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Climate effect on soil enzyme activities and dissolved organic carbon in mountain calcareous soils: a soil-transplant experiment

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Mountain soils store huge amounts of carbon as soil organic matter (SOM) which may be highly vulnerable to the strong climate changes that mountain areas currently experience worldwide. Climate modifications are expected to impact microbial activity which could change the rate of SOM decomposition/accumulation, thereby questioning the net C source/sink character of mountain soils. To simulate future climate change expected in the 21^{st} century in the calcareous pre-Alps, 15 blocks (30 cm deep) of undisturbed soil were taken from a mountain pasture located at 1400 m a.s.l. (Marchairuz, Jura, Switzerland) and transplanted into lysimeters at the same site (control) and at two other sites located at 1000 m a.s.l. and 600 m a.s.l. (5 replicates per site). This transplantation experiment which started in 2009 simulates a climate warming with a temperature increase of 4˚C and a decreased humidity of 40 % at the lowest site. In this study, we used soil extracellular enzyme activities (EEA) as functional indicators of SOM decomposition to evaluate the effect of climate change on microbial activity and SOM dynamics along the seasons. Dissolved organic carbon (DOC) was also measured to quantify the assimilable carbon for microorganism. In autumn 2012, a first sampling step out of four (winter, spring and summer 2013) has been realized. We extracted 15 cm deep soil cores from each transplant (x15) and measured (i) DOC and (ii) the activities of nine different enzymes. Enzymes were chosen to represent the degradation of the most common classes of biogeochemical compounds in SOM. β-glucosidase, β-D-cellubiosidase, β-Xylosidase, N-acetyl-β-glucosaminidase, leucine aminopeptidase, lipase, phenoloxidase respectively represented the degradation of sugar, cellulose, hemicellulose, chitin, protein, lipid and lignin. Moreover, the fluorescein diacetate (FDA) hydrolysis was used to provide an estimate of global microbial activity and phosphatase was used to estimate phosphorus mineralization. The autumn results showed no differences for global microbial activity along the climate gradient (0.37 nKatal g^{-1} dry soil), no differences and a very low activity for leucine aminopeptidase and β-glucosidase and β-Xylosidase (about 0.09 nKatal g^{-1} dry soil) and no differences for cellulose, chitin and phosphorus mineralization. Conversely, we measured a greater activity at the highest elevation site for lipase and phenoloxydase (ANOVA test, $p<0.05$). Interestingly, when differences between EEA were observed, activity was always lower at the low-elevation site suggesting that mean annual soil moisture control on lipid and lignin degradation may be more important than mean annual temperature. Similarly to global microbial activity, no differences in soil moisture and assimilable C (0.14 mg of carbon g^{-1} dry soil) were found between the three sites, even though the chemical composition of DOC may change. Overall, the climatic modification associated with our soil transplant experiment depleted the capacity of soil microorganisms to decompose specific biochemical components, but global microbial activity was not altered. Future samplings in 2013 will provide further insights on the seasonal pattern of this climate induced modification of decomposition process.