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NITROGEN, PHOSPHORUS, AND POTASSIUM BALANCE IN THE SOIL OF MOUNTAIN MEADOW AFTER ITS THREE YEAR UTILIZATION

BILANS AZOTU, FOSFORU I POTASU PO TRZECH LATACH UŻYTKOWANIA ŁĄKI GÓRSKIEJ

Abstract: The research was accomplished on a mountain meadow (650 m above sea level), its type being red fescue (*Festuca rubra* L.) and common bent grass (*Agrostis capillaris* L.), during a period from 2004 to 2006. The experiment was conducted on an acid brown soil containing a medium amount of potassium and a very small amount of phosphorus. The experiment included the total number of 4 objects: 3 objects with three fertilizing variants applied, and one control object. A lysimeter was mounted on each object to collect seepage water. The highest amount of nitrogen was determined in the meadow sward gathered which had been fertilized by applying mineral fertilizers, and the highest amount of potassium – in the meadow sward harvested that had received only barnyard manure. The highest content of phosphorus was determined in the meadow sward that had been fertilized with barnyard manure and mineral fertilizers. The effluent water leached the highest amount of nitrogen of the object fertilized by applying mineral fertilizers. The amount of mineral compounds leached out of the control object was the lowest.

Keywords: meadow, types of fertilizers, and macroelements

The cycle of natural elements in nature should be based on well-balanced principles of sustainable development; and this is possible when natural fertilizers are rationally applied and supplemented with mineral fertilizers, and when self-regulating mechanisms functioning in ecosystems are intentionally implemented und knowingly utilized. Rational application of fertilizers does not include only appropriate amounts of fertilizers to be applied, but also depends on correct proportions of individual fertilizer components, suitable application seasons and times, and types of fertilizers to be applied. In particular, in the mountain regions the soil nutrient balance should be properly determined and stable since the negative consequences of intensification of mineral fertilization for grassland in those regions are more serious than for meadows in lowlands [1]. The majority of fodder production in a mountain region should be located

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on grassland that is predominantly supplemented with natural manures. Such grassland is considered an ecosystem exerting an exceptionally favourable impact on the natural environment [2]. Thus, it is very important for both the economic and the ecological spheres that any grassland is reasonably and effectively managed. The objective of the research initiated and conducted in the region as indicated above was to compare the amounts of components supplied with fertilizers to the meadow soil with the amount of soil nutrients contained in the fodder crops harvested and with the amount of components leached out of the soil by effluent waters.

Conditions and methodology of research

The research project was conducted on a mountain meadow (650 m above sea level, 20 55′34″ E, 49 24′35″ N), its type being red fescue (*Festuca rubra* L.) and common bent grass (*Agrostis capillaris* L.), over a period from 2004 to 2006. The hillside slope where the experimental field was situated was 4° towards NE. The experiment was carried out on a field with an acid brown soil made up of magurski sandstone showing a granulometric composition of medium loam. The chemical profile of this soil was as follows: pH_{KCl} – 3.8; total nitrogen (N_{total}) – 0.29 %; organic matter – 5.0 %; P, K and Mg in the assimilable ions: 9.5, 64.8, and 94.1 mg kg^{-1}, respectively. The research included 4 different objects: 1 control object; 1 object fertilized by applying full mineral fertilizers, their dose being $P_{18}K_{50}N_{100}$; 1 object manured with sheep manure, its dose being 10 Mg ha^{-1}; and 1 object fertilized with barnyard manure plus supplementary mineral fertilizers, ie phosphorus and nitrogen, their amount being the same as when full mineral fertilization was applied. The following forms of fertilizers were applied over the periods indicated below: phosphorus in the form of tri-superphosphate was applied once in spring; potassium in the form of 56 % potash salt was divided into two equal portions and applied for the first and the second regrowth; nitrogen in the form of ammonium nitrate at a rate of 100 kg ha^{-1} was applied in 2 portions, 60 % and 40 % of the total dose, for the first and the second regrowth. The supplementary dose of nitrogen applied to the object with manure was applied in one dose for the first regrowth. The sheep manure was applied each year, in the early spring. The contents of chemical components in the manure utilized in the experiment were as follows: dry mass content – 25.4 %; total nitrogen content (N_{total}) – 0.69 %; P – 0.14 %; K – 0.60 %; Ca – 0.25 %; Mg – 0.08 %; Na – 0.06 %. The manure dose of 10 Mg supplied 69 kg of N, 14 kg of P, and 60 kg of K to the soil.

Lysimeters collecting seepage water were mounted in the early spring of the year 2003; there were 3 lysimeters mounted on the experimental objects. The soil thickness in this region was poor, thus, the lysimeters were situated at a depth of 20 cm, and the collection surface of the individual lysimeter was circle-shaped with a 50 cm diameter. The quantity and quality of water collected by lysimeters was determined several times during the summer period. The results obtained were statistically analyzed. Average values were compared using the Duncan's test. It was assumed that the significance of the results be 0.05.

The meadow sward was mowed twice during each year of the experiment period. The first regrowth was harvested at the turn of the second and third decade of June, and the second regrowth was in the third decade of August. After the meadow was mown, samples of plant material were collected and macroelements were determined.

Research results

The 3-year average amount of nitrogen determined in the harvested sward fertilized using mineral fertilizers was almost twice as high as the amount of nitrogen found in the sward gathered on the control object (Table 1).

