha	9,7	0,4 0	2,08	0,53	0,13	3,2	1,3
HIP ₀₅ , %	0,4	0,0 2	0,11	0,03	0,01		
Zootechnical norm		0,2- 0,35	1,0- 3,0	0,3-0,6	0,12- 0,26		0,7- 2,5

The analysis of these data showed that with the increase in the number of slopes, ie with multi-slope use in comparison with haymaking, the content of raw ash in the dry mass was higher by 1.1-1.3%. In this case, its content decreased from 9.7-10.0 for multi-mowing to 8.5-8.9% for hay use.

With haymaking, the content in grass of the macroelements listed in Table 4 and their ratio did not depend much on surface improvement measures. In contrast to haymaking for multi-use in the version with the introduction of $P_{30}K_{60}$ + sowing creeping clover most accumulated calcium and magnesium, namely 0.66 and 0.18% in dry weight, respectively, which is 0.10-0.13 and 0,04-0,05% more in comparison with other grass-grasses without sowing of a bean grass.

Conclusions

The current factors of improving the species composition of natural grass and the quality of grass fodder, as well as increasing productivity are surface improvement of slope meadows of the Carpathian mountain forest belt, which provides annual application of $N_{60}P_{30}K_{60}$, or 15 t / ha of manure, or $N_{60}P_{30}K_{60}$ + sowing of grassland and meadow thyme for haymaking or $P_{30}K_{60}$ + creeping clover for sowing. Compared with the options without fertilizers and with the introduction of $P_{30}K_{60}$, the share of sown cereals or legumes increases to 34-46%, the content of crude protein in the dry mass with hay use increases by 2.0-2.6%, and with multi-crop — by 2,6-4.1% and decreases the content of BER, respectively — by 1.7-3.2%, and 2.7-3.1%.

In haymaking mode, the highest productivity per 1 ha of fodder units of mountain meadows is provided by sowing a mixture of cereal grasses on the background of $N_{60}P_{30}K_{60}$ (2.86 t), and in multi-mowing — on sowing of creeping clover on the background of $P_{30}K_{60}$ (3.04 t), which is more respectively 14 and 106% compared to the options without sowing and 146 and 167% compared to the option without fertilizer. Application of $N_{60}P_{30}K_{60}$ increases the productivity of land by 115-147%, and manure at a dose of 15 t/ha — by 101-123%.

Multi-use of mountain slope meadows in comparison with hay in dry mass increases the content of crude protein by 3.9-4.3%, and protein – by 2.4-3.8%, as well as the content of feed units and metabolic energy, security feed unit digestible protein and digestibility of dry feed in vitro and reduces the content of crude fiber by 2.9-3.2% and nitrogen-free extractives by 2.5-2.6%.

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