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Effect of Cattle Grazing Routine on Erosion Processes, Harvest Yield and Quality of Fodder in Subalpine Belt of North Ossetia

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Abstract

Background/Objectives: The research is aimed at studying the effect of the pastureland use routine on altering the indicators of the soil fertility and on the erosion process development. **Methods/Statistical Analysis:** The studies were conducted in the mountains at an altitude of 1570 m above sea level on the mountain meadow subalpine soils with acidic reaction of soil solution (pH=5,9). The chemical analyses of the average runoff sample and that of the washout sample were carried out to determine the contents of the accessible forms of such nourishing elements as nitrogen, phosphorus and potassium. **Findings:** This study shows that in the middle of the last century a significant amount of agricultural products were produced in the North Caucasus Mountains; this output was significantly reduced due to soil erosion caused by poorly plant-protected surface and livestock congestion. Erosion leads to dispersion of soil horizon structure, megastructure reduction and increase in dust, it also results in increased soil specific weight and solid phase unit weight, in decreased air and capillary porosity with reduction of aggregate water stability and water permeability. In the absence of grazing, the total losses of nitrogen, phosphorus and potassium amounted to 7.84 kg/ha and 296.56 kg/ha with intensive pasturing, which was higher by 37.8 times. With the admissible levels of grazing intensity no reliable data for the productivity alteration was obtained, and in the grazing routine modes of 2/15, 3/10, 3/15 a decrease in the productivity was established. Grazing lowers the grass stand quality, while increasing the proportion of fiber, fat and ash. The yield of nutritional chemicals per 1 hectare increased under optimal grazing conditions and decreased under intensive grazing routines. Applications/ Improvements: Recommendations for cattle grazing routines have been developed with regard to degraded and normally functioning pasturelands. It is proposed to avoid excessive grazing routines.

Keywords: Cattle Grazing Routine, Erosion Processes, Fodder

1. Introduction

The damages caused by erosion are manifested by decrease in the humus-accumulated layer thickness, by the loss of nutritional chemicals, by poor physical and biological properties of the soil, by shortfall in harvest, by poor fodder quality, etc[1]. The basic precondition for the erosion in the mountain pasturelands is represented by insufficient protection of the soil by vegetation due to the excessive grazing routine, therefore developing the methods for the erosion reduction and prevention is an urgent task in both scientific and practical aspects.

2. Results

Based on different estimations in 1940 the highland area

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of North Caucasus produced almost 220 thousand tons of grain, circa 75 thousand tons of potato and vegetables, more than 200 thousand tons of hay; there were kept up to 700 thousand animals of bovine cattle, circa 2.5 million of sheep and goats, more than 100 thousand horses[2,3].

North Ossetia, with its small territory (798.7 thousand hectares) being situated within the Central part of North Caucasus, has a strongly pronounced altitudinal sequence, stipulating the presence of 24 basic types and 49 subtypes of north latitude soils.

Now, the potential for developing agriculture in North Ossetia is concentrated in the highlands, occupying more than 60% of the territory of the republic. The analysis of historical traditions, of modern social and economic conditions and trends of agricultural development made it possible to specify the priority tasks for developing arable farming in the highland area of the republic:

- Increasing the production output of basic field crops and vegetables.
- Developing the initial elements of the seed industry system in the republic.
- Obtaining the disease-treated seed grains and planting material for the field crops.
- Improving the agriculturally used areas (amelioration, reclaiming, terracing etc.) with the purpose to use them later for perennial fruit plants and for creating the stationary ecologically balanced mountainous agricultural landscapes.

In relative terms, the decrease in the areas in the highlands of North Ossetia amounted to the figures as follows: arable land – by 99%, hayfields – by 18%, pasturelands – by 68%[4].

According to expert estimations, the natural ecosystems, subject to man-made impacts, degrade with the intensity of 2% per year[5]. If this trend is to be preserved, then they will be destructed completely in 30-40 years.

The undertaken investigation of the fodder-producing areas in North Ossetia showed that 80-85% of their territory is, to a different degree, degraded: 50.7% of the pasturelands are packed, 52.8% are covered with shrubs, 90.7% are spoiled with stones to a different degree, 95.4% are eroded, 100% are weedy with harmful or poisonous grass[6].

