Improving Microbial Activity and Plant Growth with Biostimulants in Disturbed Soils

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Introduction

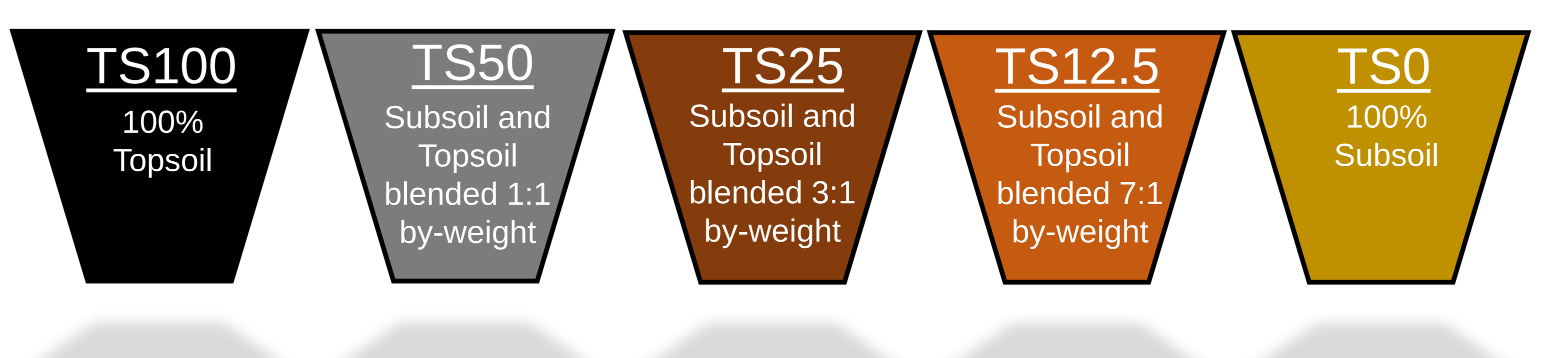
Reclamation of oil and gas-disturbed soil is challenging due to diminished function (i.e. soil physical, chemical, and biological properties) from the loss of soil organic carbon (SOC) and potential mixing of topsoil and subsoil. Biostimulants are a set of organically-derived agro-products which are applied to soil to improve SOC formation, microbial nutrient cycling, and crop yields in agricultural settings and may be a tool for improving reclamation success. However, studies on the ability of biostimulants to enhance reclamation in disturbed soils are limited. Thus, understanding how, or if, biostimulants can efficiently improve reclamation success is important. Accordingly, research was conducted to determine if biological metrics were affected by biostimulant in soil collected from an active pipeline installation project.

Objectives and Study Design

This study was conducted in a greenhouse using a completely randomized design with five soil treatments, three biostimulant treatments, and was replicated four times. Our objectives were:

- Evaluate how biostimulant and soil blending affects hard red spring wheat growth
- Determine how plant roots and arbuscular mycorrhizal fungi (AMF) symbiotic relationships respond to biostimulants
- Investigate biostimulant effects on microbial abundance and microbial CO_2 efflux

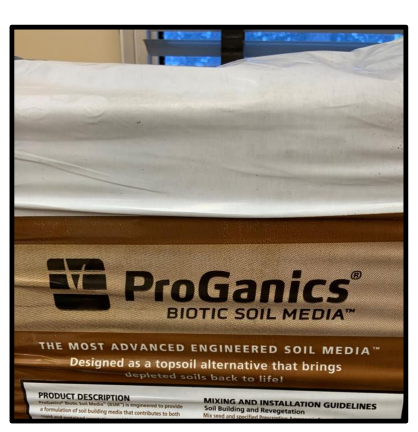
Soil Treatments



Biostimulant Treatments

Blended subsoil and topsoil with no biostimulants added

Control



Profile ProGanics™

Liventia SSB®

Methodology

Soil and Biostimulant Treatments

- Topsoil and subsoil samples were collected from an active pipeline installation in Mountrail Co., ND, air dried, and blended by-weight into 2.5kg mixtures with a shell blender
- Biostimulants were mixed according to their recommended rates
- Soil was then placed in plastic bag-lined pots, and were kept watered to 80% field capacity

Methodology Cont.

