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NUTRIENTS UPTAKE AND BALANCE BY DIFFERENT INTENSITY OF GRASSLAND UTILIZATION

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Abstract

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In 2003–2005 it was solved the issue about the nutrient balance in the permanent grasslands of Research Institute for Cattle Breeding Rapotín. In trial it was used these types of utilization: 1. Intensive – 4 cuts per year (1st cut up to 15th May, every next after 45 days), 2. Medium intensive – 3 cuts per year (1st cut from 16th to 31st May, every next after 60 days), 3. Low intensive – 2 cuts per year (1st cut up to 15th June, 2nd after 90 days), 4. Extensive – 2 cuts per year (1st cut from 16th to 30th June, 2nd after 90 days). There were following variants of the fertilization: A – no fertilization, B – P:K 30:60 kg.ha^{-1}, C – N:P:K 90:30:60 kg.ha^{-1}, D – N:P:K 180:30:60 kg.ha^{-1}. There was the considerable reaction of the permanent grassland on the nutrient application. The highest value of the coefficient of the neutral efficiency was by the fertilization N:P:K 90:30:60 kg of the pure nutrients. By the most of the variants we have noticed the negative nitrogen balance. The negative balance of the phosphorous was marked only by the unfertilized variants. All variants of the permanent grassland utilization had the negative potassium balance. The utilization had the significant influence ($P_{0.01}$) to all observed indicators. The year had the significant influence too. From the point of view of the rational plant nutrition and of the environment protection from the contamination (especially from the nitrates) it appears as the most advisable the medium intensive type of the utilization with nitrogen dose: N:P:K 90:30:60.

balance, nutrients, grassland, fertilization

The permanent grasslands are very important and precious part of landscape in all countries of Europe. In the Czech Republic the grasslands form fourth part from acreage of agricultural land with average year production 2500–2800 thousand t DM. At the present time is in the Czech Republic high contribution of arable land (72.4%) and consequently is probable to expect the increase of grassland acreage. With this increase is concerted the choice of sustainable management (Pozdišek et al., 2004). The optimal fertilization of grassland is one of principal rationalizing measures, enabling realization of production potential of grassland and preserving the out production functions (Krajčovič, 1997).

The rational fertilization is effective measure, what has the influence on the soil fertility, the yield height and quality, the animal utility, the quality of environment and economy of agriculture in LFA (Slamka et al., 2004).

The observation of different intensity of grassland management with use of different fertilizer dosages is the important condition for production forage in optimal quality (Mičová et al., 2004). Komárek et al. (2004) found that under the influence of increase dosage of mineral fertilizers decrease the species frequency.

The balance of nutrients and determination of their effectiveness are appropriate means for speed diagnostics of the situation in nutrient status under various levels of agro ecosystem (Klír, 1999; Kováčik, 2001). In principle we can state that the nutrient outputs have to be in the balance with nutrient inputs for maintenance of soil fertility in actual cultivating conditions (Hanáčková, 2004).

The aim of this paper is to evaluate the different ways of grassland managements and fertilizations from point of view of material flows and fertilization efficiency.

MATERIALS AND METHODS

We have carried out the observation at Research Institute for Cattle Breeding Rapotín holdings in 2003–2005. The locality is situated in 390–402 m above sea level and it come under the geomorphologic division Hrubý Jeseník. Geomorphologic sub grade is deeper diluvium of mica schist. The soil is sandy-loam, type cambisol (horizons Am-Bv-B/C-C). The temperatures and precipitations during observed period are shown in table I.

I: *The overview of rainfall and average monthly temperatures during observed period*

Year	Month	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
2003	Precipitation [mm]	74.6	18.7	30.9	25.8	80.8	32.1	59.8	25.9	23.7	70.2	24.8	76.3
	Temperature [°C]	–6.0	–14.3	–3.8	6.7	15.5	18.4	18.3	19.2	12.2	5.1	5.2	–4.77
2004	Precipitation [mm]	96.9	31.8	11.9	34.3	20.9	65.4	51.5	59.3	41.0	49.8	114.1	40.9
	Temperature [°C]	–9.7	–1.4	2.2	8.93	11.6	15.4	16.93	17.5	12.1	9.4	3.43	1.1
2005	Precipitation [mm]	90.0	45.0	27.5	23.5	76.0	50.0	78.0	69.0	19.0	56	120	-
	Temperature [°C]	–1.3	–4.5	–0.7	8.9	12.7	15.6	18.3	15.7	13.4	4.9	3.1	-

On the permanent grassland there are dominant these species (described by projective dominance method):

1. Taraxacum sect. Ruderalia (27–60%)
2. Poa pratentis (23–60%)
3. Dactylis glomerata (21–54%)
4. Elytrygia repens (10–25%)
5. Trifolium repens (3–37%)
6. Achillea milleflorum (3–25%)
7. Lolium perenne (4–18%)
8. rest (0–10%) (Festuca arundinacea, F. pratensis, Bromus hordeaceus, Alopecurus pratensis, Crepis biennis and others).

