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STRUCTURE OF THE TOTAL YIELD AND THE MACROELEMENTS' CONTENT IN THE MOUNTAIN MEADOW FLORA

STRUKTURA PLONU CAŁKOWITEGO ORAZ ZAWARTOŚĆ MAKROELEMENTÓW W GÓRSKIEJ ROŚLINNOŚCI ŁĄKOWEJ

Summary: The investigations were conducted in 1999–2002 in the permanent grassland in Czarny Potok near Krynica (altitude – 650 m). The investigation designed by split–splot method in four replicants was cutting utilized and 2 swards were collected every year. In the study two variants of fertilization were taken into account: $N_{80}P_{18}K_{66}$, $N_{120}P_{18}K_{66}$ and the control.

The aim of the conducted study was to determine the value and structure of total yield from the mountain meadow flora, in which the mass of agriculturally utilized plants, stubble of fundamental mineral compounds in the above–ground and underground plant mass were separated.

The highest share in the total yield was noticed for the yield of shallow root mass in the layer of 0–3 cm, and lowest allotment for the yield root mass of 3–15 cm layer.

Macroelements' content in the dry mass of the plants agriculturally utilized was usually positively related to the rising amount of nitrogen fertilization.

In the stubble and root mass of 0–3 cm and 3–15 cm the level of total nitrogen, potassium and usually calcium as well as magnesium content decreased and the amount of phosphorus and sodium increased in relation to the mass of utilized plants.

Keywords: total yield, structure, agricultural yield, stubble, yield of the root mass, content of total N, P, K, Ca, Mg, Na

Decomposing organic plant mass plays an important role in the yield keeping of the permanent grasslands because it is a great source of the nutrients [1]. The time of samples collecting, the level of fertilization, intensity of utilization, composition of the sward, level of humidification, the content of nutrients and humus in the soil as well as other factors have an effect on the quantity of the residues in the soil after harvesting [2, 3]. Location of the mountain plant biomass, in which the mass of agriculturaly utilized plants, stubble and the root mass of 0–3 cm and 3–15 cm layers were determined in the

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conducted studies. The investigations also contained the content of basic mineral compounds in the above-ground parts. The aim of this work was to determine the yield of agriculturaly utilized plants as well as so called "regeneration stem", which determines durability, stability and the ecological value of the population.

Materials and methods

The studies were conducted in 1999–2002 in the permanent grassland in Czarny Potok near Krynica (altitude 650 m a.s.l.). The investigation was located on the brown, acid soil, made from magurski sandstone with granulometric composition of light, dusting clay. Chemical characteristic of the soil was as follows: pH_{KCl} – 4.0, organic mater content 50.2, total nitrogen 4.5 g · kg^{-1} of the soil and available P – 10, K – 87, Mg – 45 g · kg^{-1} of the soil.

The investigation designed by the split–splot method in four replicants was cutting utilized and two swards were collected every year in the full heading of dominant grass species *i.e. Poa trivialis* L. and *Festuca rubra* L.

Two fertilization variants were taken into account in the studies *i.e.*: $N_{80}P_{18}K_{66}$, $N_{120}P_{18}K_{66}$ and the control object, which was not fertilized but cutted twice during the vegetation period. Fertilization was done using – phosphorus (of 18 kg P · ha^{-1}), – potassium in two equal portions (of 33 kg K · ha^{-1}) for the first and the second regrowth and nitrogen in two portions (of 80 i 120 kg N · ha^{-1}), divided as follows – 60 % N for the first and 40 % for the second regrowth.

The yield of the sward was estimated after the cutting of the plants from the area of 12 m^2. Absolutely dry matter was determined by the drying at the temperature of 105 ^oC for the average samples from the replicants. After the mineralization of the hay samples the total nitrogen content was determined using Kjeldahl method as well as the potassium, magnesium, calcium and sodium amount by the atomic absorption spectrometry (AAS) method and the phosphorus content by the colorimetric vanadium-molybdate method [4].

Additionaly the samples of the sod from the area of 30 x 30 cm and the depth of 15 cm were collected from the objects during the harvesting in order to estimate the stubble mass as well as the root mass and its location in the layer of 0–3 cm and 3–15 cm. The plants cutted at the level of 5 cm from the soil surface and utilized as animal forages were defined as the agricultural yield. The term of stubble yield was given to the meadow plants of maximum 5 cm hight remaining after the cutting.

