Examining biochar as a carrier for *Rhizobium spp.* on pea crop

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Outline

I. Introduction
II. Biochar Physical and Chemical Characterization
III. Biochar Phytotoxicity Study
IV. *Rhizobium* Survival Study
V. Pot Study
VI. Conclusion

I. Introduction

- Current *Rhizobium* inoculant carriers include clay and peat

- Room for research examining carriers that can be economically and biologically competitive with current commercial carriers

- Properties of a suitable carrier include:
  - -Readily adjustable pH
  - -Readily sterilisable
  - -Good moisture holding capacity
  - -Free of toxic materials

Nodulation

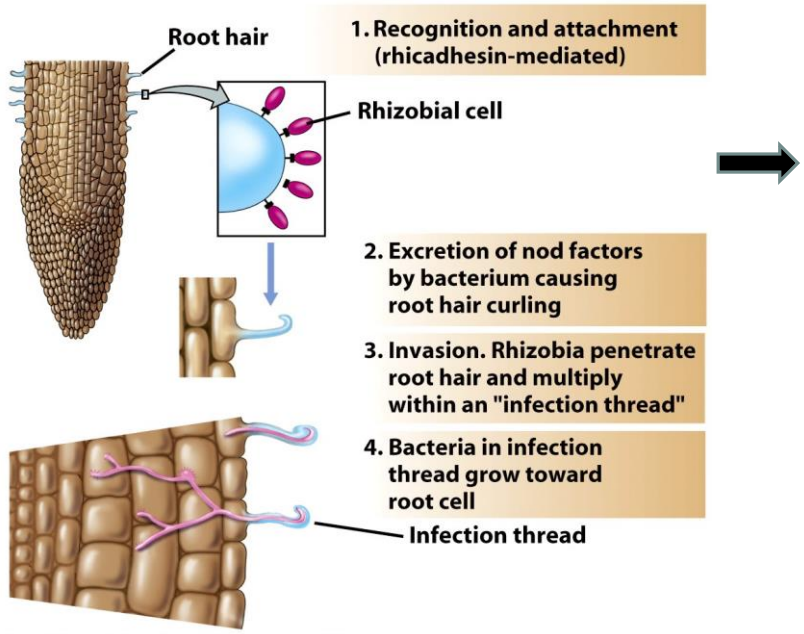

Figure 19-61 part 1 Brock Biology of Microorganisms 11/e
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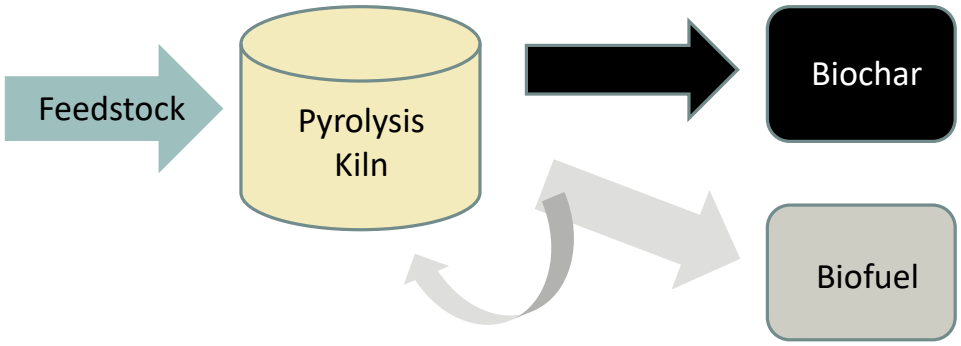
Biochar

Pyrolysis Process



Adapted from Talberg, 2009

Key properties of biochar:

- pH
- volatile matter content
- ash content
- moisture holding capacity
- pore volume
- surface area

Objectives

1) Characterize the physical and chemical characteristics of a variety of biochars and examine the relationship between biochar characteristics and survival/population loads of rhizobia supported by the biochar.
2) Assess the potential phytotoxicity of each biochar.
3) Evaluate the ability of the biochars to deliver nodulating rhizobia to pea seed in growth chamber conditions.
4) Manipulate a subset of biochars to achieve desirable measures of surface area and pore density.

