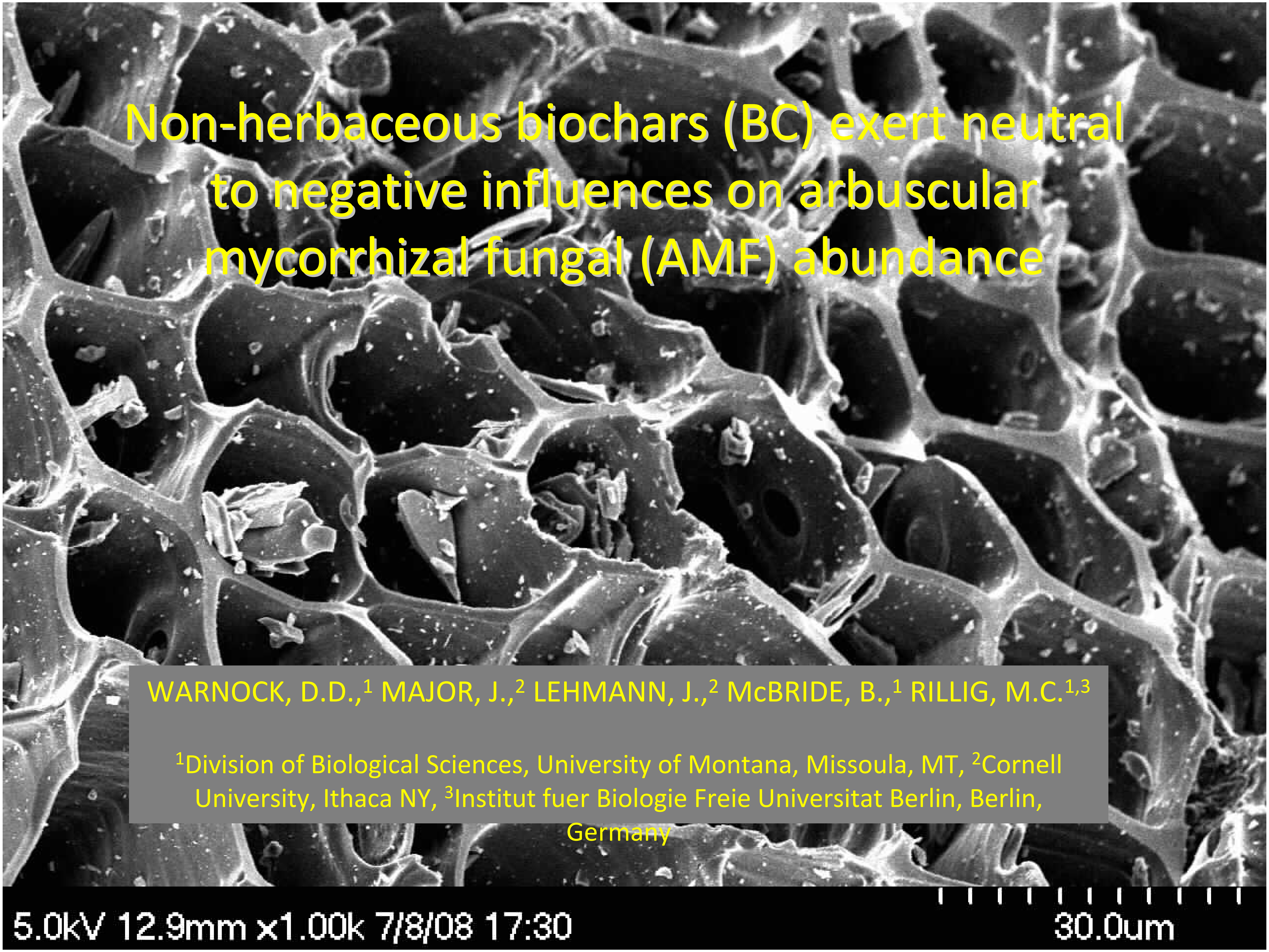
Non-herbaceous biochars (BC) exert neutral to negative influences on arbuscular mycorrhizal fungal (AMF) abundance