Annual amounts of rainfalls during the investigated period in the region of Czarny Potok fluctuated from 1136 to 1332 mm. However average amounts of rainfalls for six months (IV–IX) ranged between 671–970 mm. Average annual temeratures of the air varied between 5.6 and 6.8 ^oC and in the vegetation period they amounted to 12–13 ^oC.

Obtained data were subjected to analysis of variance (ANOVA). The means were contrasted and the differences analysed using the Duncan range test, then the least significant difference (LSD) was found.

Results and discussion

The whole production of plant biomass derived from the grasslands was defined in a term of the total (gross) yield. The control object was characterised with the lowest level of the total yield of dry matter (Table 1) and the highest yield was observed for the $N_{120}P_{18}K_{66}$ object. This relative increase amounted to 46 %.

Table 1

The total yield and its structure

Specification	Variant		
	Control	$N_{80}P_{18}K_{66}$	$N_{120}P_{18}K_{66}$
Total yield [Mg · ha^{-1} D.M.]	20.4	27.5	29.7
Share in total yield [%]			
agricultural yield	14	23	34
stubble yield	14	8	6
yield of root mass in the layer of 0–3 cm	63	63	54
yield of root mass in the layer of 3–15 cm	9	6	6

Contents of majority of the macroelements in the stubble were on the lower level when compared with the agricultural yield (Table 2). On the other hand the phosphorus content in the stubble increased about 1/3–times and for sodium on average 5-times. The highest total nitrogen, potassium, calcium, magnesium and sodium content was observed for the plants of the control object. Fertilization with the maximum nitrogen portion caused phosphorus and potassium amount in the stubble to decrease.

Table 2

Macroelements' content in the dry mass of the meadow flora in the above-ground and underground layer [g · kg^{-1} d.m.]

Specification		N–total	P	K	Ca	Mg	Na
Mass of the plants agriculturally utilized	A	18.32	2.21	19.0	3.89	2.37	0.17
	B	19.82	2.32	23.2	4.12	2.27	0.18
	C	20.03	2.43	24.3	4.11	2.40	0.20
Stubble	A	15.62	3.32	5.16	3.54	1.36	1.06
	B	14.96	3.38	4.25	3.05	1.01	0.80
	C	15.04	3.24	3.65	3.53	1.03	0.81
Root mass of the 0–3 cm layer	A	11.67	2.92	3.62	3.24	0.88	0.94
	B	11.93	3.08	3.01	2.45	0.81	0.90
	C	13.32	2.90	2.68	2.14	0.71	0.91
Root mass of the 3–15 cm layer	A	9.02	3.05	2.22	1.81	0.88	0.99
	B	9.43	3.06	2.23	1.57	0.73	0.97
	C	11.78	2.93	1.61	2.32	0.70	0.77
LSD $_{(0.05)}$		5.50	0.57	12.78	1.37	1.37	0.40

A – Control, B – $N_{80}P_{18}K_{66}$, C – $N_{120}P_{18}K_{66}$

The above-ground plant mass was richer in macroelements than the root mass. This phenomenum was particulary refered to the 3–15 cm root layer, in which the amount of total nitrogen and potassium decreased with its dept.

$N_{120}P_{18}K_{66}$ fertilization decreased the P, K, Ca, Mg content in the 0–3 cm root mass and the P, K, Mg, Na content in the 3–15 cm root mass.

According to Malicki [5] 50 % of the plant root mass from the permanent grasslands is situated 5 cm little below the soil profile. However in the conducted studies the main root mass was located in the layer of 0–3 cm and its contribution in the total yield equaled 50 %. On the other hand the yield of postharvesting residues ranged from 17.54 Mg for the control to 21.17 Mg · ha^{-1} of dry matter for the $N_{80}P_{18}K_{66}$ object. These results are not fully consisted with the investigations of Tomaskin [6], who has stated that in the mountain grasslands situated on the brown soil it remains 4.9–13.9 Mg · ha^{-1} (dry matter) of postharvesting residues.

Acting of the mineral fertilization as an important pratotechnical factor **(???)**, particulary with 120 kg N · ha^{-1} was distinctly visible as an improvement of the forage value of the agriculturally utilized plants. In this case it caused 2.5-times increase of the dry matter yield, 3.5-times increase of the total nitrogen, phosphorus, calcium and magnesium as well as 4-times increase of the potassium content. The level of nutrients' content, dependent on fertilization as well as the total nitrogen, phosphorus, calcium, magnesium and sodium amount, was relatively low in the cultivated plant mass. In the case of potassium considerable amount of this component was found in the plant material (agriculturally utilized plant mass). It is in good agreement with the common statement that grasslands forages more often contain excessive than deficient amounts of potassium [7]. Increase of the potassium content with the increasing nitrogen portions stated in these investigations are fully consisted with the studies of other authors [8].