Biochar ID	Feedstock	Source
BMB	Bone Meal	Titan Clean Energy, Saskatoon, SK
FB	Fish	Titan Clean Energy, Saskatoon, SK
OHB	Oat Hull	Titan Clean Energy, Saskatoon, SK
FHB	Flax Hull	Saskatchewan Research Council, Saskatoon, SK
WB	Wheat	Saskatchewan Research Council, Saskatoon, SK
DB	Spruce/Pine/Fir	DiaCarbon Energy Inc., Burnaby, BC
TB	Spruce/Pine/Fir	Out of Ashes BioEnergy Inc., Prince George, BC (Turtleback Biochar ®)
FFB1	Bone Meal or Creosote/Greenwood	Titan Clean Energy, Saskatoon, SK
FFB2	Bone Meal or Creosote/Greenwood	Titan Clean Energy, Saskatoon, SK

II. Biochar Physical and Chemical Characterization

- Prior to physical and chemical analysis:
  - Biochar was ground and sieved to <75µm (200 mesh)

(Somasagaren and Hoben, 1994)


6
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Results: Biochar Physical Characterization

Biochar	BET Surface Area ($m^2 g^{-1}$)	Moisture holding capacity (% of dry weight)	Inherent moisture content (% of dry weight)	Pore Volume ($cm^3 g^{-1}$)	Source
Bone Meal Biochar; **BMB**	113.35	140	4	0.0974	TCE
Fish Biochar; **FB**	9.22	96	6	0.0303	TCE
Unknown Flin Flon 1; **FFB1**	77.60	138	7	0.0707	TCE
Unknown Flin Flon 2; **FFB2**	12.35	131	4	0.0366	TCE
Oat Hull Biochar; **OHB**	0.11	195	4	0.0028	TCE
Flax Biochar; **FHB**	2.99	96	5	0.0035	SRC
Wheat Biochar; **WB**	2.92	154	4	0.0050	SRC
Spruce/Pine/Fir; **TB**	4.93	214	4	0.0050	OAB
Spruce/Pine/Fir; **DB**	153.25	45	5	0.0159	DCE

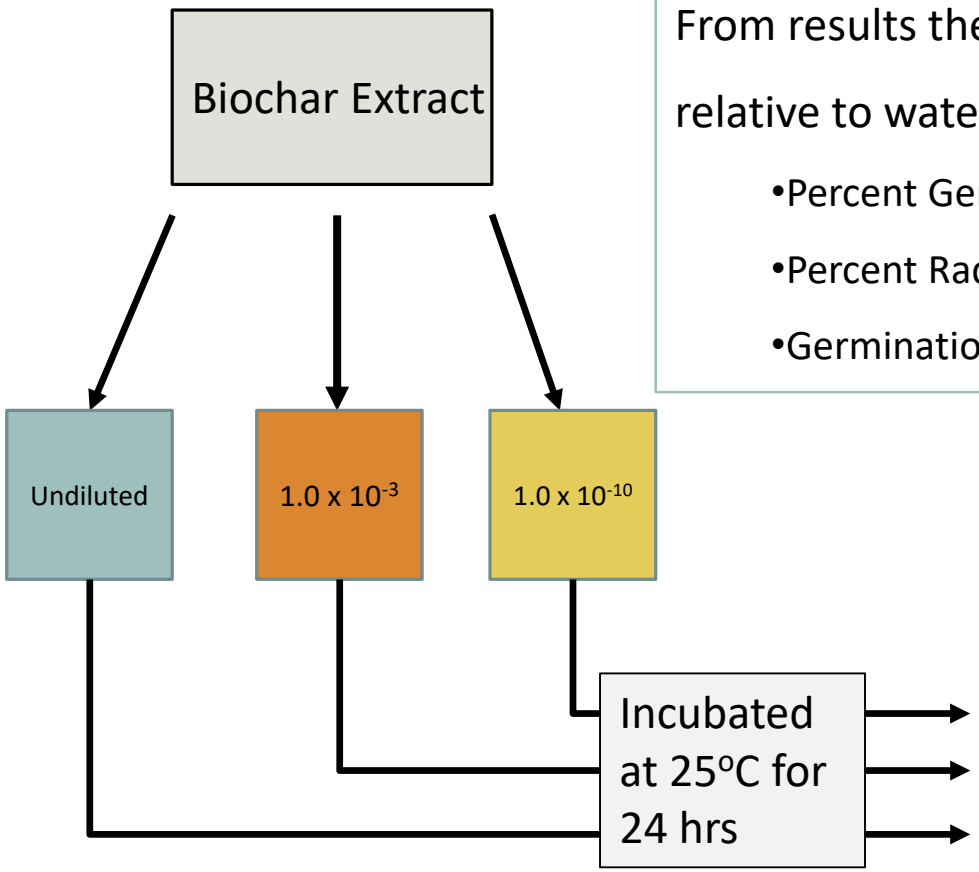
*TCE: Titan Clean Energy, Saskatoon, SK., SRC: Saskatchewan Research Council, Saskatoon, SK, OAB: Out of Ashes BioEnergy Inc., Prince George, BC (Turtleback Biochar ®), DCE: DiaCarbon Energy Inc., Burnaby, BC.