The basic precondition for the erosion of the highland pasturelands is the insufficient protection of the soil by vegetation due the heavy grazing routine and, therefore, developing the methods to reduce and to prevent the erosion processes is an urgent scientific and practical task.

These investigations were undertaken at the mountain base station of North Caucasus Scientific and Research Institute of Hill and Submontane Agriculture near Dargavs village, situated at an elevation of 1570-1600 meters below sea level. The ground elevation profile is mountainous, intensively broken with the downhill tributaries of the Terek River. The climate is moderately continental with average yearly air temperature of 5.9°C and with the daily mean temperature in winter of - 4.0°C, in spring + 4.8°C, in summer + 14.5°C and in autumn + 6.3°C. The most warm month is July (15.5°C), the most cold month is January (-5.1°C). The winter lasts for 118 days. The spring commences in the end of March. The summer is moderately warm, with the temperature in July and August of 15°C. The autumn is dry. The yearly average precipitations make 540 mm, including those in spring – 166 mm, in summer – 246 mm, in autumn – 92 mm and in winter – 36 mm. The duration of the frost-free season makes from 127 to 203, 154 days on average. Accumulated positive temperatures are 2370°C. The vegetation is represented by subalpine aggregation of the meadow-steppe type, where the following specimen dominate: purple-stem catmint (the meadow and the steppe type), motley brome, sheep fescue and motley fescue, medick, cat's clover, types of cock's head and clover, cow-parsnip, milfoil, lady's mantle, lamb's tongue etc. Thus, the plant stand is characterized as the motley grass-legume.

The soil of the plot under investigation belongs to the mountain-meadow subalpine leached soil with humic-illuvial layer, rubble-loam soil on the residual rock of the loamy shale. The characteristic feature of these soils is the high content of rotted rock (up to 30.5%) and the acid reaction of the soil solution (pH=5.9). According to the scale of the basic nourishing elements content, the soil belong to the type with the increased available phosphorus content (10.6 mg/100g of soil) and with the high exchange potassium content (15.6 mg/100g of soil).

The purpose of these investigations is to study the effect of the pastureland use routine on altering the indicators of the soil fertility and on the erosion process development. To do so, the following stationary field experimental pattern was assumed:

A	B	
One browsing session	5 animals/ha	(A_1B_1)
	10 animals/ha	(A_1B_2)
	15 animals/ha	(A_1B_3)
Two browsing sessions	5 animals/ha	(A_2B_1)
	10 animals/ha	(A_2B_2)
	15 animals/ha	(A_2B_3)
Three browsing sessions	5 animals/ha	(A_3B_1)
	10 animals/ha	(A_3B_2)
	15 animals/ha	(A_3B_3)

Also, for the purposes of comparison, the control variant (benchmark) with no browsing was included (**St**).

The shape of the plot is rectangular, total area is 40 m^2 (5x8 m), accounting area is 24 m^2 (4x6 m). The variants were located stationary on random principle. The width of the headlands was as follows: Lateral headlands – 0.5 m, end headlands – 1 m. The browsing was implemented by imitation method by means of mowing the vegetation when it was 15-20cm high, followed by packing the soil surface with the packer weighing 40 kg (average weight of a sheep). Erosion processes were studied within the framework of the model experiments, when the soil columns were taken three times per one growth and were placed in the water tables with the dimensions of 100x40x10 cm. For the purposes of modeling the slope steepness, the tables were installed at different inclination angles: 7, 14, 21 and 28^0. Onto the water tables, the water flow was fed, calculated as equaling to 10, 20 and 30 mm of precipitations with the intensity corresponding to torrential rain. The showering was implemented from the elevation of 1 m through the special type nozzle developed by[7], facilitating water distribution in droplets over all the area of the water table. In line with the method suggested by P. F. Gorbatchev[8], the generated rain was characterized as the mountain torrential rain, and its force was estimated at 35 points.

The calculations were done according to the following formula: $\Delta = i\sqrt{t}$, Where: Δ is the force of the rain; i is the intensity of the rain, mm/min; t is the duration of the rain, min.