Conclusions

1. Fertilization and usage affected the total yield production and its structure.
2. The share of the agricultural yield in the total yield had steadily increased with increasing nitrogen portions and under the maximum it was 250 % higher than in the control. The highest share in the total yield was noticed for the yield of shallow root mass in the layer of 0–3 cm, and lowest allotment for the yield root mass of 3–15 cm layer.
3. Increasing nitrogen fertilization in relation to the PK affected elevation of the total N, P, K and Na content in the agriculturally utilized plant mass.
4. Total nitrogen, potassium, calcium and magnesium content decreased and the amount of phosphorus and sodium increased, in the stubble and the root mass of 0–3 cm as well as 3–25 cm layer in relation to the agriculturally utilized plant mass.
5. There was no positive effect of the increasing nitrogen fertilization on the amount of the macroelements in the stubble and the root dry mass.

References

[1] Ondrasek L. and Gaborcik N.: *Wpływ udziału roślin motylkowatych w runi na zawartość masy organicznej i aktywność biologiczną gleby użytków zielonych*. Łąkarstwo w Polsce, 1998, **(**1), 165–172.
[2] Pałys E., Tarkowski C., Kuraszkiewicz R. and Kraska P.: *Masa korzeni odmian pszenżyta ozimego źródłem substancji organicznej na glebie lekkiej*. Fol. Univ. Agric. Stetin. 2000, **197** Agricultura (211), 387–392.
[3] Troughton A.: *Length of life of grass roots*. Grass Forage Sci., 1981, **36**(2), 118–120.
[4] Ostrowska A., Gawliński S. and Szczubiałka Z.: Metody analizy i oceny właściwości gleb i roślin. Katalog. Wyd. IOŚ, Warszawa 1991, pp. 334.
[5] Malicki L.: *Znaczenie resztek pożniwnych w płodozmianie*. Acta Acad. Agricult. Acad. Techn. Olstenensis, Agricult., 1997, **(**62), 57–66.
[6] Tomaskin J.: *Accumulation and root system development of grassland*. Zesz. Probl. Post. Nauk Roln., 1995, (421b), 101–105.
[7] Falkowski M., Kukułka I. and Kozłowski S.: Właściwości chemiczne roślin łąkowych, Poznań 2000, 66–83.
[8] Filipek-Mazur B., Mazur K., Kasperczyk M. and Gondek K.: *Wpływ długotrwałego nawożenia mineralnego i wapnowania na skład chemiczny gatunków roślin wybranych z runi łąkowej statycznego doświadczenia w Czarnym Potoku*. Zesz. Probl. Post. Nauk Roln., 1999, (465), 585–595.

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S t r e s z c z e n i e

Badania prowadzono w latach 1999–2002 na trwałym użytku zielonym w Czarnym Potoku koło Krynicy (650 m n.p.m.). Doświadczenie założone metodą losowanych bloków w czterech powtórzeniach, użytkowano kośnie, zbierając corocznie dwa pokosy. W badaniach uwzględniono dwa warianty nawozowe $N_{80}P_{18}K_{66}$, $N_{120}P_{18}K_{66}$ i kontrolę.

Celem podjętych badań było określenie ilości i struktury plonu całkowitego górskiej roślinności łąkowej, w którym wyróżniono masę roślin użytkowanych rolniczo, ścierń oraz masę korzeniową warstw 0–3 cm i 3–15 cm. W badaniach przedstawiono również zawartość podstawowych składników mineralnych w nadziemnej i podziemnej masie roślin.

Największy udział w plonie ogólnym miał plon płytkiej masy korzeniowej w warstwie gleby od 0 do 3 cm, a najmniejszy plon masy korzeniowej roślin warstwy od 3 do 15 cm.

Zawartość makroelementów w suchej masie roślin użytkowanych rolniczo była na ogół dodatnio związana ze wzrastającym nawożeniem azotowym.

W ścierni i w masie korzeniowej warstw 0–3 cm i 3–15 cm, w stosunku do masy roślin użytkowanych, malała zawartość azotu ogólnego, potasu wapnia i magnezu, natomiast wzrosła ilość fosforu oraz sodu.

Słowa kluczowe: plon całkowity, struktura plonu rolniczy, ścierń, plon masy korzeniowej, zawartość N-ogólnego, P, K, Ca, Mg i Na