Microbial CO_2 Efflux

- Total CO_2 efflux rate (g CO_2 m^{-2} h^{-1}) was quantified following Breker et al. (2018)
- CO_2 was read every three days for one week; then once every seven days thereafter

Hard Red Spring Wheat

- 14 d after mixing, 10 seeds per pot were planted and fertilized upon first watering.
- Wheat plants were thinned to 5 plants per pot upon emergence

AMF colonization:

- Roots were washed free of soil and stained following the procedures of Phillips and Hayman (1990) and quantified following a modified Allen and Allen (1980) method

Phospholipid Fatty Acid (PLFA) analysis:

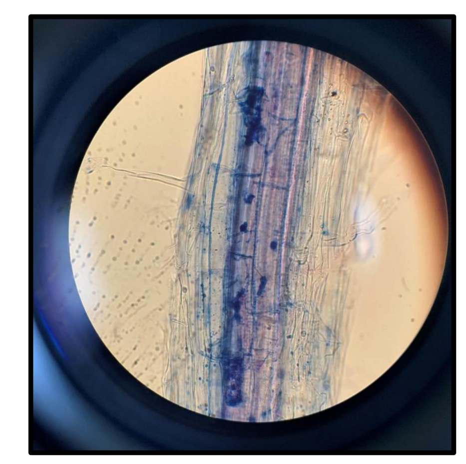
- Soil samples were collected and analyzed following Buyer and Sasser (2012)

Plant and Root Biomass:

- Aboveground plant matter was separated from the roots, and were separately weighed

Statistical Analyses:

- Single Factor Analysis of Variance was run on all parameters at α= .05, with a Tukey's HSD on means. Treatments with same letters denotes no difference at α= .05.