The flow, generated in the course of showering, came to the water table receiver, from where it was removed applying the thermostatic weighing method, the values of the runoff and of the washout were determined together with the chemical analysis of the erosion products followed by the recalculation as per 1 hectare. The obtained materials underwent mathematical processing.

The investigations have shown that erosion reduced the soil profile, worsened the agrophysical properties of the arable layer, decreased the volume of the working system, reduced the interchanging capacity of the soils and resulted in segregation of the soil particles: The finer fractions were washed out affected by the mechanical forces, and the washed rough-structured material was left instead[1].

It has been established that the soil of the natural meadow was characterized by good structure formation and was in the equilibrium state: With macrostructure content of 74.2%, rubble fraction of 22.5%, dust content of 3.3%. The grazing led to the destruction of the structure. Thus, within the period of 3 years in the soil layer of 0-10 cm under variant 3/15 the content of macrostructure decreased 10.6 times, and the ratio of dust increased 2.26 times. The grazing was also associated with the packing of soil. Within the period under investigation in variant 3/15 the bulk weight increased from 1.26 to 1.50 g/cm^3 (Figure 1). Such rate of the soil packing should be considered quite high. As a result of packing, the soil composition changed (Table 1).

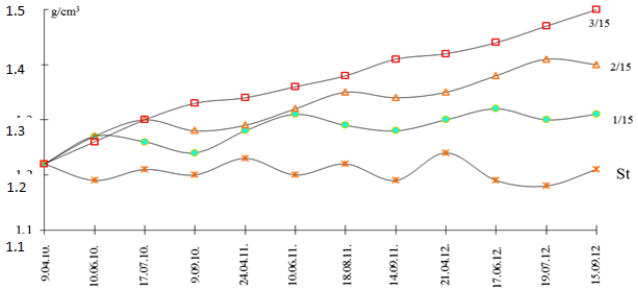

Figure 1. Dynamic pattern of changes in the bulk volume of mountain meadow soils (0-20 cm, slope 14°) under different grazing routines.

Table 1. Influence of cattle grazing routine modes on alpine humus soil composition (layer 0-20 cm, slope 14°)

Experiment variant	Soil phase ratio, %			
	Solid body	Total porosity	Non-capillary porosity	Capillary porosity
St	52.15	47.85	14.82	33.03
A_1B_1	55.68	44.32	11.71	32.61
A_1B_2	58.43	41.57	11.24	30.33
A_1B_3	61.56	38.44	10.43	28.08
A_1B_3	66.27	37.73	9.44	28.29
A_3B_3	68.62	31.38	6.40	24.98

In routine mode 3/15 the volume of the hard phase increased by 16.47%, non-capillary porosity was reduced by 8.42%, the capillary one was reduced by 8.05%. In the course of the soil packing not only the total volume of the pores used to decrease, but their specific sizes did as well. In such structure, there is an antagonism between the moisture content and aeration, the processes preventing soil generation and worsening the life of the plants.

The water stability of the aggregates decreased by 1.9-7.9% depending on the grazing intensity, and the permeability under the routine mode 3/15 decreased 12.15 times. The worsening of the water stability and permeability was associated with the decrease in the erosion withstanding capacity of the soil, which is unacceptable under the conditions of the developed water erosion.

It has been established that the increase in the slope steepness by 1° resulted in the runoff increase by 0.17 m^3/ha, as well as in the precipitation per 1 mm increase by 0.78 m^3/ha, and in the washout increase by 3.5 and 4.2 kg/ha.

The intensity of erosion, to a much larger degree, depended on the anthropogenic factors. Thus, with one rain amounting to 20 mm and with the steepness of 14° in the experimental variants, as compared to the benchmark variant, the runoff increased 1.8-39.4 times, and the washout increased 3.3-65.3 times.