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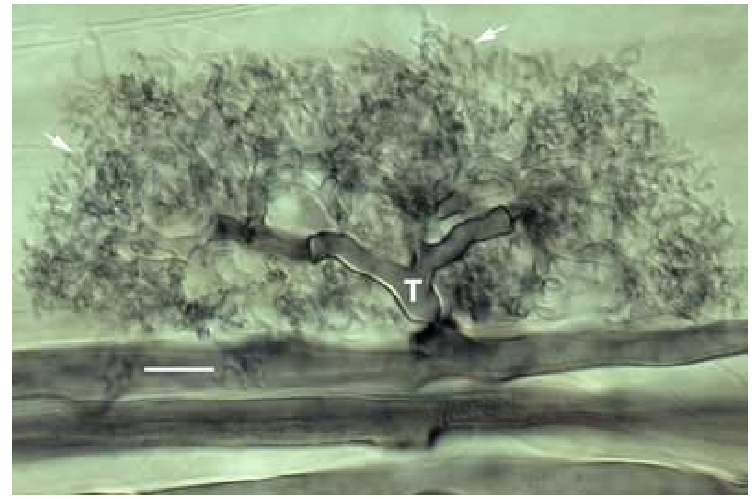
Outline

- Briefly discuss AMF biology
- Discuss BC presence in soils and their potential affects on AMF
- Describe BC potential as an AMF management tool
- Show experimental results: BCs influence on AMF abundance

AMF Biology

- AMF belong to the fungal phylum Glomeromycota (Schuessler et al. 2001)



- AMF form symbioses with plant roots, receive carbon from host plant (Smith and Read 1997)
  - AMF colonize approximately 2/3 of known plant species (Trappe 1987)
  - All AMF species are obligate biotrophs
  - Provide host plants with nutrients (P, Cu and Zn) and other benefits

- Colonization by AMF can enhance plant growth and overall ecosystem productivity (Rillig 2004)
    - Also influence other important ecosystem processes

- Soil amendments benefiting AMF, should also enhance their positive influences on plants and ecosystem processes

- Multiple sources suggest that BCs show promise for use as an AMF management tool

Experimental design	Type(s) of BC or AC applied	Response variables	AMF response	Source
BC Effects on AMF Root Colonization (RC) of *Citrus iyo* in an abandoned orchard.	H: Rice Husk	Root Colonization	+610%	Ishii and Kadoya (1994)
Effects of three BC types on AMF (*Glomus fasciculatum*) in river sand	H: Rice Husk Citrus Juice Sediment (C.J.) Woody: Western Spruce Bark (W.S.)	Root Colonization	+540% R.H. +88% C.J. +75% W.S.	Ishii and Kadoya (1994)
BC Effects on AMF in soy bean fields	Not Reported	Root Colonization	+300%	Saito (1990)
BC (ground vs. un-ground) effects on AMF infectivity	H: Rice Husk	Root Colonization	Ground: +100% Un-ground: -20%	Ezawa et al. (2002)
BC Effects on AMF (*Glomus sp.*) and *Fusarium oxysporum*	Woody: Coconut Shell	Root Colonization	10% BC: +50% 30% BC: +69%	Matsubara et al. (2002)

