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Agrochemical properties of soil in Zhůří enclave

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Abstract
The objective was to evaluate the influence of three options of extensive mountain grassland management (mulching = herbage is cut once a year, chopped and left in the meadow; no-cut, and one-cut treatment = one--cut system with mown herbage removal) on changes in agrochemical properties of soil. The results are highly variable, and often contradictory for the particular uses. But it can be concluded that after a long period of continuous nutrient export without observation of the basic rules of grassland nutrition the values of most agrochemical properties of soil are at an extreme level at the locality concerned. Differences between the treatments are insignificant for the following reasons: a) number of samples, b) short observation period, c) the change in the values of most agrochemical characteristics is very much restricted and limited by the extreme site conditions. The changes in values for the particular treatments are not clear enough. This enclave shows a trend of development that can be generalized for many similar localities if no common pratotechnics of grassland nutrition is applied.

Key words: grassland management (mulching, no cut, one cut), soil acidity, sorption capacity, exchangeable cations, available nutrients, total phosphorus and nitrogen, humus, humic and fulvic acids, colour quotient

INTRODUCTION

The objective was to evaluate the influence of three options of extensive grassland use (mulching – herbage cut once a year is chapped and left in the meadow; no-cut variant, and one-cut variant – one-cut system with mown herbage removal) on changes in agrochemical properties of soil. Taking into account new economic conditions, these practices, implying a change in the use of mountain and submontane areas, were chosen. Changes in agrochemical properties of soil due to agrochemical measures and pratotechnics can be highly specific depending on the initial site conditions. KOLÁŘ & al. (2000d) reported on the deterioration of dynamic elements of soil productivity in mountain and submontane areas being 2 to 3 times faster than is the Czech Republic's average after decrease of fertilizing and liming intensity in 1988–1998. The meadow enclave of Zhůří, where our measurements were carried out, was excluded from intensification measures for a very long time because it was part of a military the area. Mowing was probably the only management carried out in the long term. This enclave shows a trend of development that can be generalized for many similar localities if no common pratotechnics of grassland nutrition is applied. The trend of agrochemical properties of soil can be such as reported by LEDVINA & al. (2000) – a marked decrease in pH connected with calcium leaching from some Šumava soils under permanent grassland.

KOLÁŘ & al. (2000a) document a slowing down of the processes of primary organic matter transformation, mineralization and humification, in soils of mountain and submontane areas.

They ascribe it to fast acidification and subsequently reduced microbial activity in soils. So organic matter is accumulated in soils losing, after saturation with R_2O_3 sols its transformation capacity even under better microbial conditions. Organic carbon content increasing while the degree of humification is increasing and humic to fulvic acid ratio is getting worse, i.e., declining.

Locality description

Soil cover on the locality is formed by Dystric Cambisol on paragneiss, sandy loam, slightly gravelly, medium deep with no clean-cut structure, mild by moist, with loose consistence and slight biological activity, deep and densely rooted. For further characteristics and detailed description of the enclave Zhůří – Huťská hora Mt. and of the other investigalians carried out there see the paper by Mašková & al. (2001a,b).

Material and Methods

For determining chemical properties of soil, two replicated samples were taken from the surface soil layer (0.05–0.25 m) in 1999–2000 in each experimental treatment of the permanent grassland (one cut, no cut and mulching once a year) at the beginning (mid-May) and end (mid-September) of the growing season. Samples of May 1998 that had been taken from identical depths during a soil survey, were also included in the evaluation.

Table 1. – Methods used by RISWC laboratories for chemical analyses of soils from Zhůří locality.

