

CHANGES OF AGROCHEMICAL PROPERTIES OF CAMBISOL UNDER GRASSLAND AFTER ABANDONMENT

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Abstract

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On the grassland (association *Lolio-Cynosuretum cristati* R. 1937) with brown acidic soil (cambisol) the basic agrochemical properties (pH, Cox, Nt, P, K) was studied during the years 1986–2006. Various systems of management (fertilizing + cutting, liming, no management) had different influences to the cambisol qualities, but had not so significant effect. The pH of the soil decreased after application of mineral fertilization and also in the period without anthropogenic interference. The balanced content of oxidizable carbon (Cox) preserved during the experimental period. The total nitrogen content (Nt) increased in the period of fertilization and the aftermath of fertilization. The content of phosphorus (P) decreased significantly in the years of fertilization and this trend continued after the absence of fertilization too. The content of potassium (K) decreased in the period of fertilization, except for a variant with PK nutrition. The content of potassium (K) increased on the all variants in both sampling depths of almost 1.5-fold after a period without management. We found a significant effect of year and depth of soil sampling for most of soil parameters. Variants had not significant impact on all evaluated soil characteristics. Between the years there was relatively great variability at the available nutrients values (8–75 %). The available phosphorus had greatest variability (19–96 %) and also potassium (18–82 %). Medium till small variability was characteristic for pH (9–14 %), Cox (17–19 %) and Nt (8–16 %). The results are indicating that changes of management systems mean not automatically changes of soil features.

cambisol, permanent grassland, systems of utilization

Soil conditions on the grasslands should not be judged by the same pedological criteria such as arable land, because according to KRAJČOVIČ (1985) such comparison is inappropriate. Existing knowledge confirm that soil is such environment for grasslands which properties are markedly unchanged by long-term effects (KLOBUŠICKÝ, 1997). Soils under grasslands are characterized by rich rooted sod layer with typical physicochemical properties, a higher supply of organic compounds, the presence of macro and micro edafon, but mainly by permanent plant cover, which is photo synthetically active most part of the year, which greatly affecting sod soils.

Interest on long-term effects of different types of grassland on soil, its basic properties, previously has not been the subject of any research work. This is also the reason that this issue can be encountered in literary sources only marginally (KRAJČOVIČ, 1985; JANČOVIČ, 1999; KLOBUŠICKÝ, 1997; HEJDUK, 2011). In the contribution we deal with some agrochemical properties of cambisol and their possible changes in long-term experiment (FOLKMAN, JANČOVIČ, 1989; JANČOVIČ, HOLUBEK, 1993; JANČOVIČ, VOZÁR, SLAMKA, 2002; SKLÁDANKA, HRABĚ, 2008), caused by mineral fertilizers and intensive use, but also absence of fertilizing for several years.

MATERIAL AND METHODS

Field experiments with grasslands were carried out between the years 1986–2006 in Strážovské Vrchy Mts. (48° 53'N, 18° 34'E) at an altitude of 600 a.s.l., with an average annual temperature of 7.4 °C, average temperature during the vegetation period was 11.1 °C.

Long-term average of precipitation in this area is 848 mm and 431 mm during the vegetation period. Agrochemical properties of soil before the foundation of experiments are given in Table I. Original permanent grassland was characterized as an association of *Lolio-Cynosuretum cristati* R. 1937 with 73 % of grasses, 25 % of pasture and meadow herbs and 2 % of legumes.

Grasslands have been in years 1986–1993 fertilized and used according to the scheme shown in Table II. In the autumn of 1993, was applied ground limestone to all variants (80 to 98 % CaCO₃) in an amount of 2 tons per hectare. In the years 1994–1999 grasslands were used only by one mowing during the vegetation period in the term of the maximum biomass production (late June) and in the years 2000–2006 have been left without using.

In the two depths of soil profile (0–100 mm and 101–200 mm) were monitored the content of available nutrients—total nitrogen (Nt), phosphorus and potassium, organic carbon (Cox) and pH. The soil samples were taken in the spring before fertilizing.