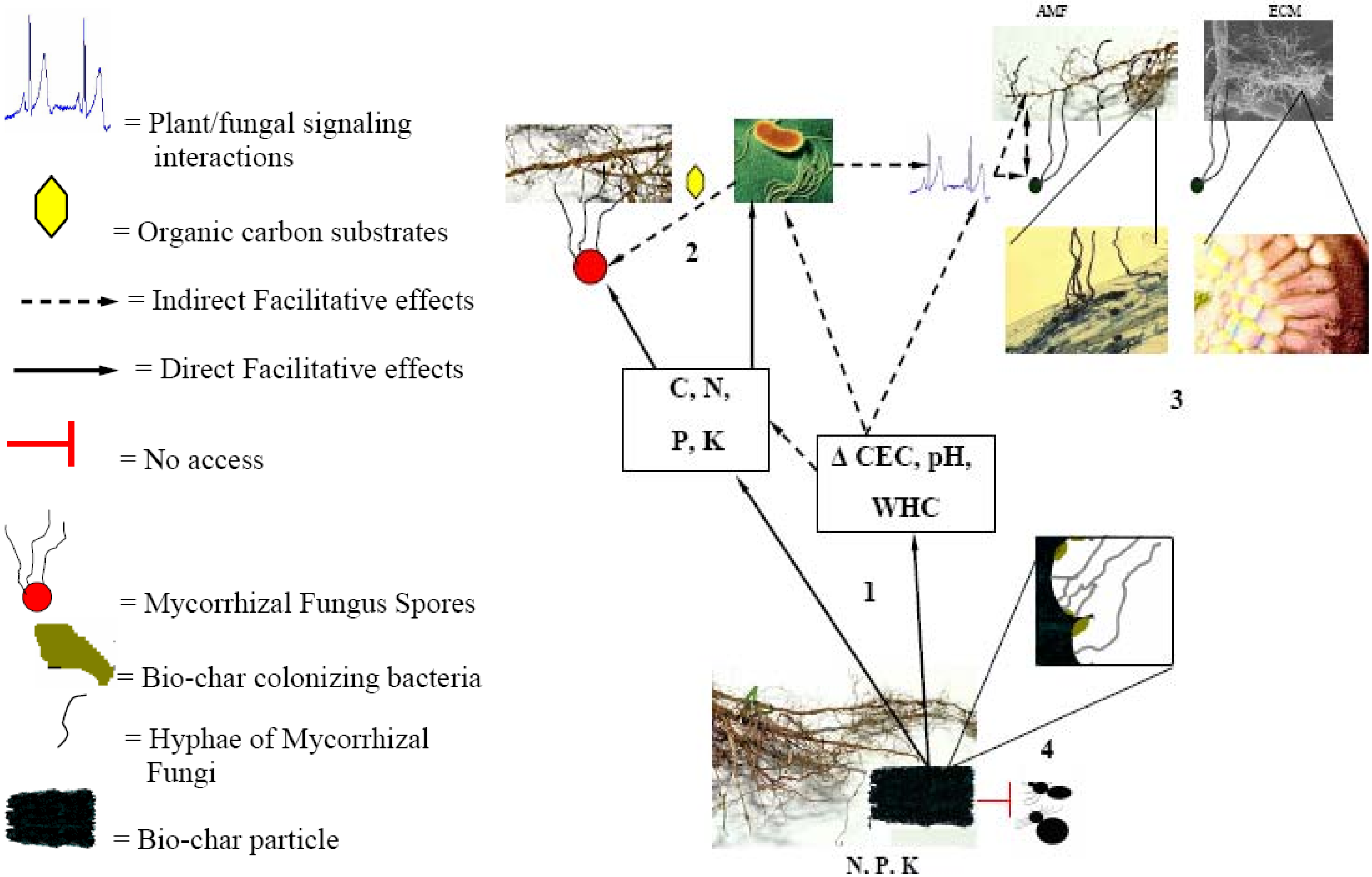


Fig. 1: A schematic representation of the mechanistic pathways for how BC could influence AMF abundance in roots and soils. Numbers in figure correspond to different mechanisms. Published in Warnock et al. (2007)

- Results illustrating how non-herbaceous BC affect AMF abundance, especially in soils remain scarce

- Use of many different non-herbaceous BCs could add value to previously un-used materials

Experimental design and predictions

- Designed three experiments to determine if non-herbaceous BCs can be used to increase AMF abundance

- Measured abundance of AMF in roots and soils as well as soil pH and phosphate availability