Results

1. Hard red spring wheat aboveground and root biomass yields and select soil properties.

Treatment	Aboveground Dry Biomass (g)	Fresh Root Biomass (g)	Root Colonization %	SOC (%)	Olsen-P (mg/kg)
TS100	0.66 (0.10) a	2.72 (0.82) a	70 (26.1) a	2.17 (0.14) a	5.75 (0.13) a
TS50	0.58 (0.09) a	2.27 (0.51) ab	65.8 (27.2) a	1.58 (0.11) b	5.08 (1.31) b
TS25	0.45 (0.07) b	1.96 (0.35) b	55.2 (28.8) b	1.35 (0.12) c	3.83 (0.72) b
TS12.5	0.47 (0.06) b	1.96 (0.63) b	60.5 (30.4) ab	1.24 (0.81) cd	3.58 (0.79) b
TS0	0.40 (0.07) b	2.24 (0.56) b	64.2 (26.4) ab	1.12 (0.13) d	3.33 (0.65) b
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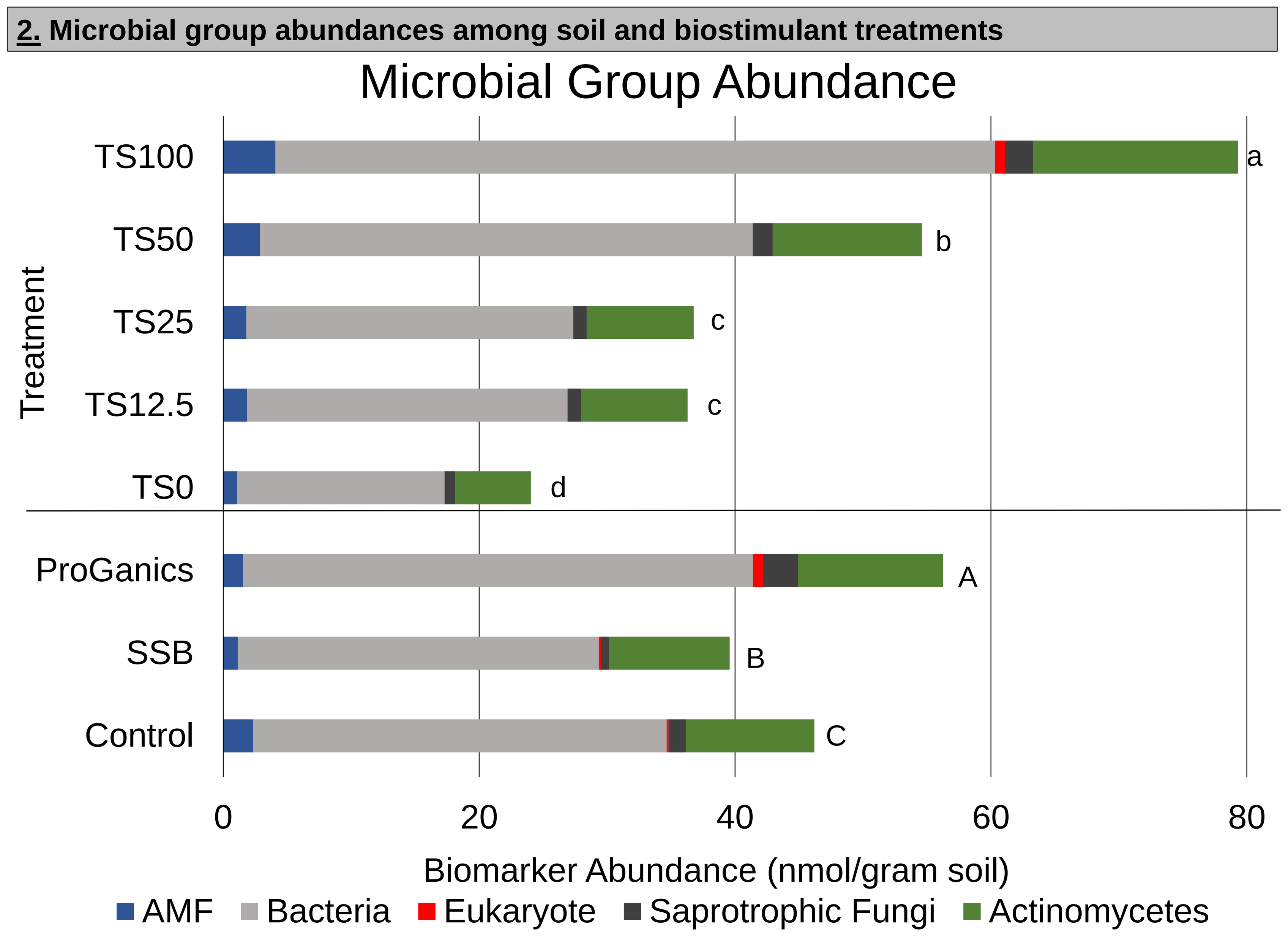
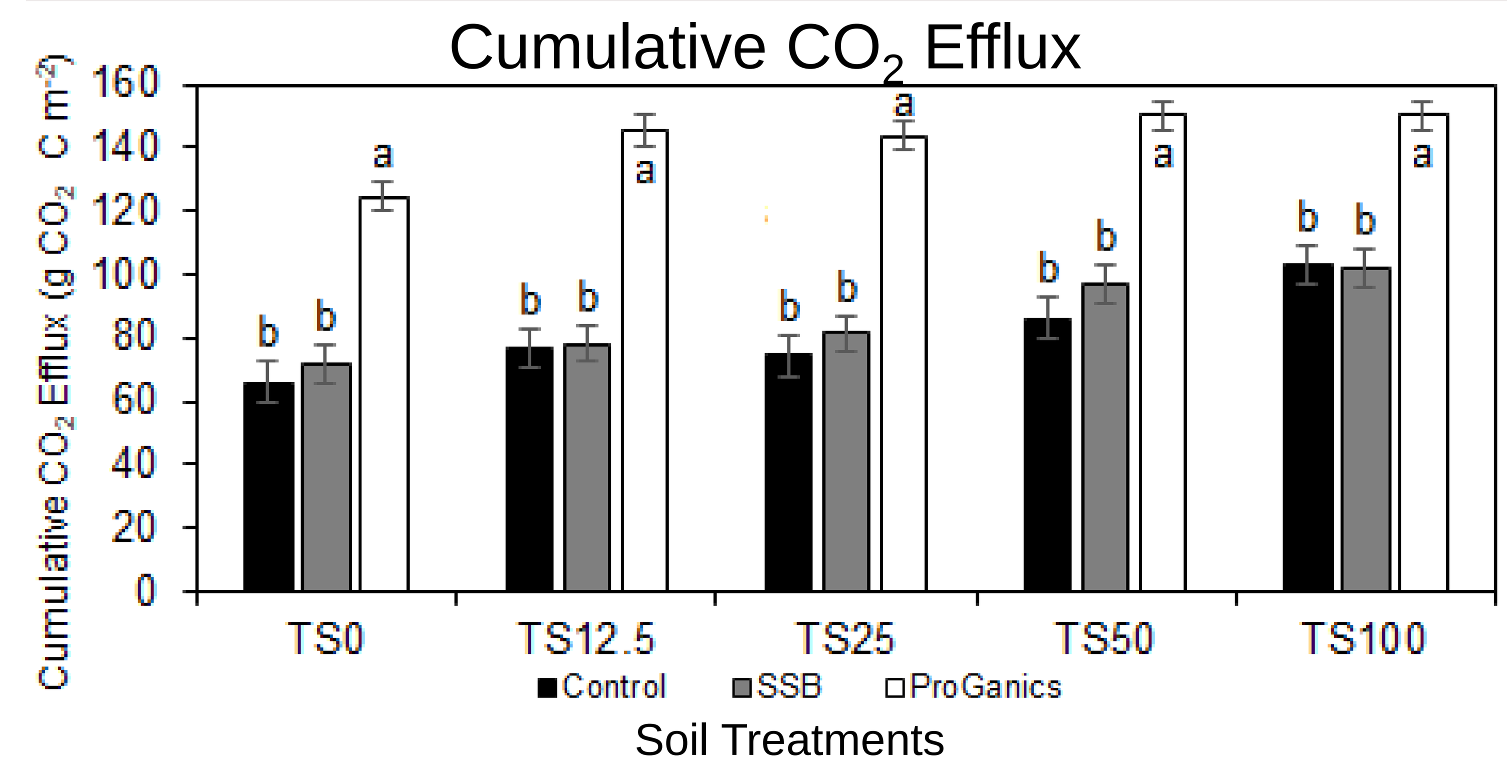
Proganics	0.49 (0.10) b	2.02 (0.62)	66.3 (29.5)	1.50 (0.36)	4.05 (1.23) b
SSB	0.55 (0.14) a	2.37 (0.66)	61.9 (27.4)	1.52 (0.43)	4.75 (0.85) a
Control	0.50 (0.11) b	2.29 (0.61)	61.2 (28.5)	1.46 (0.36)	4.15 (1.50) b