Total nitrogen content was set down by the modified method of Kjeldahl, phosphorus by the method according to Egner and potassium by Schachtschabell method. Due to wide range of obtained material we evaluate only the base year (1986) and also the years 1989, 1993, 1999 and the ending year of the experiment (2006).

The statistical analysis was carried out using Statistica vers. 7.1. StatSoft, Inc. (2005). Differences between treatments were analyzed by one way ANOVA at probability level $p < 0.95$.

Aim of this study was to evaluate the effect of mineral fertilizing and different utilization of grassland on basic agrichemical cambisol soil characteristics (pH, available nutrients) and soil organic matter.

RESULTS AND DISCUSSION

Agrochemical characteristics of cambisol obtained by comparing the measured values before the foundation of experiment (1986), during the experiment (1989, 1993 and 1999) and after its ending (2006) are presented in Tab. III–V and in Fig. 1–5.

After four years of fertilization and three mowing per vegetation period (1986–1989), the soil was acidified on all fertilized variants at both sampling depths. It is interesting that, after the next four years period of fertilizing and the using (1990–1993), in the first sampling depth of soil the acidity decreased in average about 0.15 value of pH, and a slight acidification was observed even in the second sampling depth. The liming from autumn 1993 damped out and even in 1999 was reflected by a shift of pH values above 5 in all treatments and sampling depths.

The application of ground limestone softened the soil solution acidity and the absence of mineral fertilizing partially inactivated the exchange base cations of the soil sorption complex without their significant movement, which resulted in reduced soil acidification (MASARYK, 1978). After this period (2000–2006) grassland was left to stand without use and without mineral fertilizing. The effect of liming was gradually reduced and then

I: Agrochemical characteristics of the soil before the establish of the trial (1985)

Depth of soil sampling [mm]	Nt [mg.kg ⁻¹]	pH/KCl	Cox [mg.kg ⁻¹]	P	K	Mg	Ca	Content of basic cations	Exchange sorptive capacity	Level of sorptive saturate
				[mg.kg ⁻¹]				[mval.100g ⁻¹]		
0–100	4000.0	4.6	360.0	15.7	120.0	113.7	850.0	4.71	13.80	34.10
101–200	2800.0	4.6	240.0	4.3	66.0	91.9	750.0	4.48	13.30	33.70

II: Variants of utilization and fertilizing

Variant	Number of cutting per year			Nutrients amount [kg.ha ⁻¹] in years 1986–1993			Dividing and terms of nitrogen application [kg.ha ⁻¹]		
	1986–1993*	1994–1999	2000–2006	N	P**	K**	in the spring	after 1 st cut	after 2 nd cut
1	3	1	0	-	-	-	-	-	-
2	3	1	0	-	35	70	-	-	-
3	3	1	0	60	35	70	60	-	-
4	3	1	0	120	35	70	60	60	-
5	3	1	0	240	35	70	100	80	60

Legend: * - CaCO₃ (2.0 t.ha⁻¹) application in autumn 1993, ** - the nutrients were applied one-shot in the spring

