Effects of Moisture on Extracellular Enzyme Activity in Prairie Soil

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Introduction

Prairie soils store and cycle a substantial amount of carbon (C). Climate change models predict that precipitation events across the North American Great Plains will become less frequent but larger. The response of prairie soils' microbial carbon processing and sequestration to this altered moisture regime is unknown, but will likely be a deciding factor of future C storage in prairie soils. We are approaching this issue by assessing soil microbial function and molecular indicators of dominant C allocation pathways under ambient and experimentally modified precipitation regimes.

The rainfall manipulation plots (RaMPs) at the Konza Prairie Long-Term Ecological Research (LTER), established in 1998 in eastern Kansas, are a replicated field manipulation of the magnitude and frequency of natural precipitation. The RaMPs is comprised of two treatments: (1) ambient precipitation and (2) extended precipitation interval. The extended precipitation interval involves storing rainfall and reapplying it at an interval 50% longer than that between natural rainfall events.

RaMPs plots at Konza Prairie

We collected soil before (PRE), during (POST1) and after (POST2) a rainfall event from both precipitation treatments and measured microbial response, specifically extracellular enzyme activity (EEA).

EEA assays measure the total activity of certain extracellular enzymes in soils under optimal temperature, substrate availability and moisture conditions. The resulting data are related to microbial activity, decomposition/C turnover rates and nutrient limitation status.

Methods

The oxidative enzymes, phenol oxidase (POX) and peroxidase (PER) were tested colorimetrically using L-3,4-dihydroxyphenylalanine. The hydrolytic enzymes, β-1,4-glucosidase (BG), cellobiohydrolase (CBH), β-1,4-N-acetylglucosaminidase (NAG) and phosphatase were assayed with substrates linked to a methylumbelliferyl fluor, while Leucine aminopeptidase (LAP) used a methylcoumarin substrate. Fluorimetric and colorimetric data were then statistically analyzed using multivariate ANOVA.

	Enzyme	Function
hydrolytic	β-1,4-Glucosidase (BG)	Degradation of cellulose and other β-1,4 glucans
hydrolytic	cellobiohydrolase (CBH)	
hydrolytic	β-N-acetylglucosaminidase (NAG)	Degradation of chitin and other β-1,4-linked glucosamine polymers, analogous to BG in cellulose degradation
hydrolytic	Leucine aminopeptidase (LAP)	Hydrolyzes leucine and other hydrophobic amino acids from the N terminus of polypeptides
hydrolytic	Phosphatases	Hydrolyze phosphomonoesters, and sometimes phosphodiesters, which release phosphate
oxidative	Phenol oxidases (POX)	Degradation of polyphenols (e.g. lignin, tannin and their associated degradation products)
oxidative	Peroxidases (PER)	

Results

Fig 1. Phenol oxidase activity decreases after water input

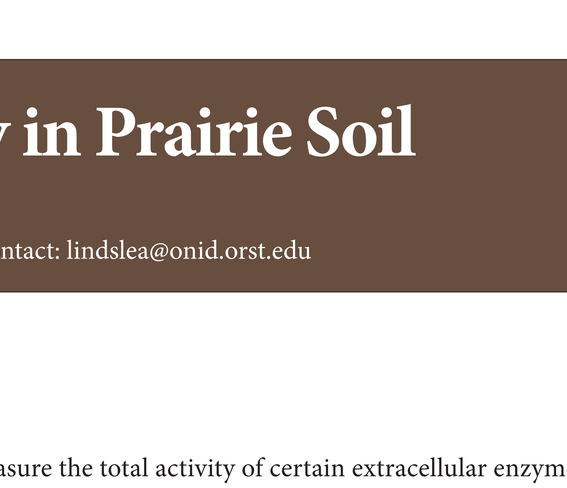

Fig 2. Cellobiohydrolase activity also decreases after water input

Sampling Time	Treatment	Phos		BG		CBH		NAG		LAP		PER		POX	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D
	PRE	469.3	413.0	385.8	425.3	100.4	81.6	184.7	199.1	6.1	5.5	168.7	176.6	46.4	40.4
	POST1	430.4	468.6	430.6	428.7	99.2	100.2	203.9	217.4	5.5	4.9	163.4	188.6	48.4	47.4
	POST2	397.5	414.1	407.8	411.7	75.0	78.5	187.4	210.1	6.4	5.7	211.8	204.8	22.0	37.2

Fig 3. No significant difference between Ambient (A) & Delay (D) moisture treatments. Note changes between CBH & POX post-rainfall; enzyme activities reported in nmol g^{-1} h^{-1}

EEA C:N	EEA C:P	EEA labile C: complex C
1.13	.99	1.16

Fig 4. EEA assays yield nutrient limitation ratios. All EEA activites are natural log-transformed; C:N ratio is BG/(NAG+LAP), C:P is BG/Phos, labile C: complex C is BG/PER

Discussion

After a rainfall event, plant growth increases, and thus root exudate quantities increase. Our results might imply that with the greater availability of simpler carbon sources (root exudates), the need to degrade lignin and cellulose is reduced, accounting for the drop in cellobiohydrolase and phenol oxidase activity. Additional data is needed to verify this hypothesis, and the next set of RaMPS samples is being gathered RIGHT NOW. The nutrient ratios from the EEA assays suggest that these soils have below average N limitation, average P limitation and a greater reliance on labile C sources than most soils.

References

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