Table 1

Quantities of mineral components determined in the crop yield and taken away by effluent waters (kg ha^{-1})

Variant	Years	Content levels of components determined in the dry mass yield			Quantity of components taken away by effluent waters		
		kg ha^{-1}					
		N	P	K	N	P	K
Control object	2004	67.2	4.8	37.7	2.6	0.1	0.7
	2005	98.3	6.9	109.6	4.1	0.2	1.0
	2006	60.3	5.0	58.6	1.2	2.4	2.6
	I X	75.3 a	5.5 a	68.6 a	2.6 a	0.9 c	1.4 a
PKN	2004	141.3	12.4	106.4	10.4	0.1	1.1
	2005	163.0	12.6	178.6	11.1	0.1	1.0
	2006	132.5	10.6	126.8	4.9	0.5	4.2
	I X	145.6 c	11.9 b	137.3 b	8.8 c	0.3 b	2.1 b
FYM 10 Mg	2004	117.5	11.9	159.3	5.5	0.2	1.9
	2005	149.0	13.4	254.3	7.0	0.2	2.3
	2006	92.7	13.0	151.2	2.4	0.3	2.1
	I X	119.7 b	12.8 b	188.3 c	5.0 b	0.3 b	2.1 b
FYM 10 Mg + PKN	2004	116.8	10.4	93.2	4.2	0.1	2.1
	2005	157.6	16.4	279.3	6.6	0.1	3.0
	2006	114.8	15.1	134.5	2.0	0.1	0.6
	I X	129.8 bc	14.0 c	169.0 c	4.3 b	0.1 a	1.9 b

The amount of nitrogen determined in the dry mass yield harvested on the objects fertilized by applying barnyard manure plus mineral fertilizers was lower by 11 %, and on the object fertilized solely with barnyard manure – by 18 % lower if compared with the amount of nitrogen contained in the object fertilized exclusively with mineral fertilizers. The quantity of nitrogen taken away by effluent waters from the object fertilized by applying only mineral fertilizers was 8.8 kg ha^{-1} and this figure was three times as high as the quantity of water taken away from the control object, and twice as high as from two other objects. The highest amount of nitrogen was determined in the

yield of the meadow sward that was fertilized with barnyard manure plus supplementary mineral fertilization (14 kg ha^{-1}), and the loss of nitrogen due to its being leached out of the soil by effluent waters was the lowest in this object. An amount of approximately 12 kg of phosphorus was found in the meadow sward harvested on the remaining objects under fertilization, and the load of phosphorus taken away by the effluent waters was twice as high as the lowest load of phosphorus. The lowest amount of phosphorus, ie 5.5 kg ha^{-1}, was determined in the control meadow sward harvested, and the phosphorus losses in this object were the highest, ie almost 1 kg ha^{-1}.

The gathered meadow sward fertilized by using only barnyard manure contained the highest amount of potassium, and the gathered meadow sward fertilized by a mixture of barnyard manure plus mineral fertilizers contained less potassium, and its amount was lower by 20 kg. With regard to the potassium content in the sward, the harvested meadow sward fertilized by applying mineral fertilizers was in the third position. The control meadow sward delivered the lowest amount of potassium, ie only 69 kg. The amounts of potassium leached out of the objects under fertilization were similar and amounted to nearly 2 kg, and of the control object: 1.4 kg ha^{-1}.

Analysis of experimental data

The dry mass yield decided on the amount of nitrogen content (yield); according to Kasperczyk [3], the nitrogen dose of 100–120 kg N ha^{-1} is mainly utilized in the process of plant mass accretion and does not impact the increase in the nitrogen content in plants. On the other hand, the contents of phosphorus and potassium were impacted by both the dry mass yield and the content of those elements in plants. Another important fact deserving attention is that effluent water leached out the highest amount of nitrogen of the objects fertilized by applying mineral fertilizers of 100 kg ha^{-1}; this result corresponds to the results obtained by other researches [4]. Insignificant losses of soil nutrients caused by effluent waters that leached them out of the objects receiving barnyard manure should be attributed to the strong buffer function and to the long-lasting impact of this fertilizer. Additionally, when mineral nitrogen was added to the object fertilized with barnyard manure plus supplementary fertilizers, the plant development was accelerated in spring. Due to this phenomenon, only limited amounts of water could penetrate through the soil profile and, thus, the amounts of soil nutrients leached out of the soil were lower [5].

Conclusions

The fertilization by applying barnyard manure and mineral fertilizers appears to be the most favourable type of fertilization as regards the amounts of components contained in the dry mass yield. Regarding the impact of this fertilization type on water environment, this fertilization type limits the eutrophication of rivers and lakes.

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BILANS AZOTU, FOSFORU I POTASU PO TRZECH LATACH UŻYTKOWANIA ŁĄKI GÓRSKIEJ

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Abstrakt: Badania przeprowadzono w latach 2004–2006 na łące górskiej (650 m n.p.m.) typu kostrzewy czerwonej (*Festuca rubra* L.) i mietlicy pospolitej (*Agrostis capillaris* L.). Doświadczenie założono na glebie brunatnej kwaśnej średnio zasobnej w potas, a bardzo ubogiej w fosfor. Uwzględniono 3 warianty nawozowe i kontrolę. Na każdym wariancie zainstalowano lizymetry, z których zbierano wodę przesiąkową. Najwięcej azotu zebrano z runią otrzymującą nawożenie mineralne, a potasu z runią otrzymującą sam obornik. Fosforu najwięcej zebrano z runią nawożoną obornikiem wraz z nawozami mineralnymi. Woda odciekowa z obiektu otrzymującego nawożenie mineralne wypłukiwała najwięcej azotu. Najmniej składników mineralnych było wypłukiwanych z obiektu kontrolnego.

Słowa kluczowe: łąka, rodzaj nawozów, makroskładniki