Short Communication

Soil Heterotrophic Respiration Potential and Maximum Respiration Rate of Differently Managed Meadows

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Abstract: In this study were compared heterotrophic respiratory potential (V_{DS}/V_{MAX}) expressing an increase in C mineralisation rate after drying and re-wetting the soil to 60% soil water content (v/w)(V_{DS}) in relation to maximum respiration rate (V_{MAX}) after glucose addition, and V_{MAX} in organomineral soil (Ah horizon) of moderately mown and for 11 years abandoned mountain meadows in Moravian-Silesian Beskids Mts. V_{DS}/V_{MAX} and V_{MAX} were assessed in soil samples taken in 30-day intervals throughout the period of May–September 2004. The results obtained showed higher V_{DS}/V_{MAX} on the abandoned meadow throughout the whole experiment except the last sampling occasion, and higher V_{MAX} throughout the whole experiment. Significantly ($P < 0.05$) higher V_{DS}/V_{MAX} on the abandoned meadow was found in May and July, V_{MAX} was significantly higher on the same meadow ($P < 0.05$) only in September. From the parameters studied, the time of sampling had no significant ($P > 0.05$) effect on V_{MAX} when the data from the moderately mown meadow were evaluated. On the abandoned meadow, V_{MAX} found was significantly ($P < 0.05$) different when the samples from May and September or July and September were compared. A significant ($P < 0.05$) effect of the sampling time on V_{DS}/V_{MAX} on the moderately mown meadow was presented by differences between May and other sampling times, on the abandoned meadow differences between September and other times of sampling except May were significant ($P < 0.05$).

Keywords: soil heterotrophic potential; maximum respiration rate; soil; meadows; mowing; abandonment

Socio-economic changes in the Czech Republic towards the end of the last century have lead to considerable changes in the environmental conservation management of nonforest ecosystems. The local population have moved away from the mountainous regions where traditional farming and mowing of meadows was practised. The abandonment of meadows has initiated secondary succession with re-colonising shrubs and tree species. Variations in the plant coverage associated with the abandonment of mowing are related to changes in quantity, quality, and distribution of root systems, soil properties, and the slowing down of the nutrient cycling (Slavíková 1986; Fiala & Zelená 1991; Fiala 1997). The abandonment of meadows is also connected with changes in the total carbon content in organomineral soil. It can be interesting to find out what sorts of effects such

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a change has on the soil heterotrophic respiratory potential (V_{DS}/V_{MAX}) which describes the increase in C mineralisation rate after the water supply in relation to maximum mineralisation rate and on maximum respiration rate (V_{MAX}) of soil. As stated in the work by Santruckova *et al*. (2005), soil heterotrophic respiratory potential is a function of microbial population size and physiology, C quality and availability. V_{MAX} is controlled mainly by the size of microbial populations, growth physiology, and C quality (Anderson & Domsch 1978; Panikov 1995).

MATERIAL AND METHODS

The experimental stand Bílý Kříž is located in the Moravian-Silesian Beskids Mountains in the northeast part of the Czech Republic (N 49°30'17", E 18°32'28"), on a slope with an elevation of 825–860 m. a. s. and southeast orientation. The local subcontinental climate in this region is characterised by the mean annual air temperature of 4.9°C, the mean relative air humidity of 80% and the mean annual precipitation of 1100 mm. The number of days with the snow cover is 160 per year. The experimental meadow (1 ha) was originally mowed regularly, the hay was removed and stored as feed for livestock. This traditional management ceased 11 years ago on a half of the meadow (abandoned meadow), while the other half has been permanently moderately mown (once a season). The moderately mown meadow plant community belongs to the Nardo-Callunetea class; the mowing treatment in the season 2004 was applied there on 28th July. The abandoned meadow is characterised by a higher representation of forbs, and the community belongs to the Molinio-Arrhenatheretea class (Zelená, unpublished). According to Holub and Tůma (2005), both meadows were characterised in the year 2004 by insignificant differences in the total biomass production (1889 versus 1758 g/m^2 abandoned/mown) having been determined on 20 July. The moderately mown part showed a higher below-ground biomass production while the abandoned meadow revealed a higher above-ground production.

