Climate Change Impacts on Alpine Soils

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INTRODUCTION

Mountain ecosystems harbor large amounts of soil carbon and are known to be especially vulnerable to climatic changes. However, the future dynamics of organic carbon in the soils is still uncertain and one of the key issues in climate change research. In this context, microorganisms deserve a special attention because of their key role in C mineralization processes. The aim of these studies was to investigate short-to medium-term changes in litter C turnover and microbial communities (based on the PLFA method) in response to 2 years of experimental flied warming simulated by high-to-low elevation soil translocation.

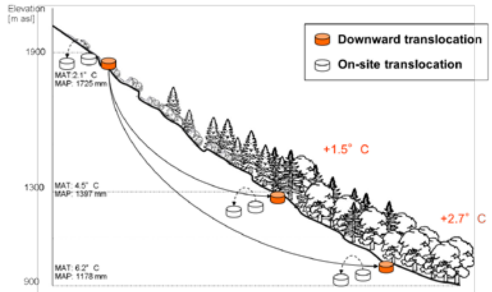

Fig.1 Altitudinal soil core translocation across tree line in the Northern Limestone Alps, Austria

The climate shifts caused

✓ significantly accelerated turnover of added maize carbon; whereby the resistant carbon pool responded much stronger to experimental warming compared to the labile pool

✓ strong influence on the microbial community composition and its substrate utilization

Outcomes of this study provide the basis for simulation of biogeochemical cycling in alpine environments

▪The mineralization of maize straw C was initial very rapid and similar at all investigated sites followed by a gradually decrease over time, with the slowest decomposition observed at the high-elevation grassland site (1900 m asl). The down-slope translocated soils showed almost the same decomposition patterns as the soils at the host sites (Fig. 2). Experimental warming resulted in only slight increases of labile pool decomposition rates (5-20%), while resistant pool decomposition rates responded considerably more strongly (100-190% increases). The observed initial increase and subsequent decrease in microbial biomass went along with the availability of C sources as well as site specific conditions (Fig.3).

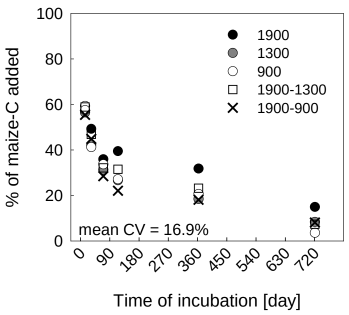

Fig. 2. Remaining maize carbon during the 2-year incubation period along the studied gradient (900–1900 m asl). 1900–1300 and 1900–900 refer to soil cores translocated from 1900 to 1300 m asl and to 900 m asl, respectively. Values are arithmetic means (n = 3–5), and mean coefficients of variation (CV) are given in %.

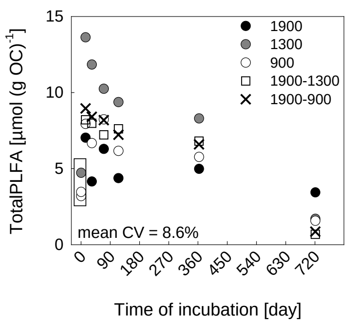

Fig. 3. Microbial biomass measured as PLFAs (TotalPLFA); framed values are before straw application) during the 2-year incubation period along the studied gradient (900–1900 masl). 1900–1300 and 1900–900 refer to soil cores translocated from 1900 to 1300 m asl and to 900 m asl, respectively. Values are arithmetic means (n = 3–5), and mean coefficients of variation (CV) are given in %.

▪Changes in the biomass of different microorganism groups are related to changes in the quality of organic substrates over time.

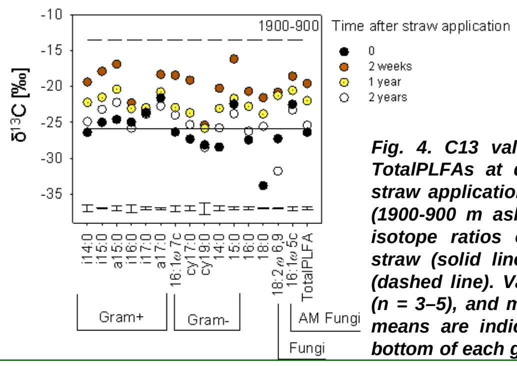

Fig. 4. C13 values of the individual and TotalPLFAs at different times after maize straw application for the translocated soil (1900-900 m asl). Reference lines indicate isotope ratios of the soil without maize straw (solid line) and of the maize straw (dashed line). Values are arithmetic means (n = 3–5), and mean standard errors of the means are indicated as error bars at the bottom of each graph.

▪Changes in substrate quantity and quality in the course of the decomposition appeared to have less influence on the microbial community composition and its substrate utilization than the prevailing environmental / site conditions, to which the microbial community adapted quickly upon change.

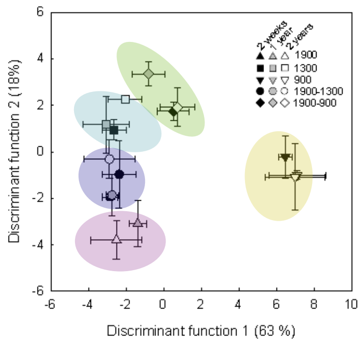

Fig. 5. Values of the first two discriminant functions calculated from 15 microbial phospholipid fatty acids (in mol %; n = 3-5) measured 2 weeks, 1 year and 2 years after the application of maize straw along the studied gradient (900 to 1900 m asl).

	2 weeks		1 year		2 years	
	% of R^2	p	% of R^2	p	% of R^2	p
T [°C]	26.5	0.545	69.6 (+)	0.005	35.3 (+)	0.003
VWC [vol%]	19.7	0.601	1.0	0.696	16.9 (+)	0.022
pH in H_2O	47.6	0.419	28.6 (+)	0.049	15.8 (-)	0.025
C-13 PLFA PC1	6.3	0.767	0.8	0.718	32.0 (-)	0.004
	$R^2 = 0.10$	0.828	$R^2 = 0.76$	0.000	$R^2 = 0.87$	0.000

▪Different parameters exert an influence on litter decomposition at different points in time and to different extents. Microbial community composition and function significantly affected substrate decomposition rates only in the later stage of decomposition when the differentiation in substrate use among the microbial groups became more evident.

Table 1. Results of univariate analysis of variance investigating the effects of climate, soil parameters and microbial substrate utilization on the decomposition of added maize straw (n = 20–23). The relative importance of each variable is indicated by the % of R^2.

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