Who benefits from biochars: Microbes, weeds or conifer seedlings?

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Background

- Projected changes in precipitation patterns could significantly affect profitability of conifer cropping systems[1]
- Incorporation of biochars should increase soil water content and reduce need for fertilizer applications[2,3]
- However, some biochar applications have negatively affected conifer trees and soil microbial communities
  - Decreased abundance of symbiotic microbes that increase drought tolerance and access to water and nutrients, [2,3] interference with pre-emergent herbicide activity, etc.
  - Limited results from field-scale trials
- More results needed before recommending widespread use of biochars in conifer cropping systems

Research Questions

How does field scale biochar application impact:

1) Herbicide efficacy and weed communities
2) Soil microbial activities related to SOM decomposition
3) Interactions between soil microbes and weed communities

Methods

- Used biochars from two local suppliers
  - Biogenic Reagents (BGR) and US Biocarbon (USB)
  - Applied both biochars at rates of 0 Mg ha^{-1} (0 BC), 25 Mg ha^{-1} (1x rate), and 75 Mg ha^{-1} (3x rate) in May 2016.
  - Biochars applied with sand spreader, disked into top 15cm of soil
  - Planted balsam fir (*Abies balsamea*) and Colorado blue spruce (*Picea pungens*) seedlings in May 2016
- Pre-emergent herbicides applied on May 13, 2016, and post emergent herbicide (Kill-Zall 2) applied on June 29
- Analyzed seedling survival, weed growth, soil properties, and extracellular enzyme activity (EEA) rates of the soil enzymes leucine aminopeptidase (LAP), acid phosphatase (AP), β-D-glucosidase (BG), and β-N-acetyl glucosaminidase

Results & Discussion

- 3x biochar treatments increased soil water contents, as well as soil pH, P, K, and CEC (Tables 1) ($P < 0.0001$)
- Biochar effects on mineral N varied significantly in August and September (Fig 1) ($P < 0.0001$)
- Biochars did not affect spruce survival, while both BGR treatments equally suppressed survival in fir transplants (Fig 2)
- Increased access to water and nutrients in biochar treated soils likely contributed to increased plant growth and soil microbial activity (Figs 2-3) ($P < 0.0001$)
  - Biotic responses to biochar treatments may be cause of depleted NO_3^- pool in canopy covered soils (Fig 1)
  - Depleted NO_3^- pools may then be contribute to increased LAP and NAG activity as plants/ microbes seek N from organic sources (Fig 3)
- Elevated enzyme activity rates in bare soils suggests that biochar treatments accelerated soil microbial activities related to SOM decomposition processes (Fig 2b, 2d)
  - Proximity to active plant communities may inhibit these interactions (2a, 2c)