- Predicted that changes in soil properties would increase AMF abundance

Materials and Methods

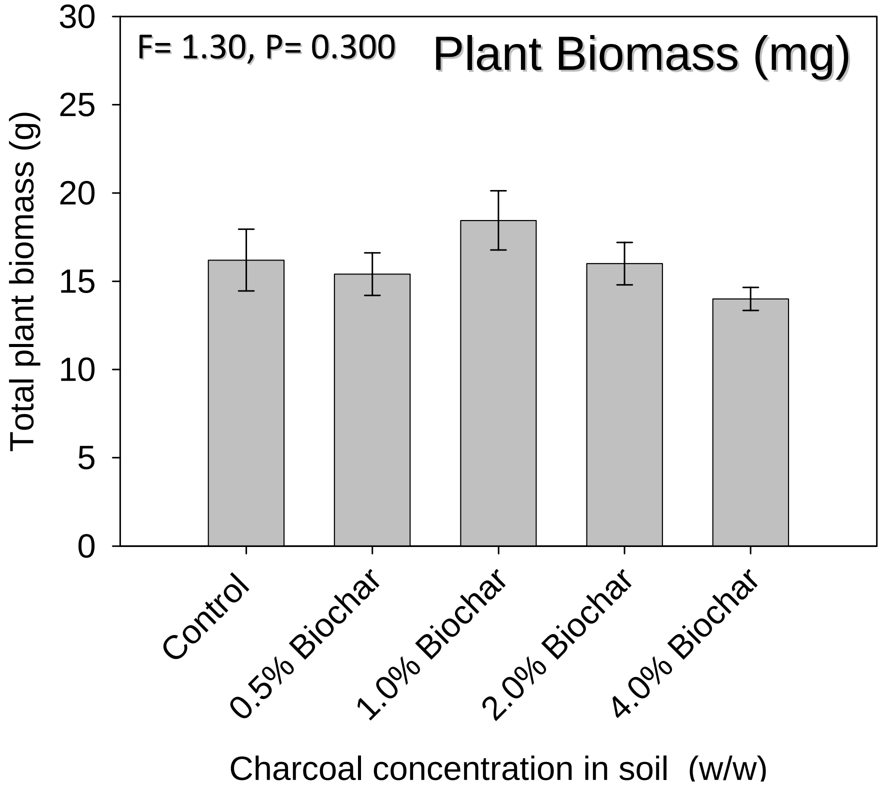
Experiment 1: multiple BC addition rates

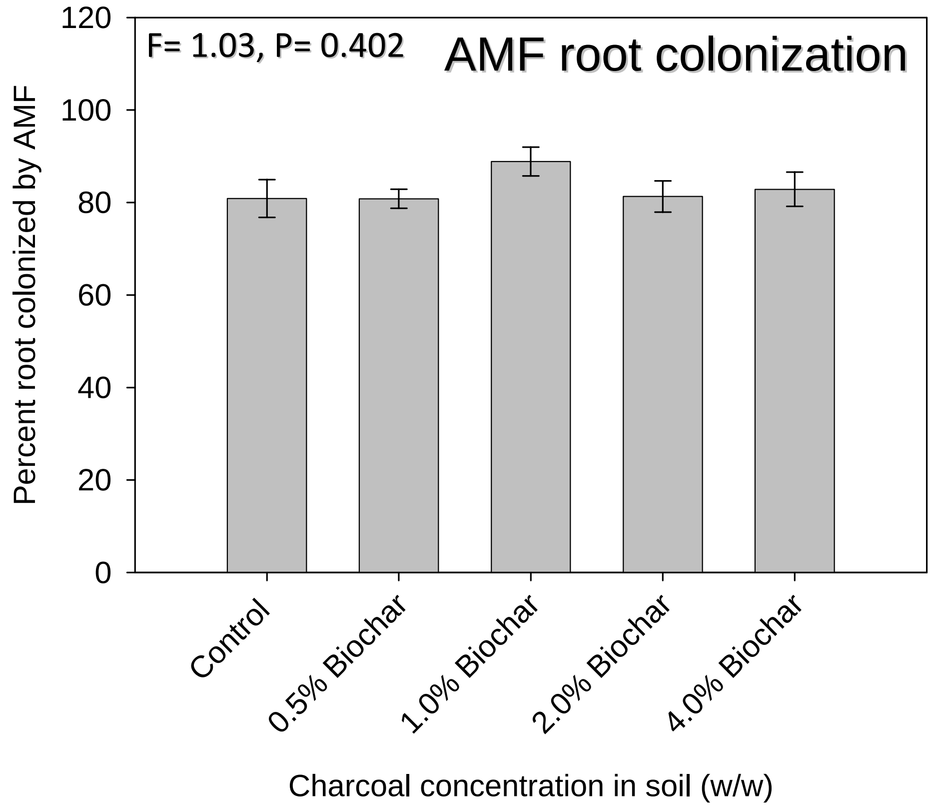
- 600^{o} C *Pinus contorta* (Lodge pole pine) wood BC applied to Nyack river flood plain soil with high Arbuscular Mycorrhizal Inoculation Potential (MIP)
  - MIP is a good predictor of AMF vigor
  - Biochar added at 0.0%, 0.5%, 2.0% and 4.0% by weight