Results: Biochar Chemical Characterization

Biochar	pH	Electrical Conductivity ($\mu S\ m^{-1}$)	Volatile Matter (% of dry weight)	Ash (% of dry weight)	Source
Bone Meal Biochar; **BMB**	9.05	1236	15	63	TCE
Fish Biochar; **FB**	9.65	1044	28	36	TCE
Unknown Flin Flon 1; **FFB1**	9.15	1861	20	64	TCE
Unknown Flin Flon 2; **FFB2**	9.86	1765	29	52	TCE
Oat Hull Biochar; **OHB**	9.88	830	25	15	TCE
Flax Biochar; **FHB**	8.58	863	55	7	SRC
Wheat Biochar; **WB**	8.88	1203	50	14	SRC
Spruce/Pine/Fir; **TB**	8.75	128	33	6	OAB
Spruce/Pine/Fir; **DB**	10.01	226	28	8	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.

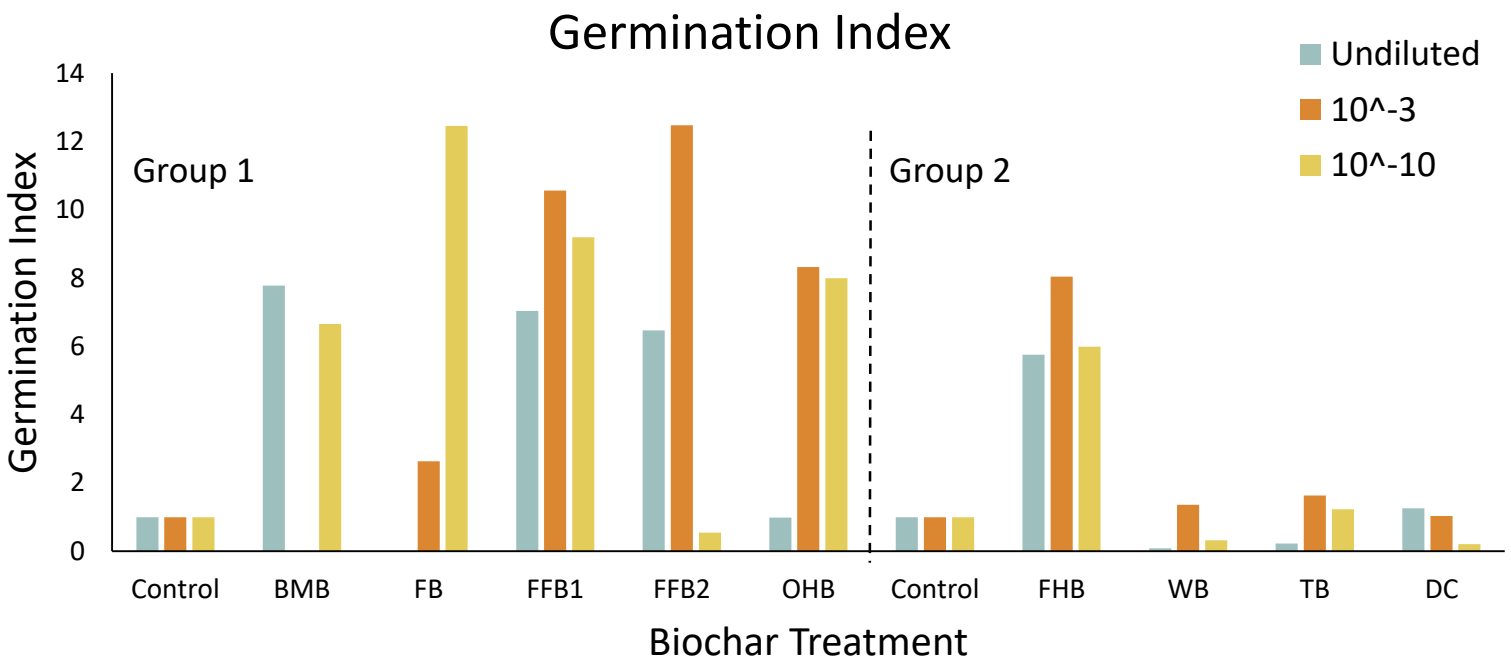
III. Garden Cress Phytotoxicity Bioassay