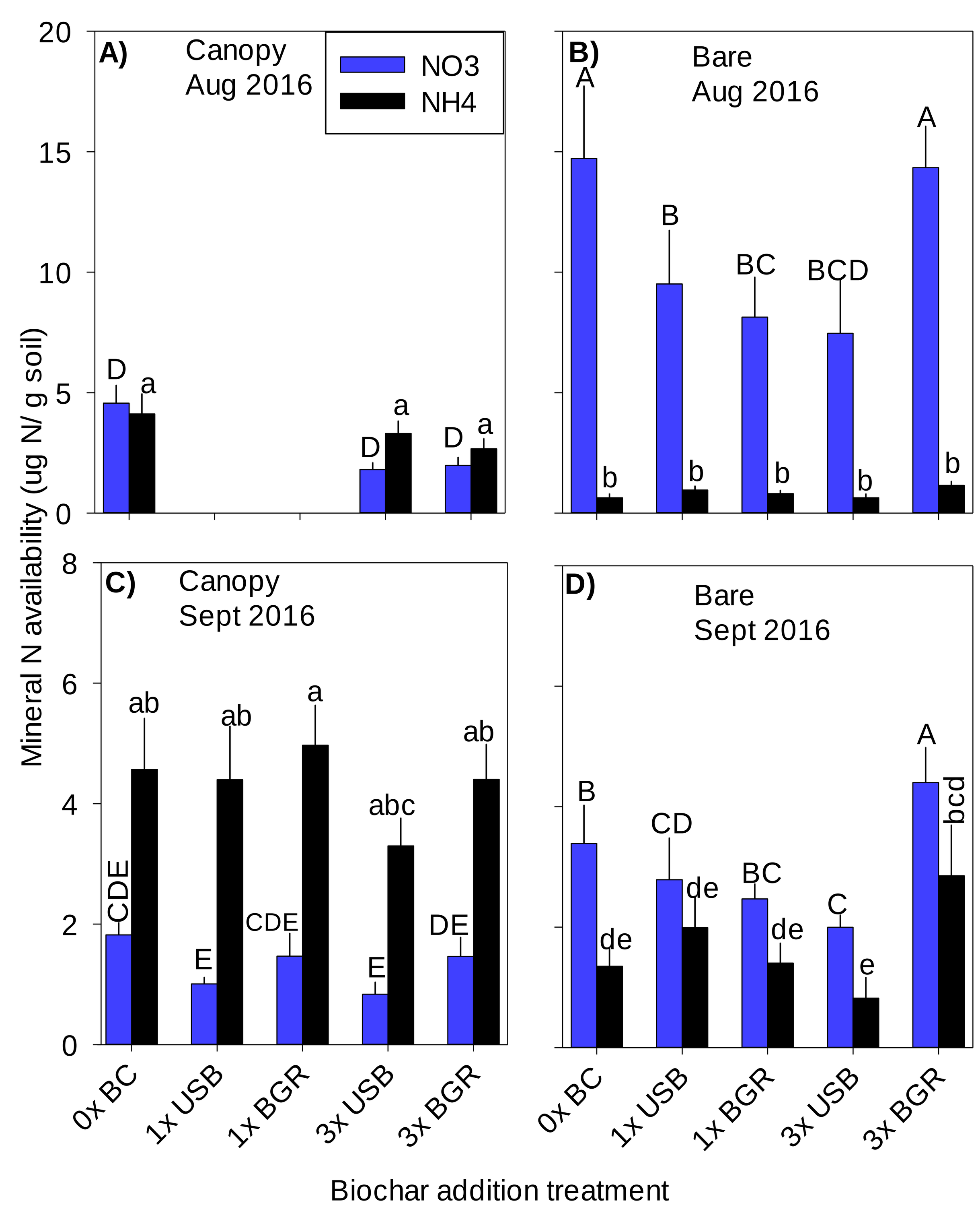

Figure 1: Mineral N availabilities in A) Canopy covered soils in August, B) Bare soils in august, C) Canopy covered soils in September, and D) Bare soils in September. Different combinations of letters in figures A) and B) as well as in C) and D) indicate a significant difference between treatments at (p < 0.05) level