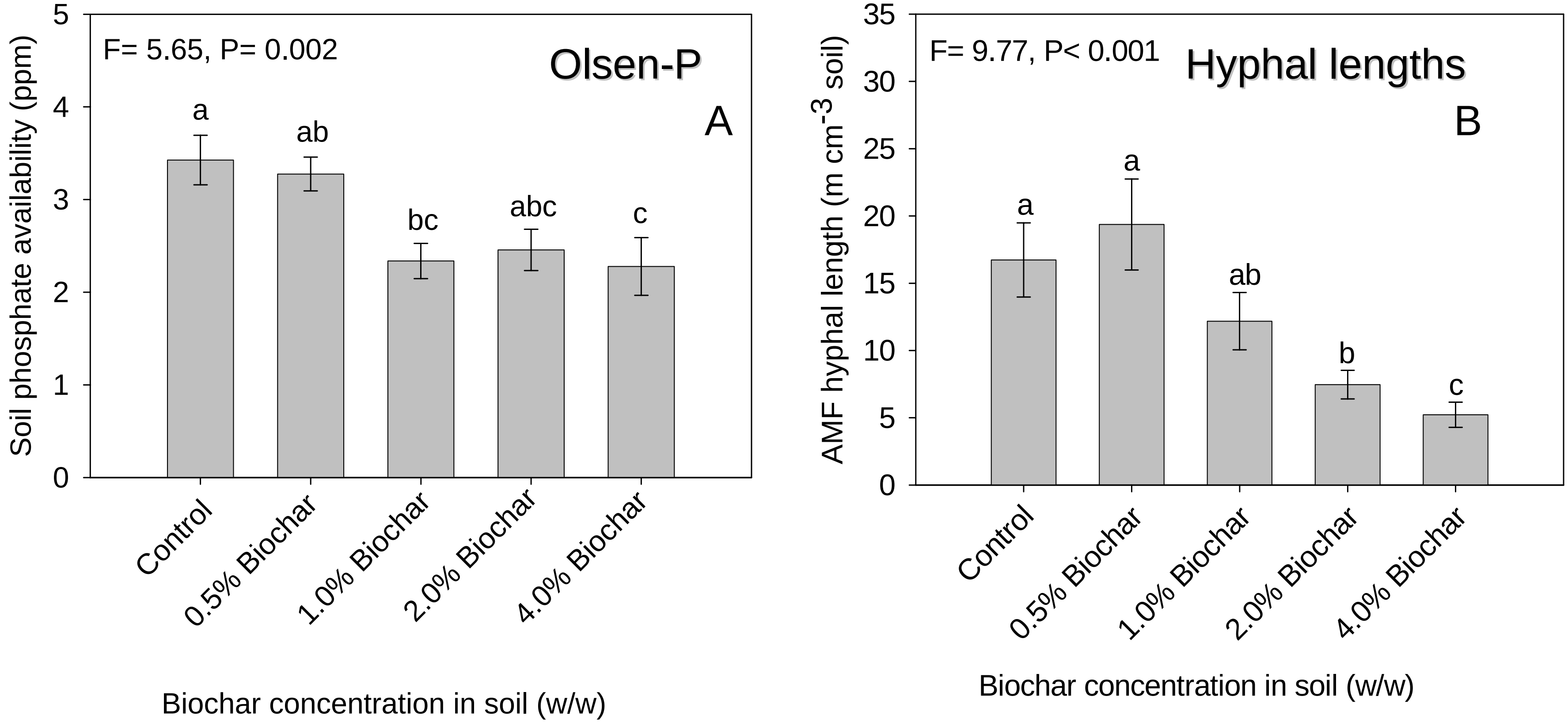
- *Plantago lanceolata* grew in the BC-treated soils for 30 days in growth chamber