III: Agrochemical cambisol soil characteristics

	year	variants									
		I.*					II.*				
		1	2	3	4	5	1	2	3	4	5
pH/KCl	1986	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60
	1989	4.10	4.40	4.10	4.30	4.40	4.20	4.60	4.40	4.50	4.50
	1993	4.30	4.50	4.20	4.50	4.50	4.20	4.40	4.10	4.20	4.10
	1999	5.14	5.02	4.04	5.01	5.17	5.15	5.14	5.10	5.17	5.05
	2006	3.88	3.82	3.88	3.83	3.82	3.95	3.87	3.95	3.81	3.86
Cox (g.kg ⁻¹)	1986	36.00	36.00	36.00	36.00	36.00	24.00	24.00	24.00	24.00	24.00
	1989	55.00	46.00	47.00	47.00	42.00	41.00	34.00	30.00	30.00	30.00
	1993	51.10	53.60	51.20	52.00	51.70	48.00	41.40	40.00	44.00	42.50
	1999	40.00	34.00	38.00	38.00	38.00	28.00	38.00	30.00	28.00	30.00
	2006	54.80	51.30	52.90	57.50	53.50	39.90	33.20	42.60	33.90	36.60
Nt (mg.kg ⁻¹)	1986	4000.0	4000.0	4000.0	4000.0	4000.0	2800.0	2800.0	2800.0	2800.0	2800.0
	1989	4300.0	4100.0	4200.0	3900.0	3600.0	2700.0	2700.0	2500.0	2100.0	2400.0
	1993	3000.0	3100.0	3300.0	3300.0	3200.0	2800.0	2200.0	2200.0	2200.0	2200.0
	1999	3690.0	3640.0	3780.0	3840.0	4060.0	2960.0	2740.0	2370.0	2460.0	2910.0
	2006	2990.0	4623.0	3650.0	3825.0	4350.0	2750.0	3027.0	2390.0	2789.0	2068.0
P (mg.kg ⁻¹)	1986	15.70	15.70	15.70	15.70	15.70	4.30	4.30	4.30	4.30	4.30
	1989	4.10	4.00	2.00	3.30	3.90	1.90	2.30	1.50	1.60	1.40
	1993	3.10	1.60	1.80	3.20	3.20	1.70	1.30	1.20	2.20	2.80
	1999	3.00	2.50	3.70	2.00	0.00	0.00	0.00	0.00	0.00	0.00
	2006	14.00	10.00	8.00	8.00	10.00	12.00	14.00	12.00	10.00	10.00
K (mg.kg ⁻¹)	1986	120.00	120.00	120.00	120.00	120.00	66.00	66.00	66.00	66.00	66.00
	1989	124.00	76.00	105.00	41.00	61.00	97.00	33.00	39.00	25.00	40.00
	1993	61.00	179.00	60.00	34.00	23.00	56.00	202.00	33.00	33.00	42.00
	1999	30.00	44.00	71.00	55.00	48.00	67.00	50.00	45.00	28.00	39.00
	2006	233.00	188.00	158.00	215.00	160.00	165.00	133.00	143.00	138.00	163.00

*Depth of soil sampling – I. 0–100 mm, II. 101–200 mm

IV: Effect of the year on the changes in soil agrochemical properties

Year	Cox [g.kg ⁻¹]	pH/KCl	Nt	P [mg.kg ⁻¹]	K
1986	30.00 b	4.60 c	3400.00 a	10.00 b	93.00 a
1989	40.20 ac	4.35 a	3250.00 a	2.60 a	64.10 a
1993	47.55 a	4.30 a	2750.00 a	2.21 a	72.30 a
1999	34.20 bc	4.99 d	3246.20 a	1.12 a	47.70 a
2006	45.62 a	3.87 b	3246.20 a	10.80 b	169.60 b

Legend: Different index indicates statistically significant differences within column (Fisher test, $\alpha = 0.05$)

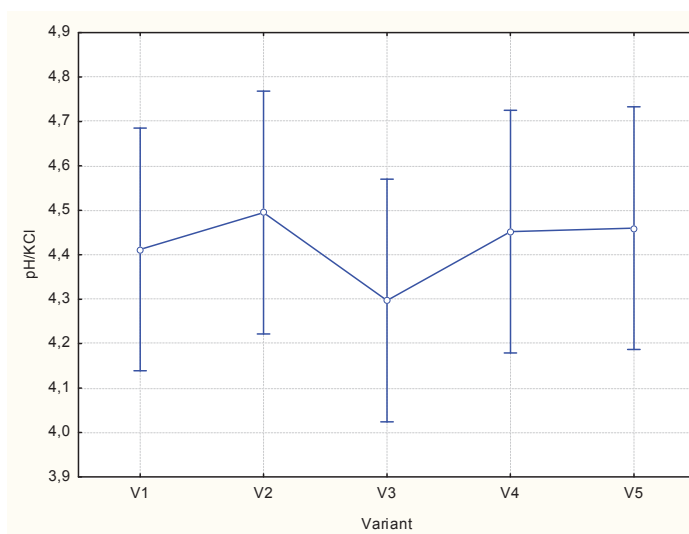
V: Effect of depth on the changes in soil agrochemical properties