Table 2. Runoff and washout required amount during vegetation season

Experiment variant	Land runoff		Moistness loss, % (from 365 mm)	Soil loss	
	m^3/ha	as % of control		kg/ha	as % of control
St	7.35	-	0.20	85.80	-
A_1B_1	16.60	225.8	0.46	156.04	181.8
A_1B_2	19.73	268.4	0.54	228.74	266.6
A_1B_3	26.16	355.9	0.72	539.98	629.3
A_2B_1	41.31	562.0	1.13	442.04	515.2
A_2B_2	132.71	1805.6	3.64	1115.76	1300.4
A_2B_3	174.77	2377.8	4.79	1870.00	2179.5
A_3B_1	103.34	1406.0	2.83	1214.10	1415.0
A_3B_2	222.54	3027.7	6.10	2173.14	2532.8
A_3B_3	345.61	4702.2	9.47	3217.26	3749.7

The experiments have shown that the value of the washout was, to a large degree, dependent on the number of grazing sessions (43.1%), on the amount of the precipitations (12.3%), on the intensity (11.0%) and on the steepness of the slope (4.8%). Pair interactions were accountable for 0.5 to 8.3%, the unforeseen random factors accounted for 2.5%. The effect of the anthropogenic factors was 3.46 higher than that of the natural factors. By calculations it was established that the runoff in variants of the experiment amounted to 7.35-345.61 m^3, and the washout amounted to 85.80-3217.26 kg/ha (Table 2).

To make the overall picture of the detrimental character of erosion complete, the losses of the nourishing elements due to erosion were determined. For this purpose, the chemical analyses of the average runoff sample and that of the washout sample were carried out to determine the contents of the accessible forms of such nourishing elements as nitrogen, phosphorus and potassium (Table 3).

Table 3. N, P2O5 and K 2O removal with runoff (cf. for 3 years), kg/ha

Variants	Hydrolyzable nitrogen (N)	Labile phosphorus (P_2O_5)	Exchange potassium (K_2O)
St	0.11	0.05	0.05
A_1B_1	0.26	0.09	0.11
A_1B_2	0.30	0.11	0.14
A_1B_3	0.40	0.14	0.18
A_2B_1	0.63	0.22	0.29
A_2B_2	2.04	0.71	0.92
A_2B_3	2.69	0.94	1.21
A_3B_1	1.59	0.56	0.71
A_3B_2	3.43	1.20	1.54
A_3B_3	5.32	1.87	2.38

The data (Table 3.) show that the losses of the nourishing elements in the benchmark variant are close to zero. They are also negligible at the low intensity of grazing. Some considerable losses of the nourishing elements have been discovered with the pastureland grazing intensity of variants 2/10-3/15. Nitrogen was mostly washed out with the runoff, which is explained by its higher solubility. Among other elements in the surface runoff there are more movable forms of potassium, than those of the phosphorus. In all, the correlation of the NPK forms accessible to the plants in the runoff amounts to 2.85:1:1.28.

The more serious losses used to occur with the soil washout (Table 4). It was discovered (Table 4.) that together with the fine earth a considerable amount of nourishing elements was lost. The amount of losses used to be directly dependent on the intensity of the grazing routine modes and on the volume of the soil washout.

The experiment have shown that in variant 3/15

together with the washed out fine earth the soil was losing 83.01 kg/ha of nitrogen, 21.56 kg/ha of phosphorus and 182.42 kg/ha of potassium. The correlation between the elements NPK in the washout used to be 3.85:1:8.46, i.e., in the washout potassium was at its maximum and phosphorus was at its minimum.

Table 4. N, P_2O_5 and K_2O removal with soil loss (cf. for 3 years), kg/ha

Experiment variants	Hydrolyzable nitrogen (N)	Labile phosphorus (P_2O_5)	Exchange potassium (K_2O)
St	2.21	0.57	4.86
A_1B_1	4.03	1.05	8.85
A_1B_2	5.90	1.53	12.97
A_1B_3	13.93	3.62	30.62
A_2B_1	11.40	2.96	25.06
A_2B_2	28.79	7.48	63.26
A_2B_3	48.25	12.53	106.03
A_3B_1	31.32	8.13	68.84
A_3B_2	56.07	14.56	123.22
A_3B_3	83.01	21.56	182.42

To give more detailed characteristic, the data on the total losses of the nourishing elements resulting from erosion have to be available (Table 5).