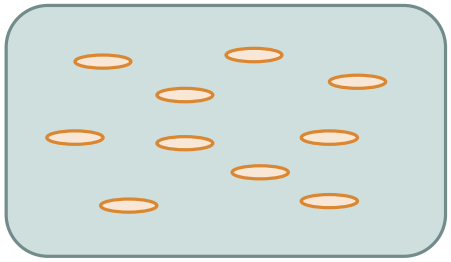
From results the following are calculated relative to water control:

- Percent Germination
- Percent Radicle length
- Germination index

Results: Phytotoxicity

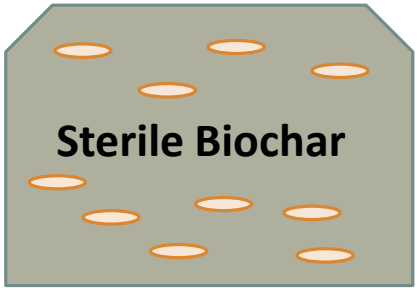


IV. Rhizobium Survival Study



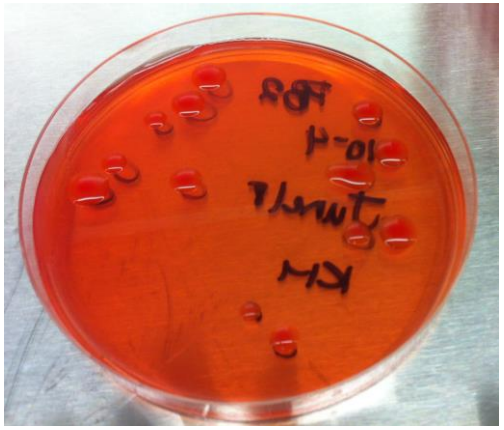
Rhizobium leguminosarum biovar *viceae*

~ 6 x 10^8 rhizobia cells ml^{-1} broth



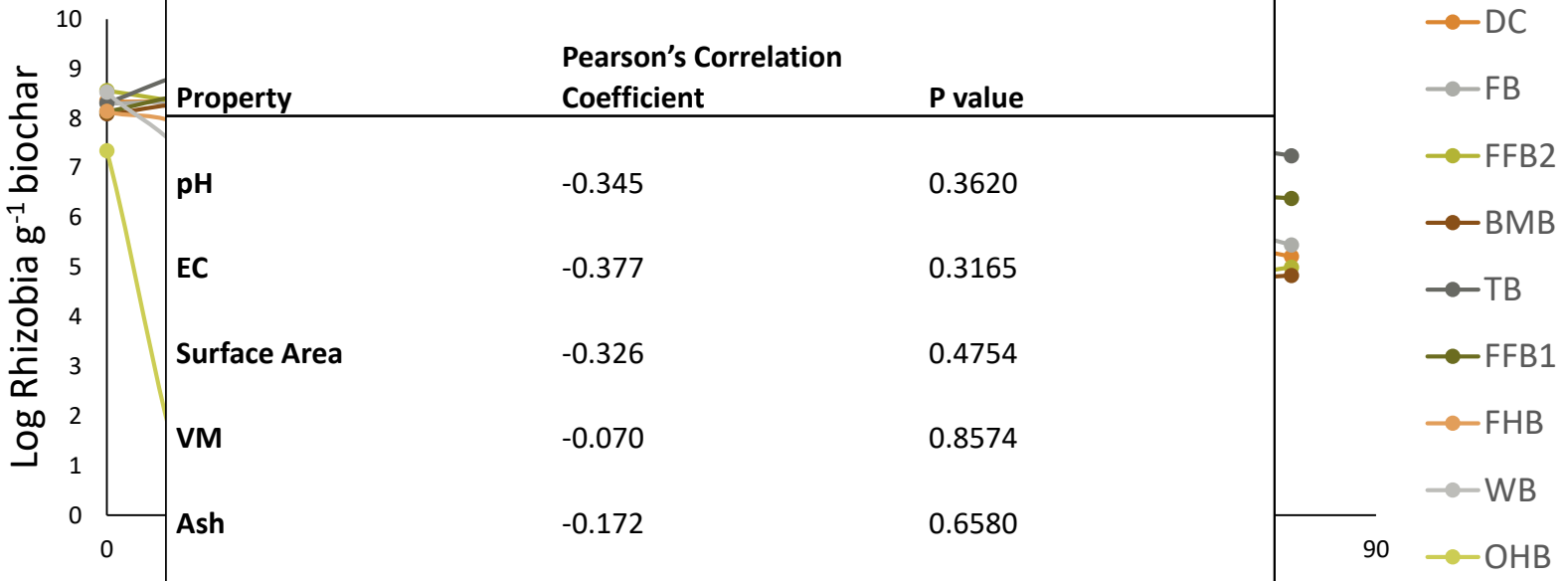
Incubated for 4 weeks at 25 – 30 °C

Sampled weekly and spread plated over a 12 week period



Lowest acceptable limit: 1.0 x 10^6 rhizobia cells g^{-1} biochar

Results: Survival Study



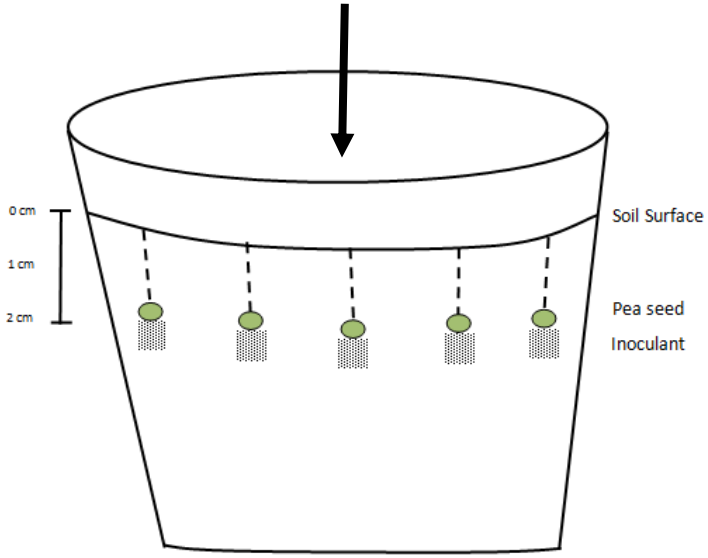
Property	Pearson's Correlation Coefficient	P value
pH	-0.345	0.3620
EC	-0.377	0.3165
Surface Area	-0.326	0.4754
VM	-0.070	0.8574
Ash	-0.172	0.6580
Moisture	-0.077	0.8432
Pore Volume	-0.148	0.7035

V. Pot Study

Treatments:
- 6 inoculated biochars

Controls:
- Uninoculated control
- Commercial inoculant
- Wheat reference crop
- Biochar uninoculated

^{15}N-urea (10 atom %) surface applied at 5 lb N/ac



V. Pot Study

Future Results:

- Root, shoot, seed and nodule dry weights
- Number of nodules
  - Biomass to be finely ground with subsamples analyzed for ^{15}N and N content via isotope ratio mass spectrometry

VI. Conclusion

- High variability in physical and chemical properties between biochars
- Observed that certain biochars support and sustain *Rhizobium* populations
- Thus far, there is no dominant property correlating to *Rhizobium* survival although it is possible that it could be an interaction between two or more properties

Acknowledgements

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Questions?