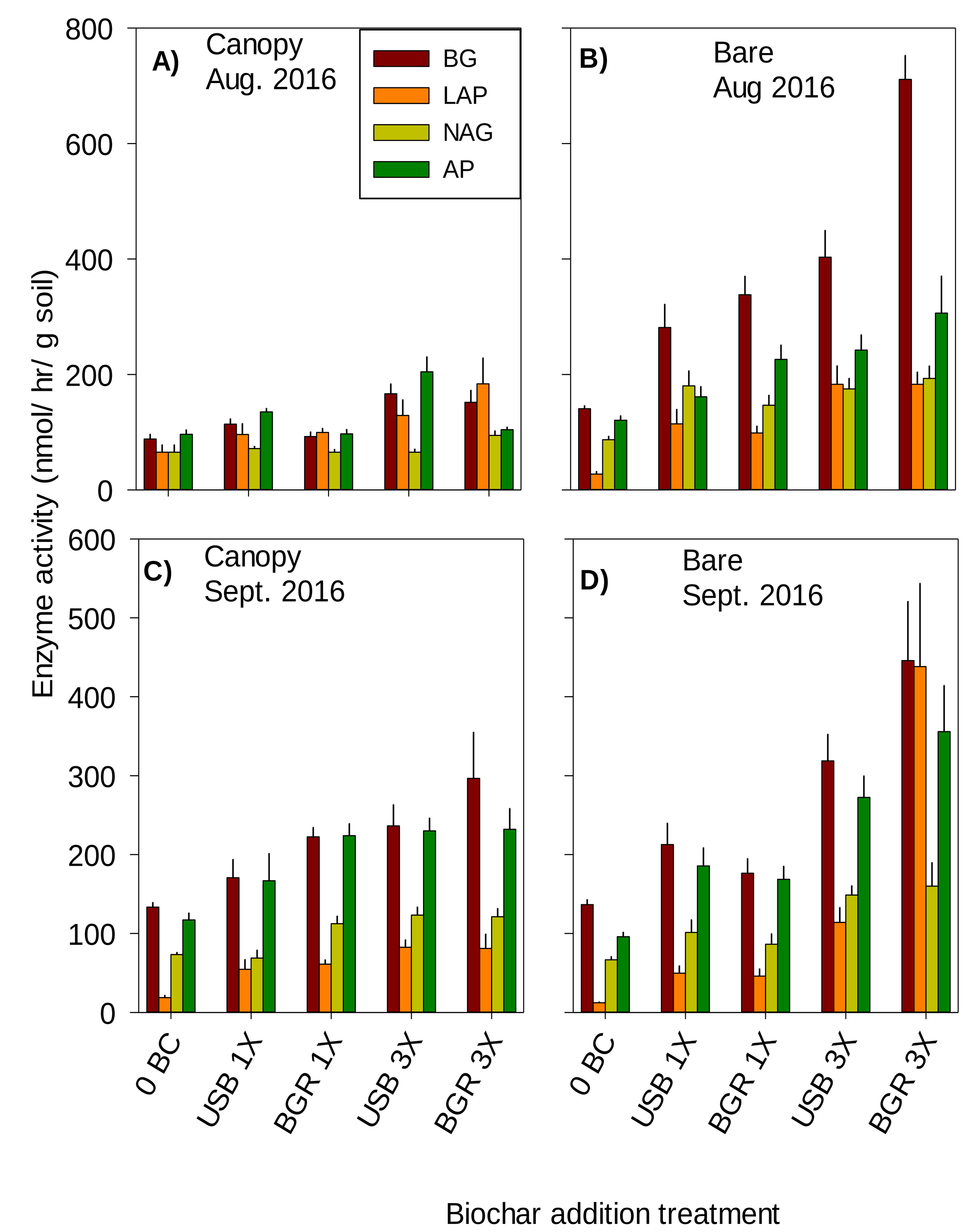

Figure 4: Soil EEA rates in A) Canopy covered soils in August, B) Bare soils in august, C) Canopy covered soils in September, and D) Bare soils in September

Treatment	pH	P mg/Kg	K mg/Kg	ECEC meq/100 g
0 BC	6.10^{C} (0.30)	3.30^{C} (0.99)	72.2^{B} (14.6)	5.88 (0.81)
1x USB	6.72^{BC} (0.24)	4.46^{BC} (1.80)	68.6^{B} (25.7)	6.52 (1.61)
1x BGR	6.44^{B} (0.17)	4.42^{BC} (0.52)	103.8^{B} (14.7)	5.38 (0.64)
3x USB	6.80^{B} (0.35)	7.38^{B} (2.31)	74.0^{B} (12.3)	7.18 (0.93)
3x BGR	7.35^{A} (0.31)	12.9^{A} (5.08)	287.8^{A} (100.9)	9.53 (2.74)

Table 1: Soil properties in samples collected in July 2016. Values by different combinations of letters indicate a significant difference between treatments