Intensity of utilization:

1. Intensive – 4 cuts per year (1st cut on May 15th at the latest, next after 45 days)
2. Medium intensive – 3 cuts per year (1st cut on May 31st at the latest, next after 60 days)
3. Low intensive – 2 cuts per year (1st cut on June 15th at the latest, 2nd cut after 90 days)
4. Extensive – 2 cuts per year (1st cut on June 30th at the latest, 2nd cut after 90 days).

Nutrition and fertilization:

A – no fertilization
B – P:K 30:60 kg.ha^{-1}
C – N:P:K 90:30:60 kg.ha^{-1}
D – N:P:K 180:30:60 kg.ha^{-1}.

The trial was originally established by a block method in four replications with the area of an experimental plot 12.5 m^2. It was used ammonium nitrate with pulverized limestone as nitrogen fertilizer, super phosphate as phosphorus fertilizer and potassium chloride as potassium fertilizer.

The samples were treated for analysis by method of Central Institute for Supervising and Testing in Agriculture (Zbíral et al., 2002). The soil samples were taken before experiment foundation from the depth up to 0.30 m. In this samples were determined the content of available nutrients in extract Mehlich III, the total nitrogen and the exchangeable soil reaction (pH in 0.2 M KCl).

After grass phytomass harvest we quantified the nutrients content in dry matter (DM). Used methods (Zbíral et al., 2004): N – Kjeldahl method, P – colorimetric and K spectrofotometric. On the basis of reached yield and determination of macronutrients content in dry matter uptake of nutrients by yield was calculated. The balance of nutrients was calculated by the following equation (Bobková, Ložek; 2002):

$$\Delta Z = A - P$$

ΔZ – net balance

A – Input of nutrients (fertilizers, N fixation by leguminous)
P – Output of nutrients.

The percentage of nutrient output substitution by nutrient inputs was calculated as follows:

% of substitution = (Input of nutrients/ Output of nutrients) x 100.

The efficiency of fertilization was expressed through the coefficient of natural efficiency. This coefficient was calculated by the following equation (Fecenko, Ložek, 2000):

$$K_{NE} = \Delta Ys/Z$$

ΔYs – increase of dry matter [kg.ha^{-1}] in consequence of fertilization
Z – dosage of pure nutrients N, P, K [kg.ha^{-1}].

The obtained data by the statistical program SPSS 13.0 were processed (average, standard deviation, coefficient of confidence and analysis of variance).

RESULTS AND DISCUSSION

The average yields of DM during years 2003–2005 according to management and fertilization variants are shown in table II. We noticed the highest mean production of DM (7.53 t.ha^{-1}) in low intensive grassland utilization. The lowest mean production of DM was noticed in intensive (6.58 t.ha^{-1}) grassland utilization.