Table 5. N, P_2O_5 и K_2O total loss with erosion (cf. for 3 years), kg/ha

Experiment variants	Hydrolyzable nitrogen (N)	Labile phosphorus (P_2O_5)	Exchange potassium (K_2O)
St	2.32	0.61	4.91
A_1B_1	4.29	1.14	8.96
A_1B_2	6.20	1.64	13.11
A_1B_3	14.33	3.76	30.11
A_2B_1	12.03	3.18	25.35
A_2B_2	30.83	8.19	64.18
A_2B_3	50.94	13.47	107.24
A_3B_1	32.81	8.69	69.55
A_3B_2	59.50	15.76	124.76
A_3B_3	88.33	23.43	184.80

Data in Table 5 show that under normal erosion with no grazing (St), the loss of nitrogen used to be at the level of 2.32 kg/ha, that of phosphorus amounted to 0.61 and that of potassium made 4.91 kg/ha. At that, NPK elements correlation was 3.80:1:8.05. Introducing the grazing, even that with the minimum intensity (variant 1/5) resulted in 1.8-1.9 times higher losses of the nourishing elements.

With the increase in the grazing intensity the losses of the elements increased considerably, and in the most intense variants it achieved quite huge values. Thus, in variant 3/15 nitrogen loss amounted to 88.33 kg/ha, that of phosphorus was 23.43 and that of potassium amounted to 184.80 kg/ha. It is known that to generate one dt/ha of greenery the perennial herbs consume 0.4 kg of N, 0.15 kg of P_2O_5 and 0.35 kg of K_2O. Consequently, the lost amount of nitrogen would suffice to generate the green harvest of 220.8 dt/ha, that of phosphorus would generate 156.2 dt/ha, and that of potassium would suffice for 528.0 dt/ha of greenery.

Thus, the grazing used to activate the water runoff and the soil washout continuously. However, with the small, that is with optimum grazing intensity the value of erosion increased gradually and was within the normal limitations. When the grazing rate exceeded the ecologically admissible level, erosion was activated drastically and its rate became very high.

In all, the alteration of the feeding, the watering and the biological modes, along with the worsening of a number of properties of the washed out soils, resulted in the drop in their potential and effective fertility and, as a consequence, in poor agricultural productivity (Table 6).

Table 6. Influence of cattle grazing on herbage productivity

Experiment variants	Fresh yield, t/ha			
	2010	2011	2012	Average
St	12.5	14.7	11.5	12.9
A_1B_1	14.0	16.6	13.0	14.5
A_1B_2	14.2	16.0	13.2	14.5
A_1B_3	12.5	14.8	11.5	12.9
A_2B_1	13.2	15.5	12.1	13.6
A_2B_2	12.6	14.9	11.7	13.1
A_2B_3	12.3	13.9	11.3	12.5
A_3B_1	12.7	15.0	11.8	13.2
A_3B_2	11.9	13.1	10.9	12.0
A_3B_3	9.6	11.3	8.7	9.9
S_x, %	0.91	1.11	1.03	1.00
HCP_{05}, t/ha	0.32	0.42	0.38	0.37

Based on the given data it may be concluded that with low intensity of grazing (variants 1/5, 1/10, 2/5) the harvest output fluctuated within the values of 13.6-14.5 t/ha. With the admissible intensity levels (1/15, 2/10, 3/5)

no reliable data on the productivity alteration have been found. The grazing routine modes 2/15, 3/10, 3/15 proved to be excessive, resulting in the productivity decrease (on average within three years) by 0.42-3.06 t/ha or by 3.25-23.65%.

The quality of the harvest is a very important integral indicator in estimating the optimum conditions for the plant growth and development. Therefore, the observations were undertaken over the product quality alteration in its chemical composition (Table 7).

