Examining biochar as a carrier for *Rhizobium spp.* on legume crops

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Introduction

The symbiotic relationship formed between legumes and rhizobia bacteria plays an integral role in the agriculture industry as the bacteria fix atmospheric nitrogen into a plant available form. In North America, peat and clay are the most common inoculant carriers available but are considered limited or, at best, slowly renewable resources. This leaves the potential for development of alternative carriers that can compete biologically and economically.

Biochar is the product of thermal degradation of organic materials in the absence of air (pyrolysis). Factors such as feedstock, pyrolysis temperature and the degree of oxygen during production have been identified to affect the resulting biochars properties which can create very different living conditions for microorganisms in the biochar pore spaces. Certain biochar properties, specifically surface area and porosity, can be manipulated to levels that are most suitable to *Rhizobium* survival and growth.

Materials and Methods

An initial set of nine biochars (Table 1) varying in feedstock and source will be used in this study. The following outlines how biochar will be examined as a carrier for *Rhizobium* inoculant for this thesis project:

- Biochars will be evaluated for physical and chemical properties including surface area, pore density, moisture holding capacity, pH, electrical conductivity, volatile compound content, ash content and functional group composition;
- Biochars have been subjected to a cress phytotoxicity bioassay (Fig. 1, Plate 1) (Leege and Thompson, 1997);
- A subset of biochars will have the surface area and porosity manipulated to desirable levels;
- Biochars will be inoculated with *Rhizobium* at a rate of 7.4 x 10^9 rhizobia g^{-1} biochar and evaluated weekly for bacterial load until the lower limit of detection at 1 x 10^6 rhizobia g^{-1} biochar (according to industry standards) is reached;
- Biochars that support *Rhizobium* populations will be used in a greenhouse study to inoculate pea crop in addition. A reference wheat crop will be grown to measure biological nitrogen fixation using the ^{15}N enriched isotope dilution method.

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Preliminary Results

Table 1. Biochar feedstock and source

Biochar	pH	EC (µS m^{-1})	BET Surface Area (m^2 g^{-1})	Source
Bone Meal Biochar; **BMB**	9.05	1236	113.35	TCE
Fish Biochar; **FB**	9.65	1044	9.22	TCE
Unknown Flin Flon 1; **FFB1**	9.15	1861	77.60	TCE
Unknown Flin Flon 2; **FFB2**	9.86	1765	12.35	TCE
Oat Hull Biochar; **OHB**	9.88	830	0.11	TCE
Flax Biochar; **FHB**	8.58	863	2.99	SRC
Wheat Biochar; **WB**	8.88	1203	2.92	SRC
Spruce/Pine/Fir; **TB**	8.75	128	4.93	OAB
Spruce/Pine/Fir; **DB**	10.01	226	153.25	DCE

*TCE: Titan Clean Energy, Saskatoon, SK., SRC: Saskatchewan Research Council, Saskatoon, SK, OAB: Out of Ashes BioEnergy Inc., Prince George, BC (Turtleback Biochar ®), DCE: DiaCarbon Energy Inc., Burnaby, BC.