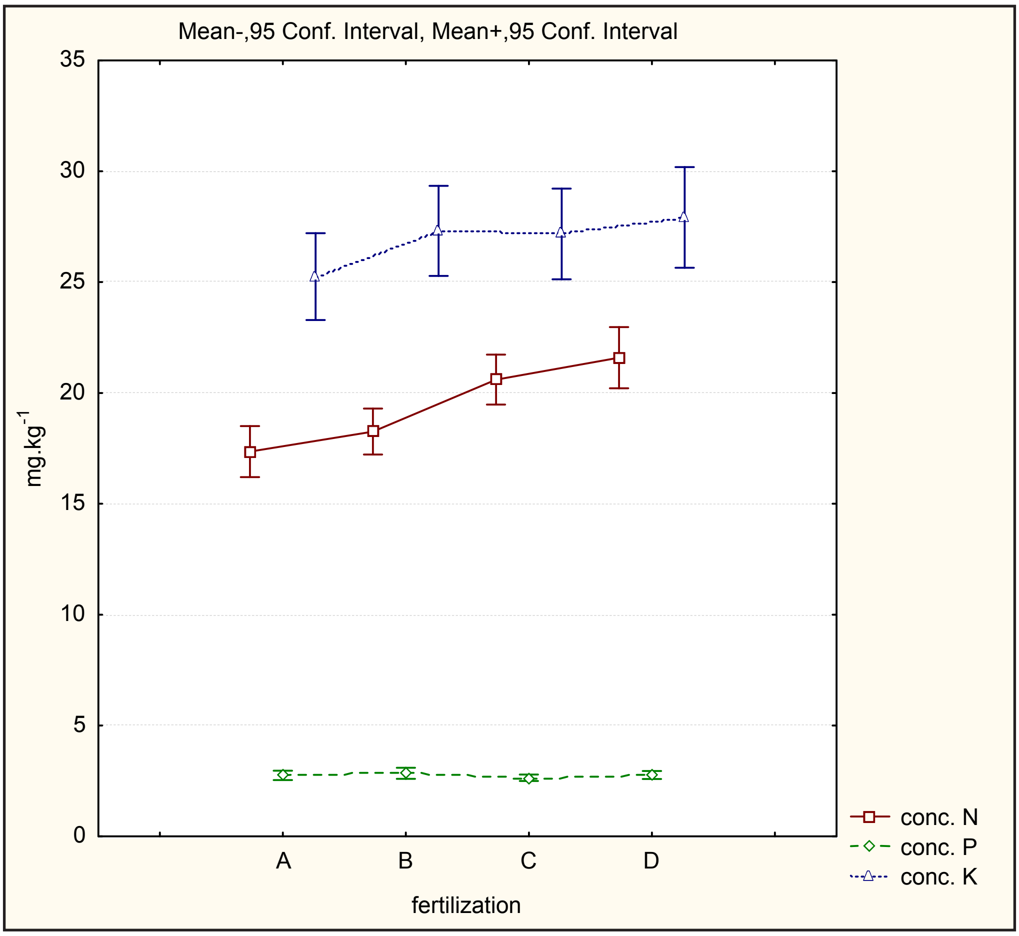
From results in the table II flows the marked reaction on application of nutrients. We found the highest values of K_{NE} in the fertilization with dosage NPK 180:30:60 kg pure nutrients per hectare. These values moved from 9.12 to 15.90. In variant of fertilization D (N:P:K 180:30:60 kg.ha^{-1}) the values moved from 2.78 to 9.34. In variant of fertilization B (dosage P:K 30:60 kg pure nutrients per ha) we noticed the values of natural efficiency coefficient in relation from 3.07 (intensive exploitation) to 7.72 (low intensive exploitation).

II: *The production indicators during observed period*

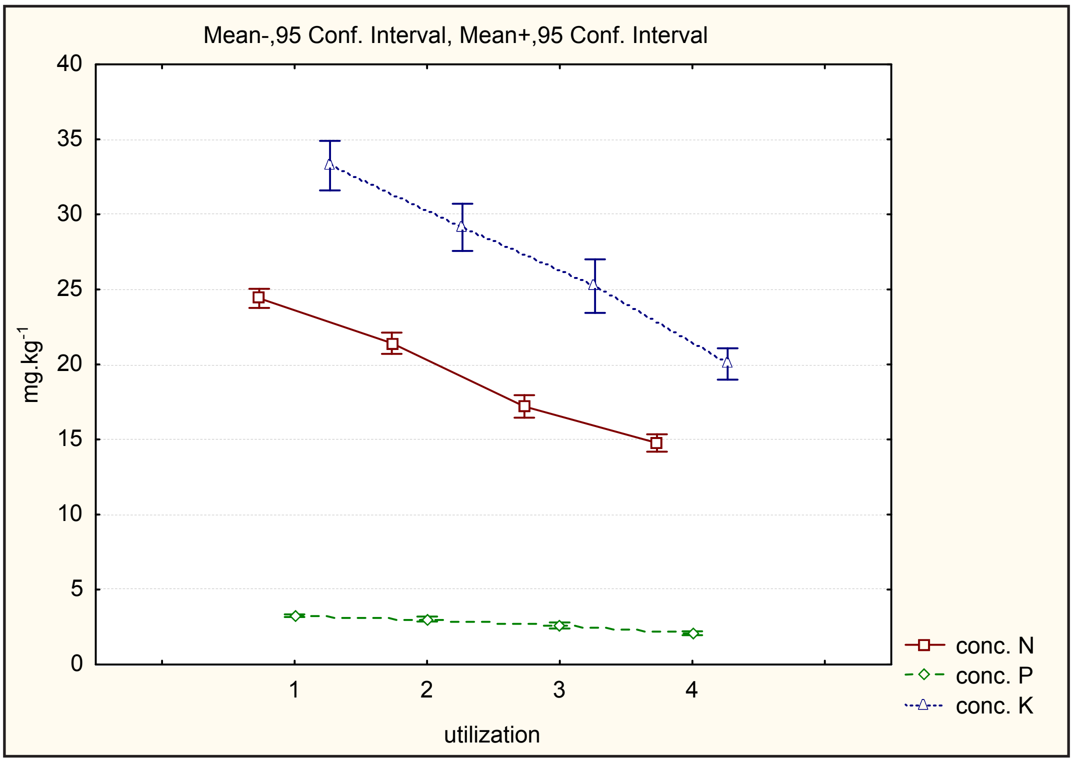
Utilization and fertilization		y. 2003 [t.ha^{-1}DM]	y.2004 [t.ha^{-1}DM]	y. 2005 [t.ha^{-1}DM]	$\bar{x}$ [t.ha^{-1}DM]	K_{NE}
1	A	6.29	5.16	4.87	5.44	-
	B	6.07	5.32	5.76	5.72	3.07
	C	7.57	7.24	7.44	7.42	10.99
	D	8.48	7.62	7.12	7.74	8.52
2	A	7.00	5.11	4.87	5.66	-
	B	7.78	5.65	5.38	6.27	6.77
	C	8.38	8.13	9.06	8.52	15.90
	D	10.15	8.59	5.81	8.18	9.34
3	A	7.09	5.73	6.23	6.35	-
	B	7.77	6.19	7.18	7.05	7.72
	C	8.38	8.13	9.06	8.52	12.06
	D	7.77	8.58	8.28	8.21	6.89
4	A	5.93	5.51	6.06	5.84	-
	B	5.79	6.28	7.36	6.48	7.11
	C	7.09	7.34	8.01	7.48	9.12
	D	7.03	8.20	4.53	6.59	2.78