Depth	Cox [g.kg ⁻¹]	pH/KCl	Nt	P [mg.kg ⁻¹]	K
I. 0–100mm	45.38 b	4.39 a	3777.92 b	6.79 b	76.04 a
II. 101–200mm	33.64 a	4.45 a	2578.56 a	3.89 a	99.80 a

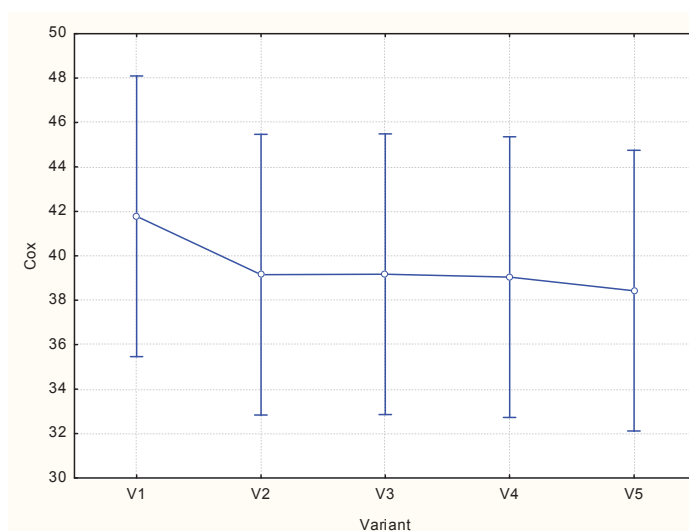
Legend: Different index indicates statistically significant differences within column (Fisher test, $\alpha = 0.05$)

the value of pH dropped sharply on all variants and sampling depths with a values of pH under 4 (Fig. 1). We assume that the liming had a negative influence

to the soil under grassland also in follow time period (2000–2006).



1: Effect of the variants on the pH value change (bars show confidence interval)



2: Effect of the variants on the organic carbon (Cox) concentration (g.kg⁻¹) (bars show confidence interval)

The value of pH dropped by displacement of base cations (Ca²⁺, Mg²⁺, K⁺, Na⁺) from the soil sorption complex, as well as increased mineralization of soil organic matter in soil (HRABĚ, BUCHGRABER, 2004). Long-term fertilization and its follow long-term exclusion influenced the properties of soil under grasslands. It reflected by changes of organic matter in soil, which are partly different in the period of fertilization and during his absence.

In the first sampling depth was always content Cox higher than in the other in monitored time period (Fig. 2).

After four years of fertilization (1989) the content of Cox increased in all variants, and this trend continued also in 1993. This finding is confirmed also by several authors (KOPČANOVÁ, 1980; ONDRÁŠEK, 1985; GÁBORČÍK, ONDRÁŠEK, 2000). Liming (autumn 1993) reduced the content

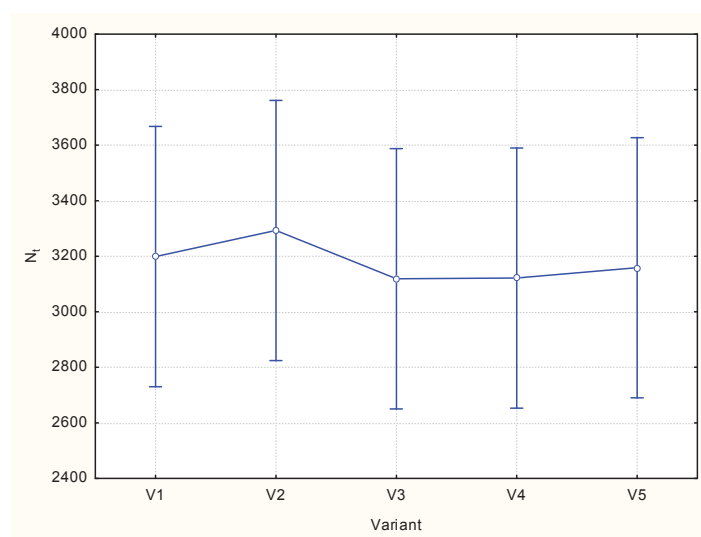
of soil organic matter on all variants and sampling depths. In a period without mineral fertilizing and no use (2000–2006) the content of Cox increased again on the level of content of Cox in the initial year (1986). On the examined variants were not recorded a very significant and dramatic changes because uniform content of Cox was substantially maintained during the entire experimental period, even in varying anthropogenic interventions. According to VELICH (1986) and KOPČANOVÁ (1980), if in the soils of fertilized variants remains the same amount of organic matter as in the control one (Cox, humic substances), it means that mineralization processes have intensified, but the dynamic balance between supply and output of matter and energy preserved in the habitat. It is documented also by our long-term results, while the total absence of fertilization and reduction of the