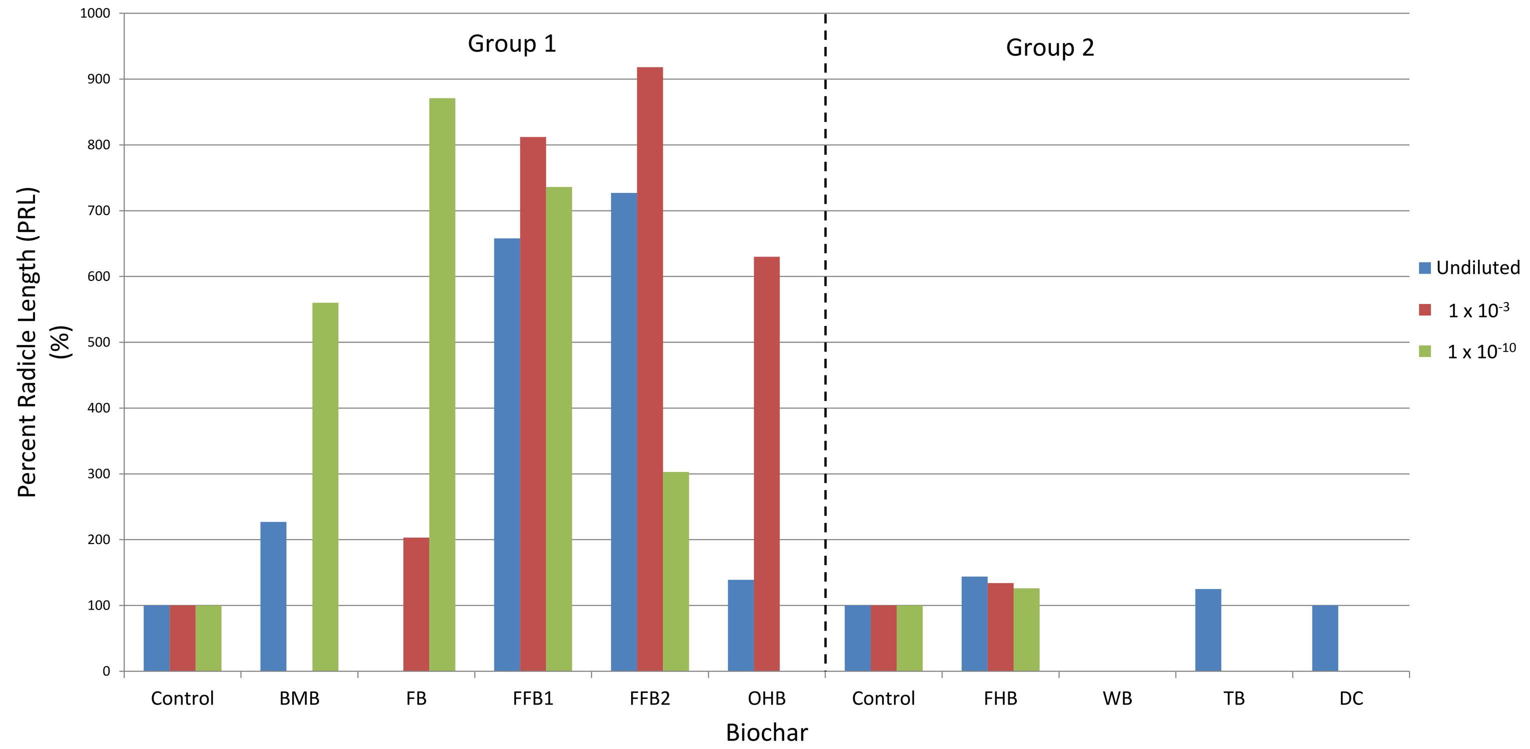

Fig. 1. Percent radicle length of garden cress seed by biochar treatment. Group 1 and 2 biochars were subjected to the phytotoxicity bioassays at different dates. Results from each group are based on the water control results from the respective study date.

Plate 1. Cress phytotoxicity bioassay plates. Left to right: water control, BMB: undiluted, BMB: 1 x 10^{-10}.

Preliminary Results

- The initial characterization of biochars indicates a high amount of variability in biochar characteristics based on feedstock and source. The surface area displays a particularly high variability with the overall range being 0.11 m^2 g^{-1} to 153.25 m^2 g^{-1}. Interestingly, biochars TB and DB resulted in surface areas of 4.93 m^2 g^{-1} and 153.25 m^2 g^{-1}, respectively, although being from the same feedstock but differing in source.
- The biochar treatments appear to cause both toxic and biostimulatory effects on garden cress seeds when examined for germination and radicle length. The diluted treatment rates typically caused an increase in germination and radicle length when compared to undiluted treatments.

Anticipated Future Results

Biochar properties, both physical and chemical, are predicted to continue to vary between biochars based on feedstock and source. It is expected that biochar properties that support *Rhizobium* growth and survival will be identified. It is not anticipated that at this stage the biochar will outperform the commercial inoculants in carrying rhizobia however, results from this study should identify the potential for biochar development as a *Rhozbium* carrier.

Acknowledgements

Financial support from Saskatchewan Agriculture Development Fund is greatly appreciated.

References

1. Leege, P.B. and W. H. Thompson. 1997. Test methods for the examiniation of composting and compost. 1st Edition. The U.S. Composting Council, Maryland, U.S.