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Increased summer precipitation decreases microbial activity during autumn in a high arctic semi desert

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Zackenberg Research Station (74° 30′ N, 21° 00′ W) situated in the NE Greenland National Park (in blue).

Introduction

Arctic tundras, polar deserts and semi deserts contain approximately 14% of the global soil C pool.[1] Therefore, the carbon balance in these regions is of great interest in order to determine positive feedback mechanisms to global warming. Climate models predict increasing temperatures and enhanced summer precipitation in the High Arctic.[2] Soil moisture content and temperature are key factors constraining microbial activity and biomass; increased soil moisture can increase nutrient availability, and higher soil temperature is associated with increased mineralization rate.[3]

How does the microbial community respond to increased summer precipitation and nutrient availability beyond the summer season?

Methods

Soil respiration and microbial biomass C were measured from the 2nd of September to the 6th of October.

Measurements were done in field plots to which water has been added weekly during summer since 1996, combined with nitrogen amendment in 1996, 1997 and 2007 in a fully factorial design.

Below-ground CO_2 efflux was measured with an EGM-4 Environmental Gas Monitor (PP Systems). Soil samples were treated to the fumigation-extraction method and subsequently analyzed for nutrient levels.

For in-depth methodology and more results please take a supplementary sheet located next to the poster

Respiration decreases during autumn

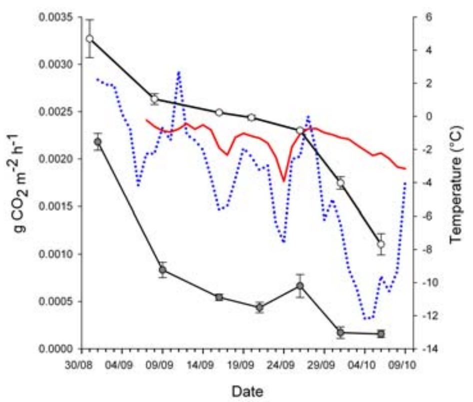

Figure 1. Belowground respiration with air and soil temperatures at the study site. Dotted blue line is air temperature at 2 meters (daily averages), red line is soil temperature at 5 cm depth (daily averages), and open circles are soil temperature at 2 cm depth, measured weekly together with the respiration measurements. Grey circles show respiration rates at control plots (without treatment).

Respiration decreases more in watered plots

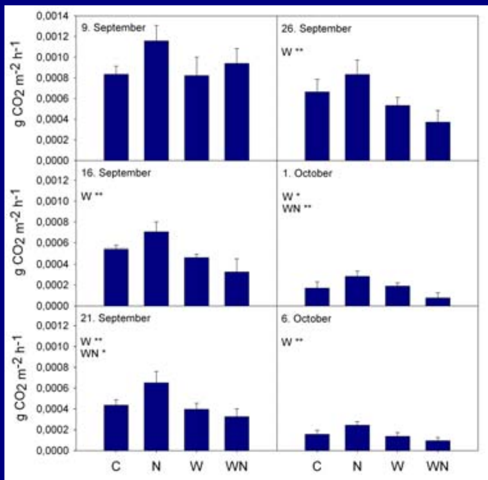

Figure 2. Soil respiration during the 2009 autumn freeze-in period. Treatments are: C-control, N-nitrogen amendment, W-water addition and combination hereof. Results of ANOVA's with significant main factor effects of treatments and interactions are shown in the top left as: *, P<0,1; **, P<0,05; ***, P<0,01

Microbial biomass is not lower in watered plots

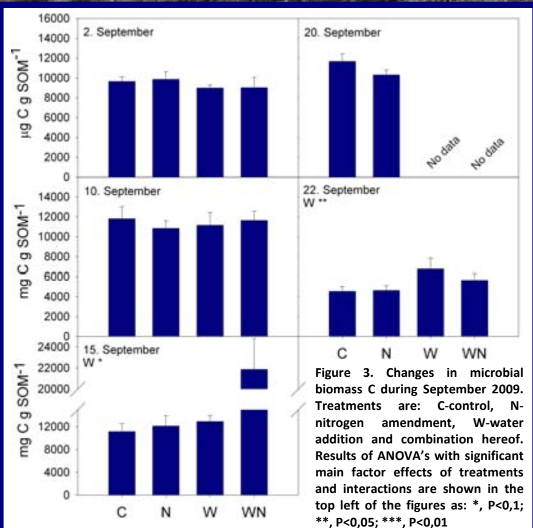

Figure 3. Changes in microbial biomass C during September 2009. Treatments are: C-control, N-nitrogen amendment, W-water addition and combination hereof. Results of ANOVA's with significant main factor effects of treatments and interactions are shown in the top left of the figures as: *, P<0,1; **, P<0,05; ***, P<0,01

Here we show that even though increased summer precipitation might increase belowground respiration during summer, this should not be extrapolated into increased autumn respiration as labile soil nutrients might be used up.

Conclusions

In contrast to findings during summer[4], summer water addition significantly decreased respiration rates during autumn.

N-fertilizer had no effect on its own.

Lower respiration rates are not the result of lower microbial biomass.

During summer, microorganisms appear to use up all of the labile nutrients available in the watered plots. Thus, they are running out of 'fuel' during the autumn freeze-in, when the microorganisms in the unwatered plots by contrast still have 'food' left.

Do you want to know more?
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Caught in the act; measuring belowground respiration in late September.

References
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