Soil sampling

The soil of both meadows is classified as a Gleyic Luvisol (ISSS-ISRIC-FAO 1998). Three mixed samples (1 mixed sample = 5 random sub-samples) were taken from both meadows in the depth of 3–13 cm (Ah horizon) in 30-day intervals. Soil sampling was performed throughout the period of May–September 2004. The samples were sieved through 5 mm mesh size as it is common in the case of fresh soil samples, and were air-dried at the room temperature. The sieving through 2 mm mesh size, which is more typical for the analyses of dry soil samples, was performed only to determine the selected physical, physical-chemical and chemical properties of Ah horizon which are shown in Table 1.

Soil analysis

Air-dried soil samples were moistened to 60% soil water content (v/w) and incubated for 7 days in the dark at the laboratory temperature. CO_2 evolution was measured 24 h after moistening (respiration response to water supply, V_{DS}), between 5th and 6th days of incubation (basal respiration rate at 60% soil water content v/w, V_{BR}), and then after glucose amendment (3.64 mg C/g dry soil) between 6th and 7th days (maximum respiration rate, V_{MAX}) (Santruckova *et al*. 2005). Glucose was added to the soils as dry powder and mixed in thoroughly. The values V_{BR} were not used for related calculations in this study. Carbon dioxide evolution was measured by its absorption into 0.5M NaOH. The number of analyses replications for each of the three soil samples was 2.

The particle size was assessed by the sedimentation method, C_t by sulphochromic oxidation, N_t by Klejdahl method, pH by combination glass electrode (soil:water or 10mM $CaCl_2$ = 1:2.5). Cation exchange capacity (CEC) was calculated by summing up the charge equivalents of exchangeable Ca, Mg, and K determined in the extract Mehlich-2, and H^+ which was determined at pH 8.0 by the Adams and Evans method (Zbíral 1995). Elemental concentrations of Ca, Mg, and K were measured by atomic absorption spectrometry. The carbons of humic and fulvic acids (C-HA and C-FA) were measured according to the Kononova and Belcikova's method (1961).

Statistics

Statistical analysis was performed by One-way Anova plus Fisher LSD or by Multi-Factor Anova plus Fisher LSD test, or by Kruskal-Wallis Anova plus Dannet's *t*-test (Statistica 7.0) when the pre-

Table 1. Selected physical, physical-chemical and chemical properties of Ah horizon on moderately mown and abandoned meadow (Mean ± SD; n = 3–8); the different letters mark significant (P < 0.05) differences between the meadows

Soil properties	Moderately mown	Abandoned
Clay (%)	18.60 ± 3.4[a]	19.93 ± 2.3[a]
Silt (%)	26.0 ± 3.7[a]	27.1 ± 7.0[a]
Sand (%)	55.40 ± 6.5[a]	52.93 ± 9.1[a]
pH (H_2O)/pH 0.01 M $CaCl_2$	4.30 ± 0.45[a]/3.80 ± 0.19[a]	4.27 ± 0.42[a]/3.78 ± 0.18[a]
CEC ($mmol_c/kg$)	159.34 ± 2.28[a]	184.85 ± 10.01[b]
C_t (%)	4.76 ± 0.76[a]	4.77 ± 0.71[a]
N_t (%)	0.29 ± 0.06[a]	0.33 ± 0.09[a]
C/N	16.91 ± 3.58[a]	15.24 ± 3.14[a]
C-HA and C-FA (%)	0.50 ± 0.05[a] and 0.72 ± 0.05[a]	0.57 ± 0.11[a] and 0.77 ± 0.05[a]

conditions for the parametric test were not fulfilled. Statistical evaluation of differences between the selected physical, physical-chemical, and chemical properties (Table 1) was performed by t-test for independent samples by groups.

RESULTS AND DISCUSSION

The results obtained in this study showed a higher soil heterotrophic respiratory potential (V_{DS}/V_{MAX}) on the abandoned meadow throughout the whole