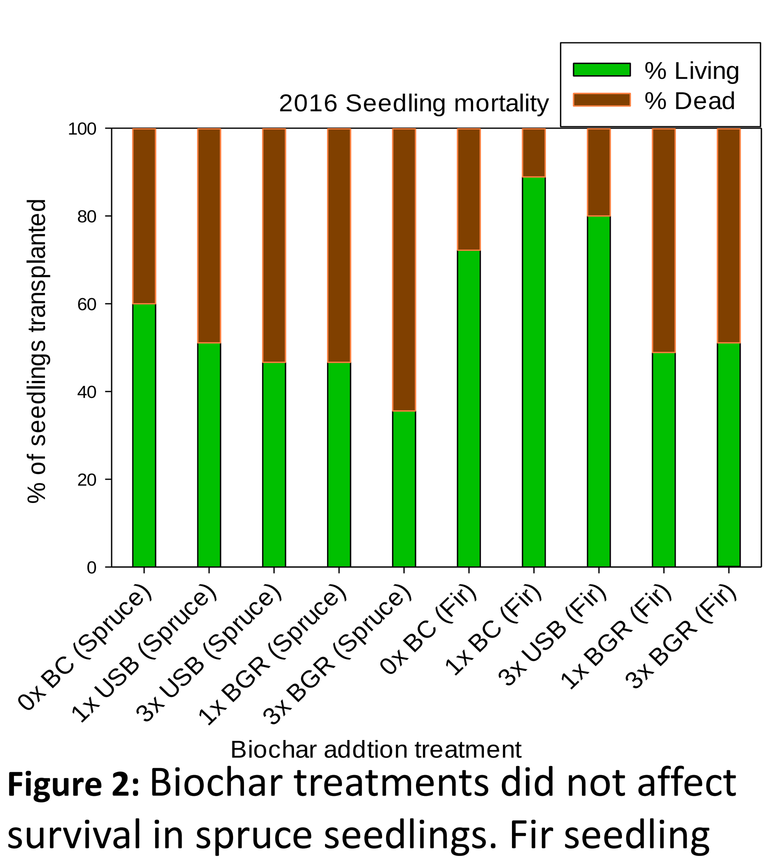

Figure 2: Biochar treatments did not affect survival in spruce seedlings. Fir seedling survival was negatively affected in both BGR treatments, but not in USB treatments ($P < 0.05$)

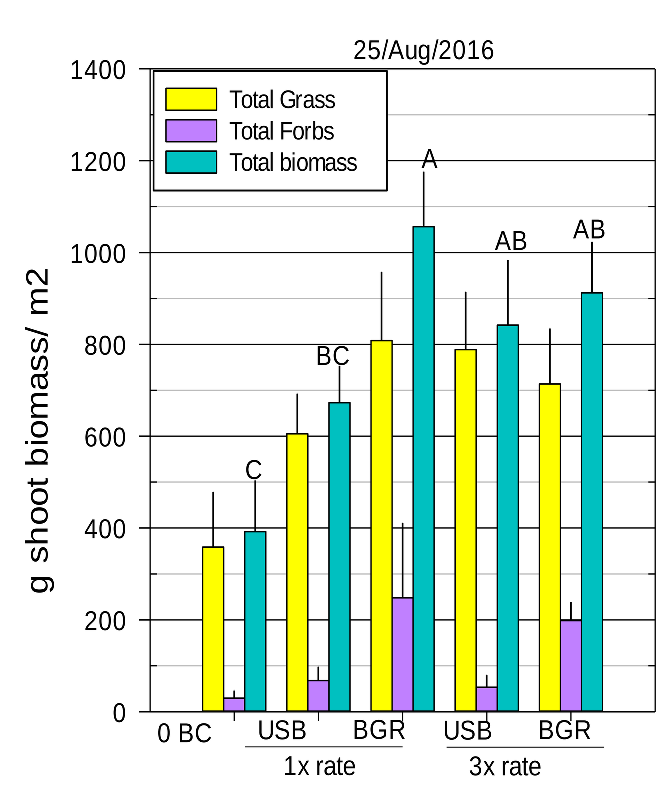

Figure 3: Multiple biochar treatments yield increased above ground weed biomass in August 2016

Conclusions

- Results from first growing show clear biochar related benefits for weeds and soil microbial communities, but neutral to negative results for spruce and fir seedlings
- Higher microbial activity rates in bare soils suggest competitive release for microbes (from weeds) and/or a biochar induced priming effect in Kill-Zall 2 treated soils. Biochars potentially enhance this effect
- Differences in activity rates between bare and canopy covered soils decline from August to September, suggesting labile substrates decrease in availability over time, especially in biochar treated soils
- Continued work at this site will show whether these initial, first season trends are persistent, or merely transient

References

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