Indicator	Method identification	Method description
Active pH	ČSN ISO 10390	Determination in a solution of distilled water, sample to water ratio 1 : 2.5
Exchangeable pH	ČSN ISO 10390	Determination in a solution of 0.2 M KCl, sample to solution ratio 1 : 2.5
Potential sorption capacity (CEC)	ISO 13536	Determination of potential sorption capacity of soil in $BaCl_2$ solution buffered to pH 8.1 in percolating columns, titration of exchangeable hydrogen.
Exchangeable H^+, Adams-Evans	Fertilizer Act No. 156/98	pH determination in special Adams-Evans buffer and calculation of exchangeable hydrogen.
Exchangeable cations	ČSN ISO 11260	Determination of exchangeable K, Mg, Ca, Al in an extract of barium chloride with flame atom absorption spectrometry (FAAS).
Available nutrients (P, K, Mg, Ca)	Mehlich II[1] method	Soil extraction with acid extractant (acetic acid, hydrochloric acid, ammonium chloride), photometric determination of P, FAAS determination of K, Mg, Ca.
Total phosphorus in mineralizate	ČSN 830550 ČSN 757923	Sample decomposition by ashing and extraction with hydrochloric acid, photometric determination of P through transformation to phosphomolybdic blue.
Total N	ČSN ISO 11261	Kjeldahl mineralization with sulphuric acid + photometric determination in Skalar apparatus.
C_{ox}-humus	ISO 14235	Oxidation with chromium-sulphur mixture + iodometric titration.
Humus fractionation	RISWC internal method[2]	Boiling extraction with NaOH solution and precipitation of humic acids with H_2SO_4, C_{ox} is determined in all fractions
Colour quotient	RISWC internal method	Absorbance ratio of lye extract at 472 and 664 nm.

[1] Zbíral (1995)
[2] Hraško (1962)

Samples were taken as mixed ones from 3 pits left after removal of Kopecký's washing cylinders (used to determine physical properties of soil) and were analyzed in the laboratories of the Research Institute for Soil and Water Conservation (RISWC), Praha, by methods shown in Table 1.

Results and Discussion

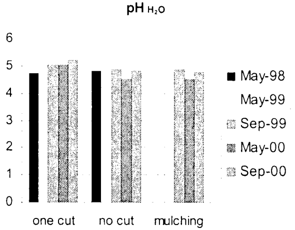
Remote values were discarded in the first stage of data processing. Tukey's test was used. Averages (of two values) were calculated for the particular sampling dates and treatments; they were arranged in tables and plotted in graphs. In comparisons the results from sampling dates of the same season were used. A certain trend between spring and autumn samples was demonstrated.

Table 2 shows average values for the particular periods and treatments.

The initial values of agrochemical soil properties determined at Zhůří during a soil survey in May 1998, indicate the following characteristics of the locality: acid or strongly acid soils, maximum sorption capacity below 30 mmol^{+}.100g^{-1}, low contents of available nutrients, very high content of organic carbon and low quality of organic matter. Soil sample classification was made pursuant to Act No. 156/1998 and Implementing Regulation No. 275/1998.

Changes in the values of active and exchange soil reaction are positive in 2000 against 1996 in the one-cut treatment (0.3 and 0.08, resp.) demonstrating a positive effect of this measure. If these results are compared with variability in pH values in other treatments, the conclusions should be corrected. We are convinced that such changes in values are a result of variability in soil conditions and correspond to the number of replicate samples. The acid soil reaction coincides with the presence of H^+ and Al^{3+} in soil and both ions cause the failure of saturation of the sorption complex. The level of sorption saturation is extremely low, ranging from 4.18% to 6.41% in 2000. In comparison with 1998, a decrease in the values of sorption saturation was determined in all treatments. This conclusion is in agreement with the results of the exchange base content when a decrease in the values was observed in all treatments. The contents of exchange cations indicate a different trends (hydrogen, potassium) as well as identical trends (calcium, aluminium – decrease, magnesium – increase) with all treatments.

A decrease in total phosphorus content was determined with all treatments; total nitrogen slightly increased in the one-cut and uncut meadow plots while it slightly decreased in the mulched meadow plot. The contents of all evaluated available nutrients decreased in the mulched and uncut plots , but the values of calcium and magnesium increased with the one-