2. Microbial group abundances among soil and biostimulant treatments



Results Cont.

3. Cumulative CO_2 Efflux from soil treatments by biostimulant type.



1.

- SSB® increased aboveground plant biomass growth compared to the control or ProGanics
- Blending subsoil with topsoil improved wheat growth only at 1:1 ratios
- Biostimulants did not affect SOC significantly in this studies timeframe

2.

- Overall, soil treatments nor biostimulants contained significant responses with AMF root colonization

3.

- ProGanics™ produced the greatest cumulative CO_2 efflux and averaged 3.6 g CO_2 C/m^2 per day
- Average topsoil blend rates were similar to rates observed in an undisturbed ND grassland soil
- Regardless of topsoil concentration, blending it with topsoil enhances microbial activity and is beneficial to soil processes
- However, improved microbial activity did not result in improved wheat growth in this 40-day study

Conclusion

Overall, topsoil concentrations dominated biological responses compared to the biostimulant treatments. Topsoil blended below a 1:1 ratio contained the least potential for reclamation success due to reduced SOC levels. Fortunately, SSB® benefitted P-availability and wheat growth, while ProGanics™ increased microbial biomass and activity/CO_2 efflux, suggesting biostimulants can benefit restoration of microbial nutrient cycles and microbial recolonization of blended soils compared to the control. However, individual microbial responses were dependent on specific biostimulant components such as woody fibers high in recalcitrant C, or specific microbial inoculants which can shift microbial community composition. Overall, our study shows opportunities for biostimulants to improve microbial recolonization and processes in disturbed soils in the short-term, but choosing products that improve plant function, microbial activity, and soil properties, such as microbial diverse biostimulants, may be the best choice. Lastly, further field evaluations of the effects of biostimulants on soil properties and plant growth are needed to fully evaluate their potential use in reclamation.

References

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