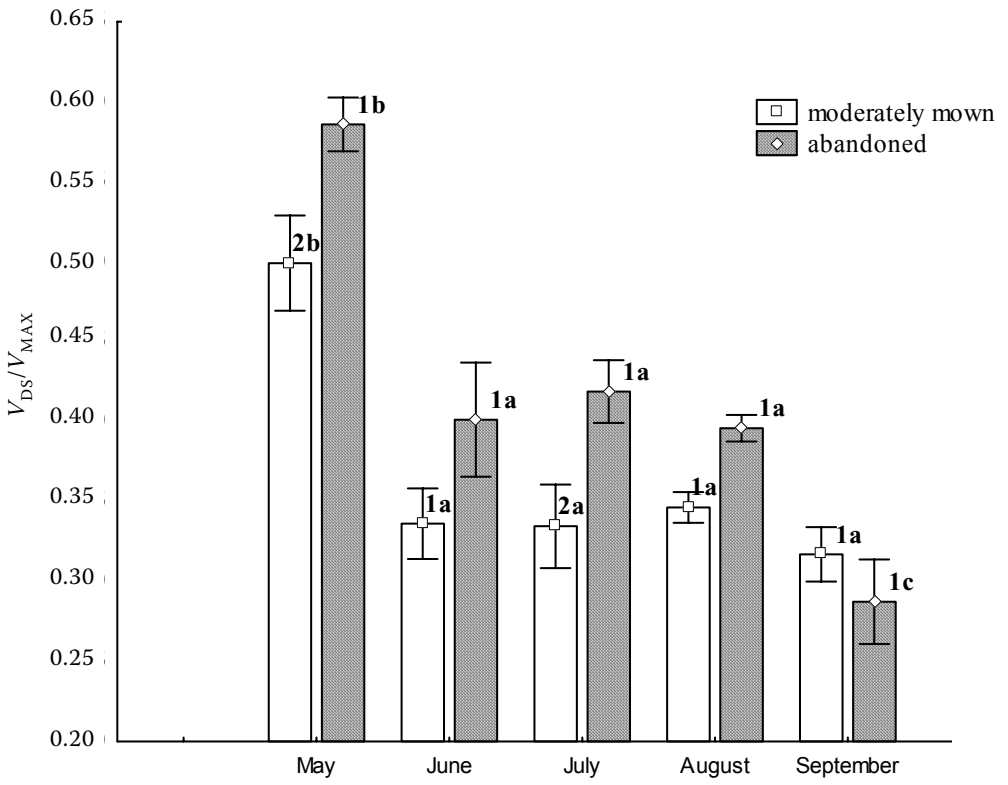

Figure 1. Soil heterotrophic respiratory potential (V_{DS}/V_{MAX}) on moderately mown and abandoned mountain meadows of Moravian-Silesian Beskids Mts (mean ± 1SE; n = 5–6). The different numbers mark significant (P < 0.05) differences between meadows, the different letters mark significant (P < 0.05) differences between sampling times