The values of nutrients uptake are shown in figure 1 and 2. In comparison with data of Lichner et al. (1983) and Fecenko, Ložek (2001) we noticed higher uptake of potassium and comparable uptake of nitrogen and phosphorus. Lichner et al. (1983) informs on follows values of nutrients uptake: 19–21 kg.t^{-1} N, 2.5–2.8 kg.t^{-1} P and 20–22 kg.t^{-1} K. We can settle the heightened uptake of potassium on good stock of this nutrient in soil and also on influence of herbs contribution in growth (r = 0,83, see figure 3).

The results of nutrients inputs and outputs balance are shown in table IV. The nutrients uptake increased according to increasing level of utilization and fertilization. The comparable results noticed Slamka et al. (2004). The highest uptake of growth was 213 kg.ha^{-1}.year^{-1} N in variant 1D (intensive utilization, dosage



1: *Influence of fertilization to N, P, K concentration in DM*



2: *Influence of utilization to N, P, K concentration in DM* of N:P:K 180:30:60). We found the lowest uptake of growth in level 73 kg.ha^{-1}.year^{-1} N in variant 4A (extensive utilization, without fertilization). We noticed the negative balance in majority of tested variants. The positive balance was found only in variants 3D and 4D, so in growths fertilized with dosage N:P:K 180:30:60 kg pure nutrients per hectare and with low intensity of utilization. The aim of rational fertilization is the balance of nutrients equilibrated. This aim has particular importance in nitrogen fertilization, in respect of extensive mobility of its mineral forms in environment. We can hold the value of nitrogen balance ± 25 kg N per hectare for sustainable from this point of view and from view of environmental protection. The input of nitrogen prevailed over output about 33 kg.ha^{-1}.year^{-1} N in variant 2C and about 74 kg.ha^{-1}.year^{-1} N in variant 4D.

We found the negative balance of phosphorus only in variants without fertilization. The phosphorus excess moved from 3 kg.ha^{-1}.year^{-1} (2D) to 15 kg.ha^{-1}.year^{-1} (4B) in fertilized variants. The even balance approached the variants with medium (2D, 3B, 3C) and intensive utilization and fertilization intensity (1D). Füleky and Orbán (2005) counted the balance of phosphorus by using the dosage 60 kg.ha^{-1}. They found the excess of phosphorus in range from 17 to 22 kg.ha^{-1}.

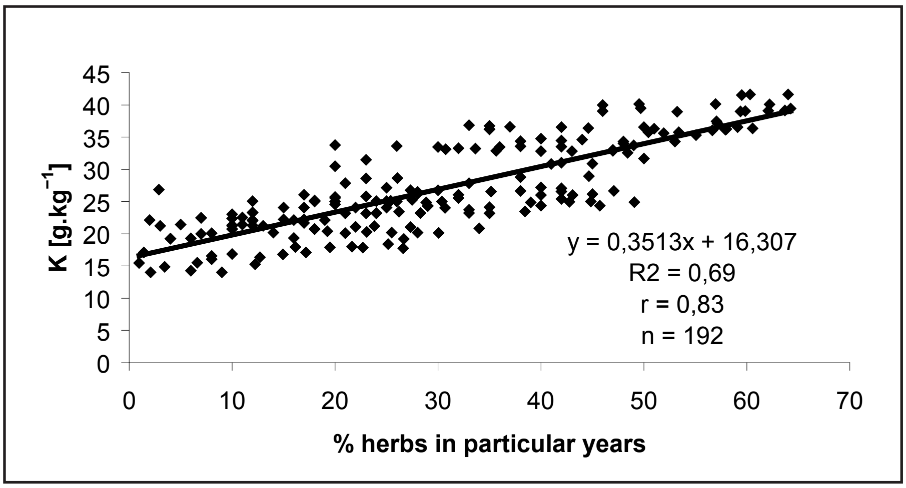
The negative potassium balance was found in all variants of grassland utilization and fertilization. The deficit was moved from –75 kg.ha^{-1}.year^{-1} (variant 4B) to –187 kg.ha^{-1}.year^{-1} (variant 1D). The even balance approached the variants 4B and D, with the percentage of nutrient substitution 50.15 and 49.34%. Our results are in concordance with Kunzova's et al. (2003) conclusions.