mowing increased the content of Cox; it is suggesting the accumulation of large amounts of humus with increased dynamics of its decomposition, thus the reverse process as in the case of increased mineralization influenced by N-fertilization effects. KOPČANOVÁ (1980) found that pure mineral fertilization reduces the ability of soil microflora to synthesize new organic nitrogenous substances.

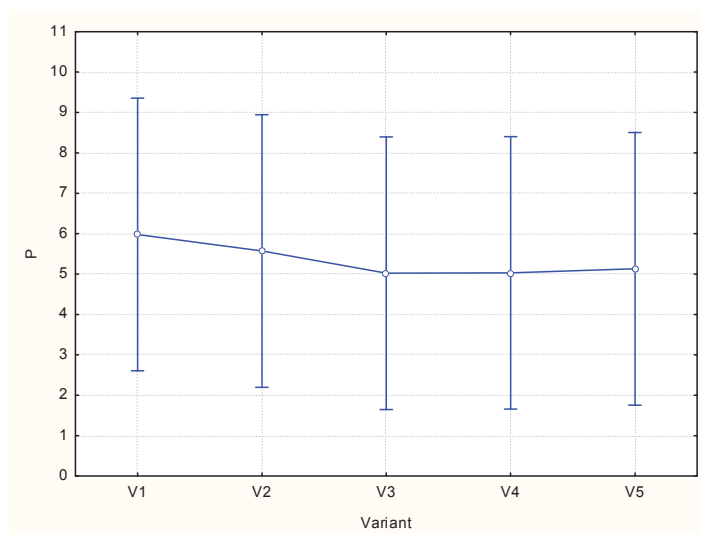
Due to fertilization of permanent grassland with mineral nitrogen (1986–1993) was partly changed its contents in the soil. After four years of fertilization the total content of nitrogen at a depth of 0–100 mm increased and then decreased in 1993, in comparison with the initial year of research (1986). Reducing of the effect of liming (1999) increased the content of Nt on control variant and also on all fertilized variants. In the last year of research (2006)

was recorded a sharp increase of Nt content on the variant with PK-fertilization and on the N240 treatment (Fig. 3). Vice versa, on the control variant was the lowest content of Nt for the whole examined period. Content of Nt in the second sampling depth was in average of variants almost 35% lower, but with a balanced content of Nt on control variant and the more varying on the previously fertilized variants by graded doses of nitrogen. These changes suggest an imbalance in income and output of nitrogen in the ecosystem according to the nature of changing conditions in the botanical composition of grassland and its demands on the nutritional needs of nitrogen and other nutrients.