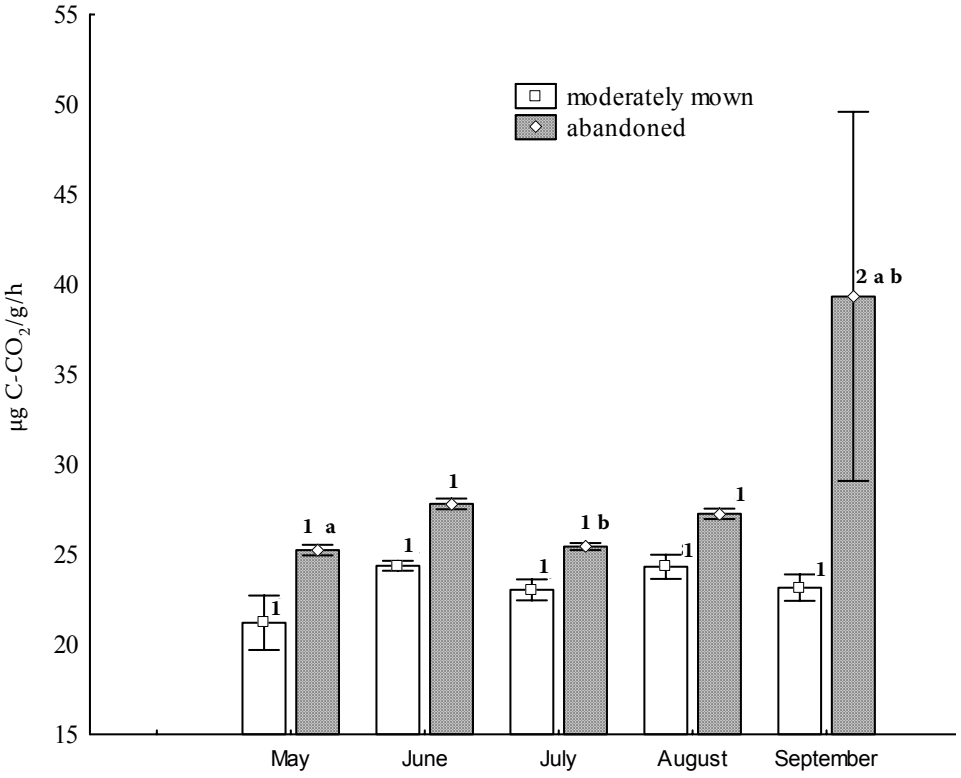

Figure 2. Maximum respiration rate (V_{MAX}) of soil on moderately mown and abandoned mountain meadows of Moravian-Silesian Beskids Mts (mean ± 1SE; n = 6). The different numbers mark significant (P < 0.05) differences between meadows, the same letters mark significant (P < 0.05) differences between sampling times

experimental period, except the last sampling occasion (Figure 1). Nevertheless, a significantly (P < 0.05) higher V_{DS}/V_{MAX} on this meadow was found only in samples from May and July. Organomineral soil of the abandoned meadow also showed a higher maximum (potential) respiration rate throughout the whole experiment when related to its moderately mown counterpart (Figure 2). A significantly (P < 0.05) higher V_{MAX} was found only in the samples from September. The time of sampling had no significant (P > 0.05) effect on maximum respiration rate only when the data from the moderately mown meadow were analysed; in the case of V_{MAX} on the abandoned meadow, significant (P < 0.05) differences occurred between the samples from May and September and from July and September (Figure 2). The sampling time had a significant (P < 0.05) effect on the moderately mown meadow on V_{DS}/V_{MAX} when the samples from May were compared with other sampling times. On the abandoned meadow, significant (P < 0.05) differences were found between the samples from May or September when compared with other sampling times (Figure 1).

The V_{DS}/V_{MAX} on both meadows was the highest at the beginning of the experiment. Its values in the range from 0.21 to 0.65 indicate, according to Santruckova *et al.* (2005), either a low quality of biologically available C or a low microbial biomass. The abandonment of the meadow caused an increase of V_{DS}/V_{MAX} and V_{MAX}. The increased V_{DS}/V_{MAX} also indicate that the seasonal fluctuations of the soil heterotrophic respiration on the abandoned meadow will be higher as reported in the work of Kisza (2005). V_{DS}/V_{MAX} and V_{MAX} are functions of more properties including microbial population size, physiology, and C quality (V_{MAX}) plus C availability in the case of V_{DS}/V_{MAX} (Anderson & Domsch 1978; Panikov 1995; Santruckova *et al.* 2005). From the results of Kafka (2005), it is known that the abandonment of the meadow increased the microbial biomass in Ah horizon throughout the whole vegetation season 2004. The 11-year abandonment did not increase C_t and only slightly increased N_t in Ah horizon. It resulted in an improvement of C/N from 16.91 to 15.24, and, speculatively, it also caused a higher availability or quality of biologically available C

which is released after the drying and re-wetting of the soil. Therefore, the abandonment of the meadow was connected with significantly ($P < 0.05$) higher CEC, possibly as the result of a better quality of the soil organic matter.

Carbon in the coarse fraction of the soil is weakly bound when related to that in the fine fraction, giving thus a high proportion of the available carbon (Santruckova *et al.* 2005). In our case, the proportions of different particle-size fractions were very similar on both meadows, and thus the texture was not the factor influencing the results obtained. The abandonment of the meadow decelerated the nutrient cycling, and as reported in the work by Formanek *et al.* (submitted for publication), Ah horizon of the abandoned meadow showed a higher net N immobilisation, probably as the result of a higher C availability and needs of N for its utilisation. The increasing temperature increases the solubility of organic compounds as well as the ability of microbial populations to produce extracellular enzymes and mineralise more complex organic materials (Christ & David 1996; Andrews *et al.* 2000; Santruckova *et al.* 2005). We do not have the information on the temperature differences in Ah horizon between both meadows studied, nevertheless, we suppose they are very small and insignificant. Thus, probably the main effect of the abandonment on the organomineral Ah horizon of the meadow resides probably in the increasing quality of the total soil organic matter and the increasing availability of C. Due to the increasing availability of the biologically utilisable C, the soil microbial biomass of Ah horizon of the abandoned meadow is exposed to higher seasonal fluctuations; and such soil possesses a higher V_{MAX}.

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