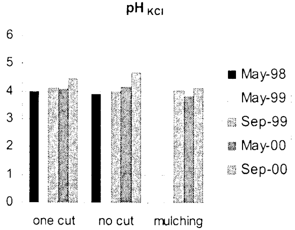
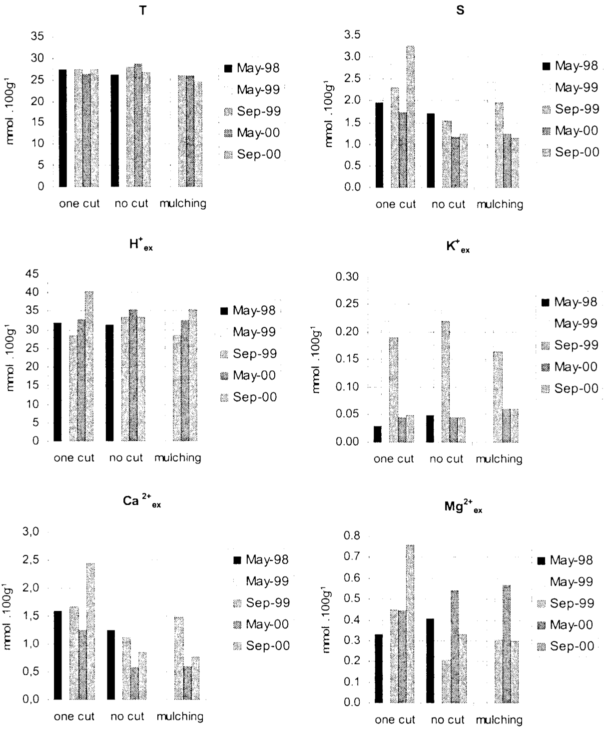


Fig. 1. – Average values (2 samples) of soil reaction (active pH – pH_{H_2O} and exchangeable pH – pH_{KCl}) in depth 0.05–0.25 m on experimental site Zhůří in 1998–2000.

Table 2. – Average values of chemical properties of soil for different manageme treatments of moutain grassland at Zhůří (depth 0.05–0.25 m, years 1998 and 2000).

Treatment		One-cut			No-cut			Mulching		
Year (May sampling)/ Agrochemical parameter		1998	2000	Difference in value +/–	1998	2000	Difference in value +/–	1999[2]	2000	Difference in value +/–
pH_{H_2O}		4.75	5.05	+0.3	4.80	4.50	–0.3	4.40	4.53	+0.13
pH_{KCl}		4.00	4.08	+0.08	3.90	4.14	+0.24	3.88	3.80	–0.08
Potential cation exchange capacity – T ($mmol.100g^{-1}$)		27.4	26.5	–0.9	26.2	28.7	+2.5	29.3	26.0	–3.3
Content of exchange bases – S ($mmol.100g^{-1}$)		2.0	1.7	–0.3	1.7	1.2	–0.5	2.4	1.2	–1.2
Degree of sorption saturation – V (%)		7.29	6.41	–0.88	6.48	4.18	–2.3	8.19	4.61	–3.58
Exchangeable cations ($mmol.100g^{-1}$)	Hydrogen H^+	32.0	32.75	+0.75	31.5	35.5	+4.0	35.5	32.5	–3.0
	Potassium K^+	0.03	0.05	+0.02	0.05	0.05	0	0.23	0.06	–0.17
	Calcium Ca^{2+}	1.59	1.25	–0.34	1.25	0.58	–0.67	1.70	0.60	–1.10
	Magnesium Mg^{2+}	0.33	0.45	+0.12	0.41	0.54	+0.13	0.52	0.57	+0.05
	Aluminium Al^{3+}	4.49	3.92	–0.57	3.73	3.42	–0.31	7.98	4.44	–3.54
Total phosphorus[1] ($mg.kg^{-1}$)		1440[1]	1287	–153	1425[1]	1324	–101	1400	1340	–60
Total nitrogen – N_t (%)		0.31	0.41	+0.10	0.30	0.43	+0.13	0.46	0.42	–0.04
Available nutrients ($mg.kg^{-1}$)	Phosphorus	< 2	4.5	>2.5	< 2	0.5		14.0	1.2	–12.8
	Potassium	58	41	–17	61	44	–17	84	45	–39
	Calcium	258	441	+183	429	220	–209	478	184	–294
	Magnesium	35	61	+26	38	13	–25	46	16	–30
Oxidizable carbon – C_{ox} (%)		4.68	4.47	–0.21	4.40	4.63	+0.23	4.75	4.40	–0.35
C/N ratio		15.10	10.92	–4.18	14.57	10.8	–3.77	10.33	10.61	+0.28
Humic substances – H_t (%)		3.27	3.63	+0.36	2.66	3.40	+0.74	3.01	3.30	+0.29
Humification ratio – H_t/C_{ox}		0.70	0.81	+0.11	0.60	0.74	+0.14	0.60	0.75	+0.15
Humic acids – C_{ha} (%)		1.56	1.56	0	1.10	1.52	+0.42	1.43	1.39	–0.04
Fulvic acids – C_{fa} (%)		1.71	2.07	+0.36	1.56	1.88	+0.32	1.58	1.92	+0.34
C_{ha}/C_{fa} ratio		0.91	0.91	0	0.71	0.81	+0.10	0.91	0.72	–0.19
Colour quotient – $Q_{4/6}$ [1]		5.2[1]	6.2	+1.0	5.3[1]	6.0	+0.7	5.3	5.8	+0.5