Table 7. Fodder chemical composition depending on grazing routine modes (cf. for 3 years)

Variants	Content, % of dry matter				
	Protein	Fat	Fiber	Nitrogen-free extractive substances	Ash
St	13.24	3.30	28.18	47.98	7.30
1/5	13.31	3.29	28.16	47.95	7.29
1/10	13.14	3.32	28.30	47.84	7.40
1/15	12.93	3.33	28.50	47.78	7.46
2/5	13.05	3.32	28.39	47.91	7.33
2/10	12.79	3.33	28.54	47.99	7.35
2/15	12.41	3.39	28.87	47.94	7.39
3/5	12.59	3.36	28.71	47.96	7.38
3/10	12.44	3.40	28.88	47.90	7.38
3/15	12.13	3.41	29.07	47.97	7.42

The analysis of the given data has shown that the dry matter of the pastureland fodder contained 13.24% of protein, 3.30% of fat, 28.18% of fiber, 47.98% of nitrogen-free extractive substances and 7.30% of ash. The grazing used to negatively affect the quality of the plant stand on a continuous basis. Protein contents used to decrease by 0.10-1.11%, the ratio of fiber used to increase by 0.12-0.89%, that of fat increased by 0.02-0.11% and that of ash increased by 0.03-0.12%. Specific weight of nitrogen-free extractive substances remained almost stable, and only under the grazing routine mode 1/5 the quality of fodder became somewhat better.

Increase in protein ratio means that the nourishing characteristics of fodder are improving, and, as the content of fiber increases, the fodder becomes coarser and its consumable amount becomes lower. In the benchmark variant, the ratio of protein to fiber amounted to 1:2.13. In variants with grazing, it used to increase and under routine mode 3/15 it reached 1:2.40.

It was found that when grasses and especially legumes were excluded from phytocenosis, it resulted in the decreased content of protein, and the increased ratio of motley grasses stimulated the growth of the specific weight of fiber.

To determine the nourishing characteristics of fodder, the grass was evaluated in terms of the fodder unit content and of the raw protein content (Table 8.), which showed that 1 kg of dry matter of fodder contained 87 g of raw protein, which is considered equal to the nourishing value of 0.733 fodder units. When grazing was introduced, the nourishing value of the plant stands somewhat decreased: The content of fodder units in dry matter was lower by 0.004-0.023, and that of digestible protein was lower by 1-10 g.

Table 8. Fodder nutritional value at different grazing routine modes (cf. for 3 years)

Variants	Content of fodder units in 1 kg of dry matter	Content of raw protein in 1 kg of dry matter, gr	Providing fodder units with raw protein, gr/kg
St	0.733	87	118.7
1/5	0.734	88	120.0
1/10	0.729	86	188.0
1/15	0.724	84	116.0
2/5	0.728	85	116.8
2/10	0.724	83	114.6
2/15	0.716	80	111.7
3/5	0.719	81	112.7
3/10	0716	80	111.7
3/15	0.710	77	108.5

It was established that the obtained fodder was balanced in proteins. Thus, in the benchmark variant one fodder unit contained 118.7g of raw protein. With low intensity of grazing (variant 1/5) this indicator increased up to 120.0 g. Further increase in the rate of the pastureland use resulted in lower content of raw protein in a fodder unit by 0.7-10.2 g.

The investigations have shown that in 1 kg of dry matter of grass from the benchmark plot there were 18.51 MJ of gross and 9.51 MJ of metabolic energy with metabolic indicator of 51.4%. Only under grazing routine 1/5 some minor increase in the fodder energy was observed (Table 9).

Table 9. Influence of cattle grazing on fodder caloric content (cf. for 3 years)

Variants	Gross energy, MJ/kg of dry matter	Metabolic energy, MJ/kg of dry matter	Metabolic capacity of energy, %
St	18.51	9.51	51.4
1/5	18.52	9.52	51.4
1/10	18.49	9.49	51.3
1/15	18.48	9.45	51.1
2/5	18.50	9.48	51.2
2/10	18.49	9.45	51.1
2/15	18.48	9.40	50.9
3/5	18.49	9.42	50.9
3/10	18.48	9.39	50.8
3/15	18.46	9.35	50.7

The given data (Table 9.) have shown stability and low dependence of the gross energy content on the grazing rate. Even with the maximum rate of grazing (3/15) it used to decrease just by 0.05 MJ/kg or by 0.27%. The alteration in the content of metabolic energy was somewhat higher. In variant 3/15 it decreased by 0.16 MJ/kg or by 1.68% as compared to the benchmark variant.