The mean total nitrogen content in soil was in level 1.84 g.kg^{-1} before the foundation of experiment. The total nitrogen content decreased on mean level 1.77 g.kg^{-1} after three years of grassland exploitation. We show the overview of total nitrogen changes in figure 4. From this figure results, that with exception of fertilization variant D and extensive utilization, the total nitrogen stock was decreased.

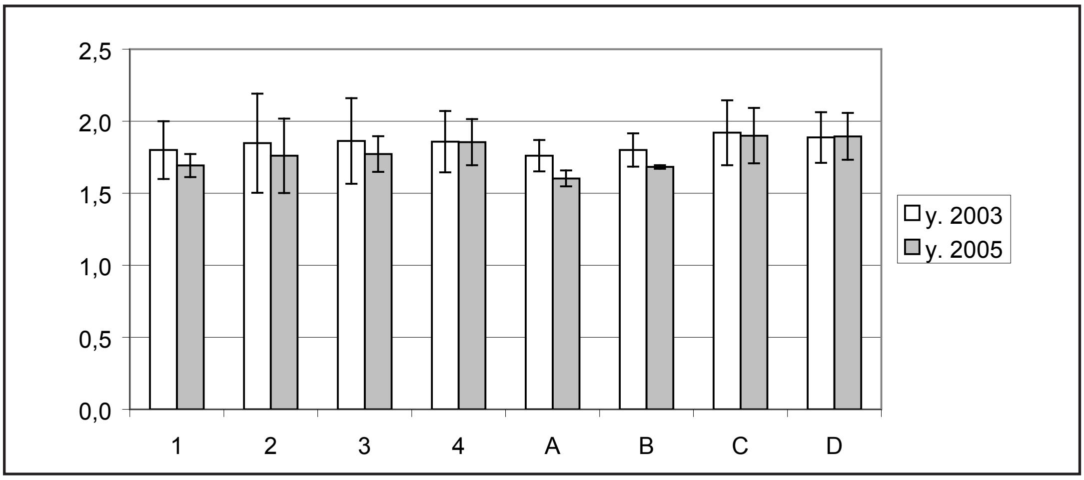
The content of available potassium in soil (fig. 5) was decreased from the mean level 220 to 149 mg.kg^{-1} during three years period. The overview of available potassium uptake is shown in figure 6. We noticed the decreasing tendency of potassium uptake, with exception of variants 4A and 4B.

The content of available phosphorus in soil was decreased from the mean level 100 to 53 mg.kg^{-1} although its positive balance. We think that the low values of pH are the reason of available phosphorus decrease. We noticed the most favorable content of available phosphorus in variants with application of calcium (Ca is complement of nitrogen fertilizer). The differences in values of soil reaction are concluded in figure 7. We found the biggest decrease of pH in variant of fertilization B, also in variant with application of physiologically neutral (super phosphate) and acid fertilizers (KCl), without calcium application.

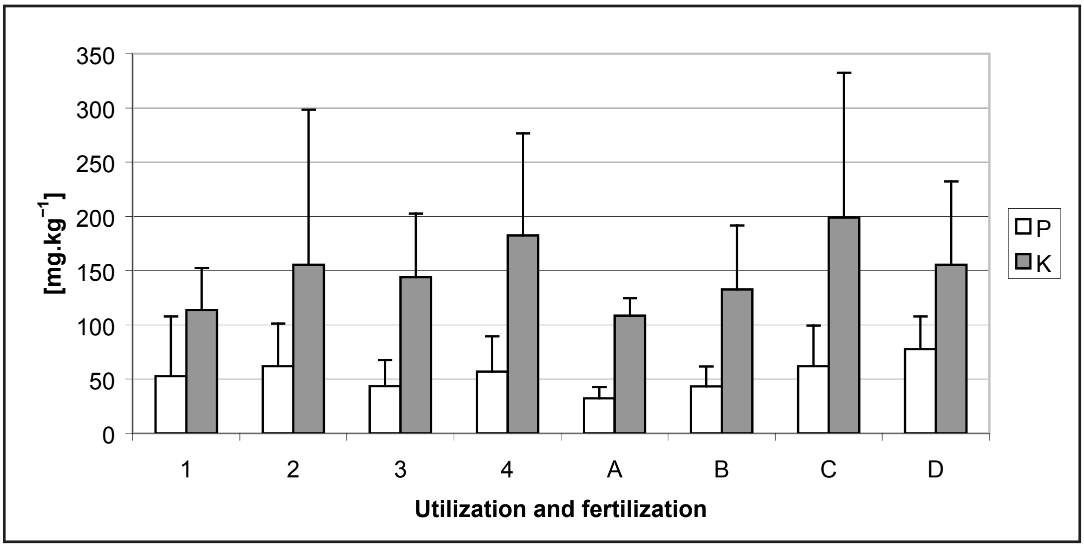
The results of variance analysis are shown in table III. The utilization had the significant influence to all observed indicators ($P_{0.01}$). The year had the significant influence, as well. The fertilization did not have significant influence only to phosphorus concentration in phytomass DM. The differences in nutrient concentration are shown in figure 1 and 2. We noticed the increase of DM production by potassium and phosphorus fertilization (variant B) in comparison with variant without fertilization; but this difference was not significant. The dosages of NPK 90:30:60 and 180:30:60 kg per hectare increased the DM production conclusively. The obtained results correspond with results of Michalec, Kanošova (2004), Kohoutek et al. (2002) and others.