[1] Agrochemical parameter determined since 1999.
[2] 1998 sample was discarded as a remote value.



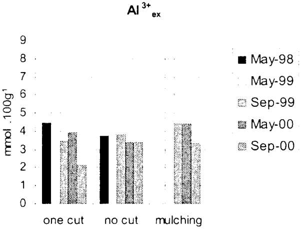


Fig. 2. – Average values (2 samples) of sorption capacity of soil and of the content of exchangeable cations (potential cation exchange capacity T, content of exchange bases S, exchangeable hydrogen H^{+}_{ex}, exchangeable potassium K^{+}_{ex}, exchangeable calcium Ca^{2+}_{ex}, exchangeable magnesium Mg^{2+}_{ex} and exchangeable aluminium Al^{3+}_{ex}) in depth 0.05–0.25 m on experimental site Zhůří in 1998–2000.

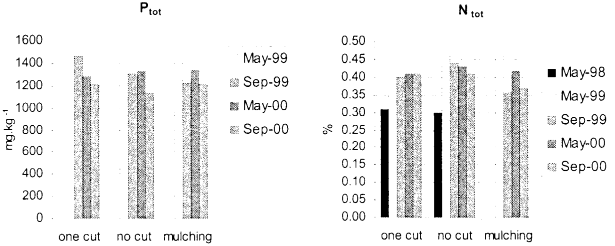


Fig. 3. – Average values (2 samples) of total phosphorus P_{tot} and of total nitrogen N_{tot} in depth 0.05–0.25 m on experimental site Zhůří in 1998–2000.

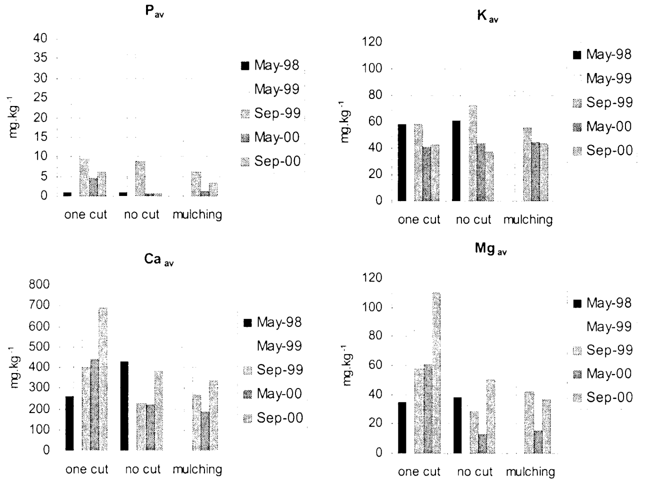


Fig. 4. – Average values (2 samples) of content of available nutrients (phosphorus P_{av}, potassium K_{av}, calcium Ca_{av} and magnesium Mg_{av}) in depth 0.05–0.25 m on experimental site Zhůří in 1998–2000.

cut treatment. The results presented in this paper are consistent with those reported by LEDVINA & al. (2000) when unfavorable soil reaction caused a decrease in nutrient uptake by plants and parallelly higher leaching of nutrients from the soil. The acid soil reaction leads to iron chemosorption of soil phosphorus, which means no further losses of this plant nutrient.