Variation of the energy content of the pastureland fodder has been stipulated by the alteration in the botanical composition of the plant stand. It is known that the dry matter of the plants of different agricultural and botanical groups (grasses, legumes, motley grasses) are just slightly different in energy content, but their nutrient availability in the organisms of the animals is considerably different. Therefore, the indicator of gross energy is quite stable, but that of the metabolic energy is more variable.

The metabolic capacity of the energy in the experiment was fluctuating depending on the variants in the range of 50.7-51.4%, which testifies of the good quality of fodder.

The more objective characteristic of the meadow pastureland grass productivity is represented by the gross yield of nourishing elements. This indicator summarizes the harvest data and the qualitative characteristics.

The data in Table 10 prove the gross nourishing yield dependency on the applied grazing routine. In the benchmark variant the gross protein yield amounted to 5.75 dt/ha. In variants 1/5 and 1/10 it increased by 0.57-0.68 dt/ha or by 9.9-11.8%, which is related, to a large degree, to the increase in the yield of the greenery.

In variant 2/5 the productivity, as compared to the benchmark, increased, and the content of protein matters became lower. As a result, the yield of protein appeared to be at a standard level, exceeding it only by 0.11 dt/ha or by 1.9%. In grazing routines 1/15, 2/10 and 3/5 the harvest of greenery was at the benchmark level, but the bulk protein content was lower. Consequently, the total yield of protein decreased by 0.24-0.36 dt/ha or by 4.2-6.3%.

Under the intensive grazing routine modes the gross yield of protein used to decrease even more considerably. It was explained by the fact that in those variants the decrease in the productivity of the greenery occurred, and the quality of fodder became poorer. Therefore, the yield of protein decreased in variant 2/15 by 0.70 dt/ha or by 12.2%, in variant 3/10 it decreased by 0.96 dt/ha or by 16.7%, in variant 3/15 it decreased by 1.94 dt/ha or by 33.7%. Similar dependency was found for other nourishing elements such as fat, fiber, nitrogen-free extractive substances and ash.

Table 10. Influence of cattle grazing on nutrient yield (cf. for 3 years)

Variants	Gross yield, dt/ha				
	Protein	Fat	Fiber	Nitrogen-free extractive substances	Ash
St	5.75	1.43	12.23	20.82	3.17
1/5	6.43	1.59	13.60	23.13	3.52
1/10	6.32	1.60	13.62	23.05	3.56
1/15	5.51	1.42	12.14	20.45	3.18
2/5	5.86	1.49	12.75	21.57	3.29
2/10	5.45	1.42	12.16	20.43	3.13
2/15	5.05	1.38	11.75	19.54	3.01
3/5	5.39	1.44	12.29	20.54	3.16
3/10	4.79	1.30	11.12	18.44	2.84
3/15	3.81	1.07	9.13	15.08	2.33

Table 11. Picking of fodder units, digestible protein and energy at different grazing routine modes (cf. for 3 years)

Variants	Fodder units, dt/ha	Digestible protein, dt/ha	Gross energy, GJ/ha	Metabolic energy, GJ/ha
St	31.82	3.78	80.33	41.29
1/5	35.45	4.24	89.42	45.97
1/10	35.08	4.15	88 .95	45.64
1/15	30.90	3.60	78.89	40.36
2/5	32.76	3.84	83.26	42.66
2/10	30.82	3.54	78.76	40.26
2/15	29.13	3.24	75.21	38.26
3/5	30.79	3.48	79.10	40.33
3/10	27.56	3.08	71.16	36.19
3/15	22.30	2.42	57.98	29.40

To characterize the productivity of the fodder-producing areas, such indicator as the ratio of the yield to the unit of digestible protein and to energy is of very high significance (Table 11).

The investigations showed that variant 1/5 and 1/10 are the best in their productivity, ensuring, as compared to the benchmark, the growth in the eyelid of the fodder units by 3.26-3.63 dt/ha, growth in digestible protein by 0.37-0.46 dt/ha, increase in gross energy by 8.62-9.09 GJ/ha, increase in metabolic energy by 4.35-4.68 GJ/ha. Some increase in productivity was also noted in variant 2/5.