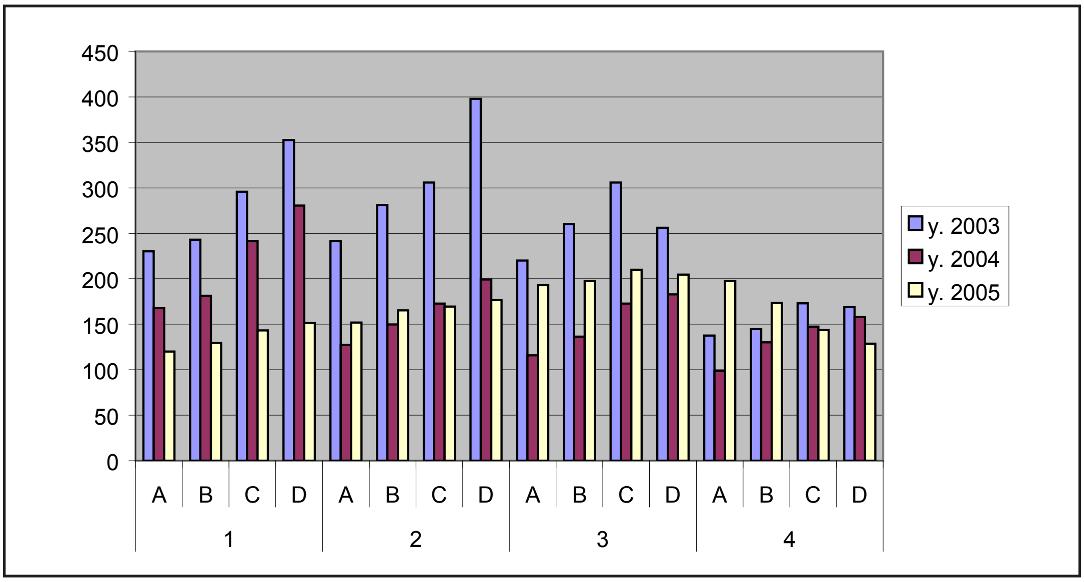
3: *Dependence of potassium concentration in DM on herbs abundance in plant cover*



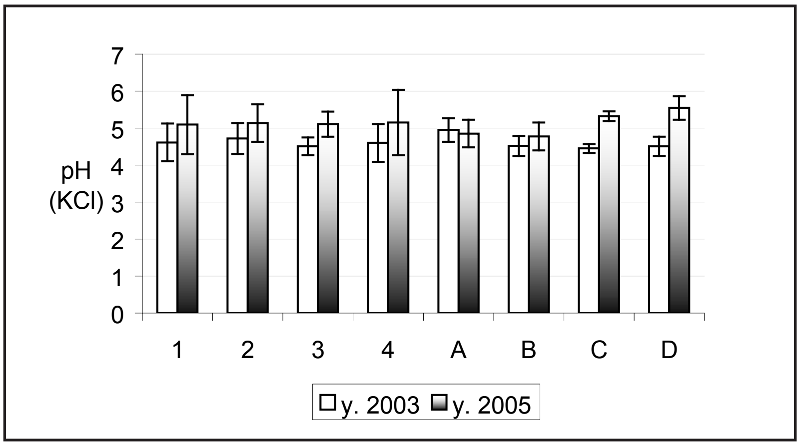
4: *Content of total nitrogen in soil [g.kg^{-1}]*



5: *Content of available phosphorus and potassium in soil after three years exploitation*



