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Heterotrophic and autotrophic soil respiration in an alpine grassland

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While soil respiration has been well characterized for a wide range of forest ecosystems, comparatively little is known for grasslands.

Related to this, our study was aimed at monitoring of soil CO_2 efflux and at its partitioning into heterotrophic and autotrophic contributions, applying the indirect linear regression method, in a sinkhole (about 1.5 ha) of Italian southern Alps (Valchiavenna – Lombardy) used as cattle pasture, at about 1900 m a.s.l.

The measurements of soil CO_2 rates were carried out on 8 dates during the growing season (June-September 2010), between 11 a.m. and 2 p.m., using a portable infrared gas analyzer (PP-system) equipped with a dynamic chamber; 33 monitoring points were selected, distributed to cover the main soil (Cambisols, Leptosols, Podzols, Phaeozems) and vegetation types (Nardetum, Seslerio-Semperviretum, earth hummocks, tall herbs), as well as the different aspects. Aboveground vegetation was removed before the beginning of the measurements. Together with soil respiration, soil temperature and soil water content at a depth of 5 and 0-6 cm respectively, were measured. Only at the end of the experiment, samples were collected from the upper 10 cm of the soil to determine root density ($<$2 mm and $>$2 mm diameter class) and soil organic carbon content.

Results showed that the mean soil respiration was 4.5$\pm$2.1 μmol CO_2 $m^{-2}s^{-1}$, ranging from 1.5 (September) and 7.4 (July) μmol CO_2 $m^{-2}s^{-1}$.

For all the sampling dates the total soil respiration resulted significantly correlated (p value $<$0.05) with soil organic carbon content and root density (0-2 mm diameter).

Soil CO_2 efflux was strongly affected by temperature (R^2=0.72), while soil water content influenced the emission rates only at extreme values.

The application of multivariate analysis techniques confirmed the relations just underlined, and showed clusters corresponding to soil and vegetation types.

The cumulative CO_2 emission, computed during the period of snow absence (1^{st} June-30^{th} September), as the sum of hourly fluxes estimated using the dependance of measured respiration from soil temperature, was 354$\pm$84 g C m^{-2}.

The partitioning of the total CO_2 flux into its autotrophic and heterotrophic components revealed that the ratio of their contributions remained quite constant for the entire investigated period; the heterotrophic component highly prevailed, counting for about 70% of the total CO_2 efflux.

Both contributions showed an exponential dependence from soil temperature ($R^2_{heterotrophic}$=0.87; $R^2_{autotrophic}$=0.85).

Based on the relationships identified between respiration, soil parameters, vegetation, pedoclimate and topography, it was possible to spatialize CO_2 fluxes to neighbouring pastures, using data obtained by previous surveys.

Keywords: soil CO_2 efflux, autotrophic respiration, heterotrophic respiration, alpine grassland.