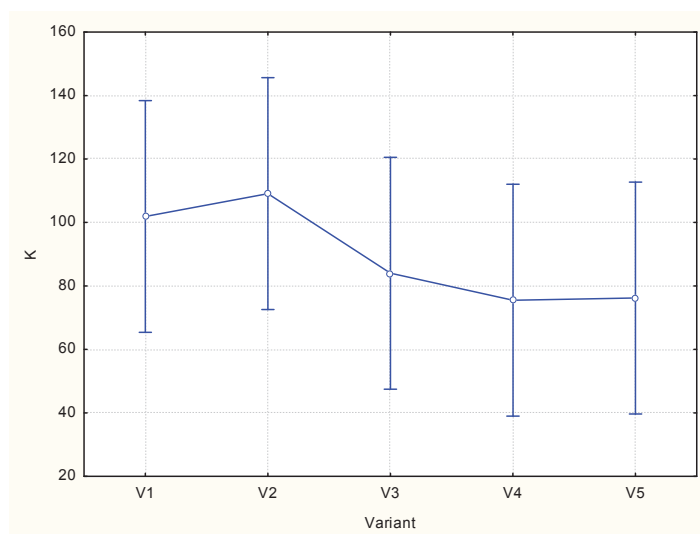
The part of the research was also monitoring the concentration of available nutrients (phosphorus, potassium) in the soil. Fig. 4 shows that the



3: Effect of the variants on the change of total nitrogen content (mg.kg⁻¹) (bars show confidence interval)



4: Effect of the variants on the phosphorus content (mg.kg⁻¹) (bars show confidence interval)



5: Effect of the variants on the potassium concentration (mg.kg⁻¹) (bars show confidence interval)

concentration of phosphorus (P) in the years of fertilization significantly decreased (by 52 to 91%) and this trend continued even after the absence of fertilization.

In the second sampling depth was found only traces of accessible phosphorus in the soil. These results show its low mobility and fixation in insoluble forms on one side and on the other side the doses of phosphorus were not apparently sufficient to maintain, respectively increase the concentration of phosphorus in the soil. In 2006 (after the 12 years of the absence of fertilization) were measured in both sampling depths of soil greater content of accessible phosphorus, almost identical to its content in the initial year of experiment (1986). This finding suggests an increased mineralization of organic phosphorus in the soil; the plants themselves effect by the secretion of hydrogen ions the increasing of soil acidity in the immediate proximity of roots, which makes available the phosphates from labile compounds to soil solution (FECENKO, LOŽEK, 2000).

The concentration of potassium content gradually decreases by the influence of fertilization (1986–1993) on all variants over the years (Fig. 5).

The exception was the variant with PK nutrition, where was the potassium content at the end of the period of fertilization (1993) almost 8-fold higher compared with other variants (Tab. III). In 1999, the potassium concentration slightly increased also on the other variants and this trend continued till the end of the experiment (2006). In 2006, the potassium content increased on all variants and both sampling depths of almost 1.5-fold, which obviously depends on the overall level of accessible potassium in the soil, which usually has been associated with content of exchange potassium (MASARYK, 1978; FECENKO, LOŽEK, 2000).

From a practical point of view has always been the available concentration of nutrients in the soil considered as important.

In our experiences there is not in compliance with production order of the variants, therefore this relationship as problematic should be considered in a larger file. Observed variability of available nutrients is significant between the years (8–75 %). Nutrients with high variability are the phosphorus (19–96 %) and potassium (18–82 %) and moderate to low variability is characterized for pH (9–14 %), Cox (17–19 %) and Nt (7–16 %).

SUMMARY

On the grassland with associations of *Lolio-Cynosuretum cristati* R. 1937 with brown acid soil (cambisol) in the years 1986 to 2006 we followed the changes of the basic agrochemical properties of soil (pH, Cox, Nt, P, K). Different systems of management (fertilization + mowing, liming, absence of management) differently affected the properties of cambisol, but did not affect them significantly. We found a significant effect of year and depth of soil sampling for most of soil parameters. Variants had not significant impact on all evaluated soil characteristics. Between the years was found relatively large variability in terms of available nutrients (8–75 %). Characterized by high variability was available content of phosphorus (19–96 %) and potassium (18–82 %). Moderate to low variability were characterized the pH (9–14 %), Cox (17–19 %) and Nt (8–16 %). The results suggest that a change of systems of management are not negatively reflected on the changes of soil properties.