6: *Uptake of potassium by growth [kg.ha^{-1}]*



7: *Values of exchange soil reaction in autumn 2003 and 2005*

III: *Variance analysis of estimated parameters*

		Year	Fertilization	Utilization
	d.f.	2	3	3
Phytomass production	MS	13.41	44.195	9.56
	F	11.19**	36.59**	7.98**
Nitrogen uptake	MS	17184	50645	39011
	F	34.31**	101.12**	77.89**
Phosphorus uptake	MS	102.93	274.70	625.72
	F	6.66**	17.77**	40.48**
Potassium uptake	MS	198734	50675	75961
	F	161.84**	41.27**	61.86**
Concentration of N in phytomass	MS	65.48	187.67	886.31
	F	38.89**	111.47**	526.45**
Concentration of P in phytomass	MS	1.18	0.32	12.75
	F	4.43*	1.20	48.02**
Concentration of K in phytomass	MS	2087.5	64.3	1524.3
	F	416.4**	12.83**	304.06**
Nitrogen balance	MS	15891.5	157132.7	38478.8
	F	32.08**	317.17**	77.67**
Phosphorus balance	MS	102.9	8230.7	625.7
	F	6.66*	532.55**	40.48**
Potassium balance	MS	198734	18417	75961
	F	161.84**	14.99**	61.86**

Statistic importance * P<0.05; ** P<0.01

CONCLUSION

We can form the follows conclusion in basis of obtained results:

- In grassland fertilization is important to make emphasis on equilibrium of phosphor and potassium fertilization, but also on maintenance of soil reaction
- The high herbs abundance can cause the highly potassium uptake in grassland
- By the high intensity of grassland utilization can be the balance of nitrogen in deficiency although the use of nitrogen dosage crosses over 170 kg.ha^{-1}
- From view of rational fertilization we consider the medium intensive utilization with nutrients dosage NPK 90:30:60 as most favorable.

IV: *Balance of nutrients N, P, K (average of years 2003–2005) [kg.ha^{-1}]*

Utilization		1				2				3				4			
Nutrient	Fertilization	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
N	Output	122	129	186	213	106	126	162	199	100	112	162	148	73	93	117	106
	Input	1	2	91	181	1	1	92	181	1	2	92	182	1	1	91	180
	Balance	–121	–127	–95	–32	–105	–125	–70	–18	–99	–110	–70	33	–72	–92	–26	74
	% of substitution	1.08	1.48	49.12	85.13	0.89	0.86	56.53	90.73	1.17	1.55	56.53	122.48	1.72	1.11	77.55	169.73
P	Output	17	19	22	24	21	19	22	27	19	24	24	21	16	15	17	16
	Input	0	30	30	30	0	30	30	30	0	30	30	30	0	30	30	30
	Balance	–17	11	8	6	–21	11	8	3	–19	6	6	9	–16	15	13	14
	% of substitution	0.00	154.42	138.56	125.46	0.00	160.24	133.88	111.40	0.00	127.44	124.48	140.95	0.00	194.78	171.60	184.31
K	Output	173	185	227	262	174	199	216	258	176	198	230	214	145	150	155	152
	Input	15	75	75	75	15	75	75	75	15	75	75	75	15	75	75	75
	Balance	–158	–110	–152	–187	–159	–124	–141	–183	–161	–123	–155	–139	–130	–75	–80	–77
	% of substitution	8.69	40.60	33.07	28.67	8.64	37.75	34.71	29.08	8.51	37.87	32.68	34.97	10.36	50.15	48.46	49.34

SOUHRN

Odběr a bilance živin při různé intenzitě využívání trvalých travních porostů

V letech 2003–2005 byla na pozemcích Výzkumného ústavu pro chov skotu Rapotín řešena problematika bilance živin TTP. V pokusu byly uplatněny následující způsoby využívání: 1. Intenzivní – 4 seče za rok (první seč do 15. 5., následující po 45 dnech), 2. Středně intenzivní – 3 seče za rok (1. seč od 16. do 31. 5., další po 60 dnech), 3. Málo intenzivní – 2 seče za rok (1. seč do 15. 6., druhá po 90 dnech), 4. Extenzivní – dvě seče za rok (první seč od 16. do 30. 6., druhá po 90 dnech). Varianty hnojení byly následující: A – bez hnojení, B – P:K 30:60 kg.ha^{-1}, C – N:P:K 90:30:60 kg.ha^{-1}, D – N:P:K 180:30:60 kg.ha^{-1}. Z výsledků vyplývá výrazná reakce TTP na aplikaci živin. Nejvyšší hodnoty koeficientu naturální efektivnosti byly zjištěny při hnojení dávkou N:P:K 90:30:60 kg čistých živin. U většiny variant byla zaznamenána negativní bilance dusíku, záporná bilance fosforu byla zjištěna jen u nehnojených variant.U všech variant využívání TTP byla zjištěna záporná bilance draslíku. Využívání významně ovlivňovalo všechny sledované ukazatele. Z pohledu racionální výživy rostlin a ochrany životního prostředí před kontaminací zvláště dusičnany se jeví jako nejvhodnější středně intenzivní využívání porostu s dávkou živin N:P:K 90:30:60.