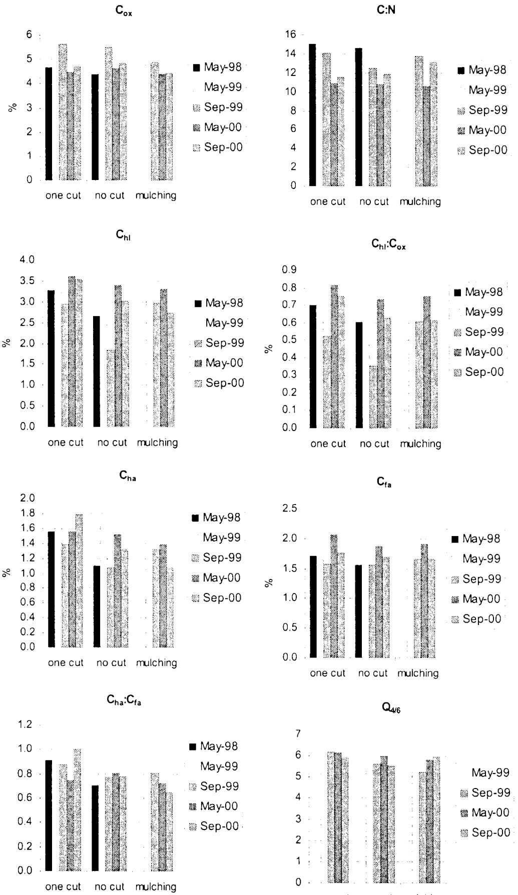


Fig. 5. – Average values (2 samples) of humus content and quality (content of oxidizable carbon C_{ox}, ratio of C:N, content of carbon in humic and fulvic acids C_{hl}, ratio of humification, i.e. ratio of C_{hl}:C_{ox}, content of carbon in humic acids C_{ha}, content of carbon in fulvic acids C_{fa}, ratio of C_{ha}:C_{fa} and colour quotient $Q_{4/6}$) in depth 0.05–0.25 m on experimental site Zhůří in 1998–2000.

Contents of oxidizable carbon were fairly balanced with all treatments in both years, ranging from 4.40% to 4.75%. A slight increase was determined in the uncut plots.

C/N ratio was fairly balanced with all treatments in 2000, ranging from 10.61 to 10.92. Its values for one cut and uncut treatments decreased considerably against 1998 (15.10 and 14.57, resp.). These results are surprising, especially if we consider that the two treatments are so different.

The humic to fulvic acid ratio indicates humus quality and/or its changes. No change was observed with the one-cut treatment; on the contrary positive changes were recorded in the uncut plot. A negative trend was observed in the mulched plot. The impairment of humus quality is indicated by an increase in the values of colour quotient $Q_{4/6}$ that was determined in all variants. The values range from 5.8 to 6.2, corresponding to humus quality for Cambisols (Pospíšil 1981). On the other hand, a slight increase in the ratio of humification, i.e. the ratio indicating the proportion of higher-quality humus that underwent the process of humification, is evident in all variants. Tesařová & al. (1999) report C_{ox} content to be substantially influenced by grassland management methods. The highest C_{ox} increase and humus quality improvement were recorded after grassland started to be mown. Our results do not agree with these conclusions; this contradiction can most probably be explained on the basis of conclusions by Ledvina & al. (2000). They state that soil microorganisms participating in soil organic matter transformation are killed by high soil acidity and by extreme agrochemical properties of soil. Mineralization and humification of soil organic matter are thus slower at our locality, where strong acidic fulvic acids are dominant in the process of humification. Similarly, Kolář & al. (2000b,c) believe that the rare failure of microbial decomposition of carbon sources is caused by mummification of organic matter in Bohemian Forest soils through iron and aluminium sols. The lack of decomposable energy yielding substrate and low pH result in a reduced microbial biomass and carbon contents.

Our results are rather variable and often contradictory for particular treatments. But the values of most agrochemical properties of soil appear to be at an extreme level at the locality concerned after a long period of continuous nutrient export when the basic principles of grassland nutrition were not observed. The lack of significant differences between the treatments is due to: a) small number of samples, b) short period of observations, c) the character of the locality, where any changes in the values of most agrochemical characteristics are very restricted and limited by the extreme site conditions. The changes in the values for the particular treatments are therefore not sufficiently evident.