REFERENCES

- FOLKMAN, I., JANČOVIČ, J., 1989: Uplatnenie stupňovaných a striedavých dávok dusíka na poloprírodných trávnych porastoch. Záverečná správa. VŠP Nitra. 72 s.
- FECENKO, J., LOŽEK, O., 2000: Výživa a hnojenie poľných plodín. SPU v Nitre a Duslo, a.s., Šaľa, 452 s. ISBN 80-7137-777-5.
- GÁBORČÍK, N., ONDRÁŠEK, L., 2000: Štúdium trávnych ekosystémov z hľadiska environmentálne prijateľného obhospodarovania v marginálnych podmienkach. Syntetická záverečná správa. VÚTPHP Banská Bystrica, 286 s.
- HEJDUK, S., 2011: Changes of soil agrochemical characteristics in pastures influenced by mineral fertilizing. *Acta univ. agric. et silvic. Mendel. Brun.*, 2011, LIX, No. 1, pp. 113–120.
- HRABĚ, F., BUCHGRABER, K., 2004: Pícninářství (Travní porosty). MZLU, Brno, 151 s. ISBN 80-7157-816-9.
- JANČOVIČ, J., 1990: Zmeny niektorých agrochemických vlastností pôd prírodných trávnych porastov. In: Zbor. ref. z odb. vedeckého seminára pri príležitosti nedožitých 90-tych narodenín prof. Dr. h. c. Ing. A. Frídeczkého, DrSc., VŠP Nitra: 118–129.
- JANČOVIČ, J., HOLÚBEK, R., 1993: Uplatnenie stupňovaných a striedavých dávok dusíka na poloprírodných trávnych porastoch. Záverečná správa. VŠP Nitra. 50 s.
- JANČOVIČ, J., VOZÁR, L., SLAMKA, P., 2002: Vplyv dlhodobého hnojenia trávnych porastov a jeho absencie na zmeny niektorých agrochemických vlastností pôdy. In: *Agrochémia*, roč. VI. (42), (2):15–19.
- JANČOVIČ, J., 1999: Vybrané biologické, produkčné a kvalitatívne charakteristiky trávnych porastov zväzu Cynosurion ovplyvnené hnojením: Monografia. Nitra: SPU Nitra, 93 s. ISBN 80-7137-601-9.
- KLOBUŠICKÝ, K., 1997: Dlhodobé pôsobenie rôznych trávnych ekotypov na pôdne vlastnosti. In: Zbor. ref. z medzinár. vedeckej konferencie „Ekologické a biologické aspekty krmovinnárstva“. Nitra: SPU Nitra, s. 190–193.
- KOPČANOVÁ, L., 1980: Mikrobiálne procesy v pôdach intenzívne hnojených trvalých trávnych porastov. In: Zbor. ref. zo seminára „Ekológia trávneho porastu“. ČSVTS-VÚLP Banská Bystrica, s. 78–86.
- KRAJČOVIČ, V., 1985: Pôdne pomery v ovplyvňovanom trávnom poraste. In: Zbor. ref. z medzinárodnej vedeckej konferencie „Ekológia trávneho porastu II.“ ČSVTS-VÚLP Banská Bystrica, s. 10–21.
- MASARYK, Š., 1978: Zmeny agrochemických vlastností pôd s trávny porastom pri intenzívnom hnojení dusíkom. In: *Poľnohospodárstvo*, 24 (10): 873–882.
- ONDRÁŠEK, L., 1985: Hlavné zmeny pedobiologických vlastností lúčneho ekosystému pri rôznej intenzite hnojenia a využívania. In: Zbor. ref. z medzinárodnej vedeckej konferencie „Ekológia trávneho porastu II.“ ČSVTS-VÚLP Banská Bystrica, s. 22–34.
- SKLÁDANKA, J., HRABĚ, F., 2008: Effect of fertilization and cutting frequency on botanical composition, diversity and grassland quality. *Agriculture (Poľnohospodárstvo)*, Vol. 54, 2008, N. 1. pp. 1–8.
- StatSoft, Inc., (2005): STATISTICA Cz [Softwarový systém na analýzu dat], verze 7.1. www.StatSoft.Cz.
- VELICH, J., 1986: Studium vývoje produkční schopnosti trvalých lučních porostů a drnového procesu při dlouhodobém hnojení a jeho optimalizace. VŠZ Praha, Videopress MON, 162 s.

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