bilance, živiny, trvalý travní porost, hnojení

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REFERENCES

BOBKOVÁ A., LOŽEK O.: Hodnotenie bilancie živín v integrovanom a ekologickom systéme hospodárenia na pôde. In: Aktuálne problémy riešené v agrokomplexe. Nitra: SPU, 2002, s. 65–68. ISBN 80-8069-126-4.

FECENKO J., LOŽEK O.: Výživa a hnojenie poľných plodín. Nitra: SPU, 2000, 452 s. ISBN 80-7137-777-5.

FÜLEKY G., ORBÁN M.: Improving nutrient supply of grassland soil. In Optimalisation of nutrient cycling and soil quality for sustainable grasslands. Wageningen: Wageningen Acaademic Publishers, 2005. pp. 93. ISBN 90-7699-872-8.

HANÁČKOVÁ E.: Bilancia živín pri pestovaní kukurice na siláž hnojenej vyhnitým kalom po výrobe bioplynu. In: Produkčné, ekologické a krajinotvorné funkcie trávnych a krmnych plodín. Nitra: SPU, 2004, s. 205–211. ISBN 80-8069-409-5

KLÍR J.: Bilance rostlinných živin. Rostlinná výroba –studijní informace. Praha: ÚZPI, 1999. 60 s. ISBN 80-7272-063-1

KOHOUTEK A., KOMÁREK P., ODSTRČILOVÁ V., NERUŠIL P.: Vhodná pratotechnika pro trvale udržitelné obhospodařování travních porostů. In Chov a šlechtění skotu pro konkurenceschopnou výrobu a obhospodařování drnového fondu. VÚ pro chov skotu, s.r.o. Rapotín, 2002, s. 95–106.

KOMÁREK P., KOHOUTEK A., ODSTRČILOVÁ V., NERUŠIL P.: Botanické složení travního porostu při změně intenzity využívání a hnojení. In: Pastvina a zvíře. Brno: MZLU, 2004, s. 49–54. ISBN 80-7157-775-8.

KOVÁČIK P.: Metodika bilancie živín v pôdach ekologicky hospodáriacich podnikov. Nitra: SPU, 2001. 44 s. ISBN 80-7137-957-3.

KRAJČOVIČ V.: Štyri okruhy päťdesiatročných aktivít v odvetví krmovinárstva. In: Ekologické a biologické aspekty krmovinárstva. Nitra: SPU, 1997, s. 91–103.

KUNZOVÁ E., KLÍR J., ČERMÁK P.: Bilance živin v zemědělských podnicích. In Pedologické dny 2003. Ochrana a využití půdy v nivních oblastech.. Brno: MZLU. 2003, s. 141–145. ISBN 80-7157-735-9.

LICHNER et al.: Krmovinárstvo. Bratislava: Príroda, 1983, s. 91–103.

MIČOVÁ P., SVOZILOVÁ M., POZDÍŠEK J.: Vliv intenzity obhospodařování TTP na chemické složení a obsah NDF a ADF v píci. In: Pastvina a zvíře. Brno: MZLU, 2004, s. 73–81. ISBN 80-7157-775-8.

MICHALEC M., KANOŠOVÁ K.: Striedavé využívanie trvalých trávnych porastov. In Produkčné, ekologické a krajinotvorné funkcie trávnych a krmnych plodín. Nitra: SPU, 2004, s. 54–59. ISBN 80-8069-409-5.

POZDÍŠEK J., KOHOUTEK A., BJELKA M., NERUŠIL P.: Využití trvalých travních porostů chovem skotu bez tržní produkce mléka. Praha: ÚZPI, 2004, 103 s. ISBN 80-7271-153-9.

SLAMKA P., JANČOVIČ J., VOZÁR Ľ.: Hodnotenie ekonomickej a naturálnej efektívnosti hnojenia a odberu živín trávnym porastom. In: Produkčné, ekologické a krajinotvorné funkcie trávnych a kŕmnych plodín. Nitra: SPU, 2004, s. 68–78. ISBN 80-8069-409-5.

ZBÍRAL J. et al.: Analýza půd I: jednotné pracovní postupy. Brno: ÚZKUZ, 2002, 197 s. ISBN 80-86548-15-5.

ZBÍRAL J. et al.: Analýza rostlinného materiálu: jednotné pracovní postupy. Brno: ÚZKUZ, 2005, 192 s. ISBN 80-86548-73-2.

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