Variants 1/15, 2/10 and 3/5, in terms of their productivity, used to be just slightly lower than the benchmark. Thus, the yield of the fodder units decreased by 0.92-1.03 dt/ha, that of digestible protein decreased by 0.18-0.30 dt/ha, that of the gross energy decreased by 1.23-1.57 GJ/ha, that of metabolic energy was lower by 0.93-1.03 GJ/ha. With the most intensive grazing rate (3/15), the yield of the fodder units decreased by 9.52 dt/ha or by 29.9%, that of digestible protein decreased by 1.36 dt/ha or by 36%, that of the gross energy was lower by 22.35 GJ/ha or by 27.8%, that of metabolic energy decreased by 11.89 GJ/ha.

3. Summary

- Grazing (pasturing) results in the destruction of the structure of the upper turf layer (0-10 cm). Under grazing routine 3/15 the content of mega-structure decreased 10.6 times, and the content of dust increased 2.26 times. The bulk weight of the soil increased from 1.26 to 1.50 g/cm^3, the volume of the hard phase increased by 16.47%, the non-capillary porosity decreased by 8.42%, the capillary one decreased by 8.05% together with the decrease in the water stability of the aggregates by 7.9% and that in permeability 2.15 times.
- With the products of erosion large amount of nourishing elements were lost. In normal erosion, with no grazing, the total losses of nitrogen, phosphorus and potassium amounted to 7.84 kg/ha, with intensive grazing (3/15) they amounted to 296.56 kg/ha or they were 37.8 times higher.
- With low grazing intensity (1/5, 1/10, 2/5), as well as with the admissible intensity (1/15, 2/10, 3/5), no reliable data on the productivity alteration were found (13.6-14.5 t/ha). The routine modes 2/15, 3/10, 3/15 are the excessive ones, resulting in the productivity decrease by 0.42-3.06 t/ha or by 3.25-23.65%.
- Dry matter of the pastureland fodder contained on average 13.24% of protein, 3.30% of fat, 28.18% of fiber, 47.98% of nitrogen-free extractive substances and 7.30% of ash. The grazing affected the quality of the plant stand negatively, decreasing the content of protein by 0.11% and increasing the ratio of fiber by 0.12-0.80% simultaneously, decreasing the content of fat by 0.02-0.11% and decreasing the content of ash by 0.03-0.12%. The specific weight of nitrogen-free extractive substances remained almost stable, its deviation from the benchmark amounted to just 0.01-0.20%. Intensive grazing resulted in poor nourishing values of the pastureland fodder.
- One kg of the dry matter of fodder from the benchmark variant contained 18.51 MJ of gross energy and 9.1 MJ of metabolic energy with metabolic index of 51.4%. When grazing was introduced a decrease in both types of energy was observed.
- In the benchmark variant the gross yield of the nourishing elements amounted to the values as follows: protein – 5.75 dt/ha, fat – 1.43, fiber – 12.23, nitrogen-free extractive substances – 20.83 and 3.17 dt/ha of ash. Under optimum grazing routine modes (1/5 and 1/10) it used to increase together with the increase in the yield of the fodder units by 3.26-3.63 dt/ha, with that in digestible protein by 0.37-0.46 dt/ha, with that in the gross energy by 8.62-9.09 GJ/ha, with that in metabolic energy by 4.35-4.68 GJ/ha, and under the intensive grazing routine modes (3/10 and 3/15) it used to decrease by 4.26-9.52 dt/ha of fodder units, by 0.70-1.76 dt/ha of digestible protein, by 9.17-22.35 GJ/ha of gross energy and by 5.10-11.89 GJ/ha of metabolic energy.

4. Conclusion

- At degraded pasturelands the grazing routine with the intensity of one browsing session with up to 10 animals (1/5, 1/10) or two browsing sessions with 5 animals (2/5) per 1 ha should be adopted.
- At normally functioning pasturelands one browsing session with up to 15 animals (1/15) or two browsing sessions with up to 10 animals (2/5, 2/10) per 1 ha should be adopted.
- The excessive grazing routine, such as three browsing sessions with more than 5 animals per 1 ha (3/10, 3/15) should be avoided.

5. References

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