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References

Hraško J. (ed.), 1962: Rozbory pôd [Soil Analyses]. *Slovenské vydavateľstvo pôdohospodárskej literatúry Bratislava, 335 pp. (in Slovak).*

Kolář L., Gergel J., Ledvina R., Kužel S. & Šindelářová M., 2000a: Agrochemická charakteristika půd horských a podhorských oblastí jihovýchodní Šumavy [Agrochemical characteristics of soils in mountain and submountain areas of south-east Bohemian Forest]. *Rostlinná výroba, 46 (12): 533–542 (in Czech).*

Kolář L., Gergel J., Ledvina R., Kužel S. & Šindelářová M. 2000b: Železo, hliník a mikrobiální aktivita půd horských a podhorských oblastí jihovýchodní Šumavy [Iron, aluminium and microbial activity of soil in mountain and submountain areas of south-east Bohemian Forest]. *Rostlinná výroba, 46 (12): 543–548 (in Czech).*

Kolář L., Kužel S., Šindelářová M. & Ledvina R., 2000c : Půdní organická hmota, humus a mikrobiální aktivita půd podhorských a horských oblastí [Soil organic matter, humus and microbial activity of soils submontain and mountain regions]. *Collection of Scientific Papers, Faculty of Agriculture in České Budějovice, Series for Crop Sciences, 17: 53–63 (in Czech).*

Kolář L., Ledvina R., Kužel S. & Šindelářová M., 2000d: Charakteristika půdní úrodnosti půd horských a podhorských oblastí Šumavy [Characteristic of fertility of soils in mountain and submontain areas of the Bohemian Forest]. *Collection of Scientific Papers, Faculty of Agriculture in České Budějovice, Series for Crop Sciences, 17: 47–51 (in Czech).*

LEDVINA R., KOLÁŘ L., KUŽEL S. & ŠINDELÁŘOVÁ M., 2000: Vývoj změn půdní reakce půd horských a podhorských oblastí ve srovnání s průměrem České republiky [Development of soil reaction in mountain and submontane regions in comparison with the average of the Czech Republic]. *Collection of Scientific Papers, Faculty of Agriculture in České Budějovice, Series for Crop Sciences 17, (1): 65–69. (in Czech).*

MAŠKOVÁ Z., KVĚT J., ZEMEK F. & HEŘMAN M., 2001a: Functioning of mountain meadows under different management impact – research project. *Silva Gabreta, 7: 5–14.*

MAŠKOVÁ Z., ZEMEK F., HEŘMAN M. & KVĚT J., 2001b: Post World War II development of the study area in mountain grassland at Zhůří – Huťská hora Mt. *Silva Gabreta, 7: 15–29.*

POSPÍŠIL F., 1981: Group and fractional composition of the humus of different soils. *Proceedings of the 5th International Soil Science Conference Prague, Part I: 135–138.*

PROVÁDĚCÍ VYHLÁŠKA MZE Č. 275/1998 SB. O agrochemickém zkoušení zemědělských půd a zjišťování půdních vlastností lesních pozemků [Implementing Regulation No. 275/1998 of the Ministry of Agriculture on agrochemical testing of agricultural soils and determination of soil properties of forest land]. *(in Czech).*

TESAŘOVÁ M., KLAŠKA F., GRUNDA B. & HRABĚ F., 1999: Dynamika organické hmoty v půdách různě obhospodařovaných lučních porostů [Dynamics of organic matter in soils under different systems of grassland management]. *Sborník přednášek z mezinárodního semináře "Bilancování organických látek a optimální zásoba organické hmoty v půdě: VÚRV Praha: 55–59 (in Czech).*

ZBÍRAL J., 1995: Analýza půd, jednotné pracovní postupy [Soil analysis, unified working methods]. *Ústřední kontrolní zkušební ústav zemědělský (UKZUZ) Brno. (in Czech).*

ZAKON Č. 156/1998 Sb. O hnojivech [Fertilizer Act No. 156/1998]. *(in Czech).*