Matthias Rillig

Results Different BC addition rates



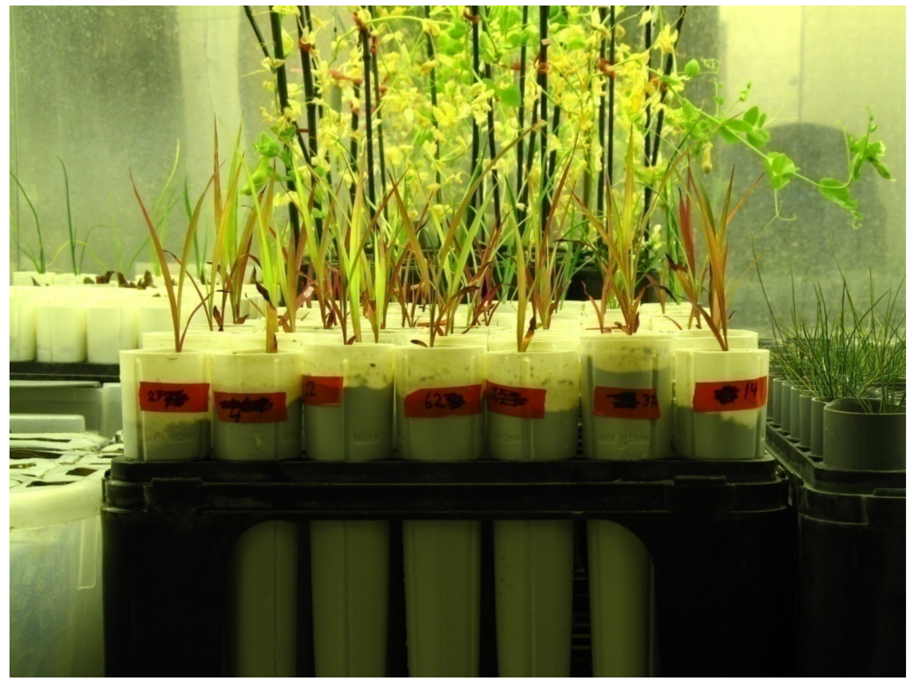



F= 5.65, P= 0.002
Olsen-P
A
Soil phosphate availability (ppm)
a
ab
bc
abc
c
Control
0.5% Biochar
1.0% Biochar
2.0% Biochar
4.0% Biochar
Biochar concentration in soil (w/w)
F= 9.77, P< 0.001
Hyphal lengths
B
AMF hyphal length (m cm-3 soil)
a
a
ab
b
c
Control
0.5% Biochar
1.0% Biochar
2.0% Biochar
4.0% Biochar
Biochar concentration in soil (w/w)

Materials and Methods

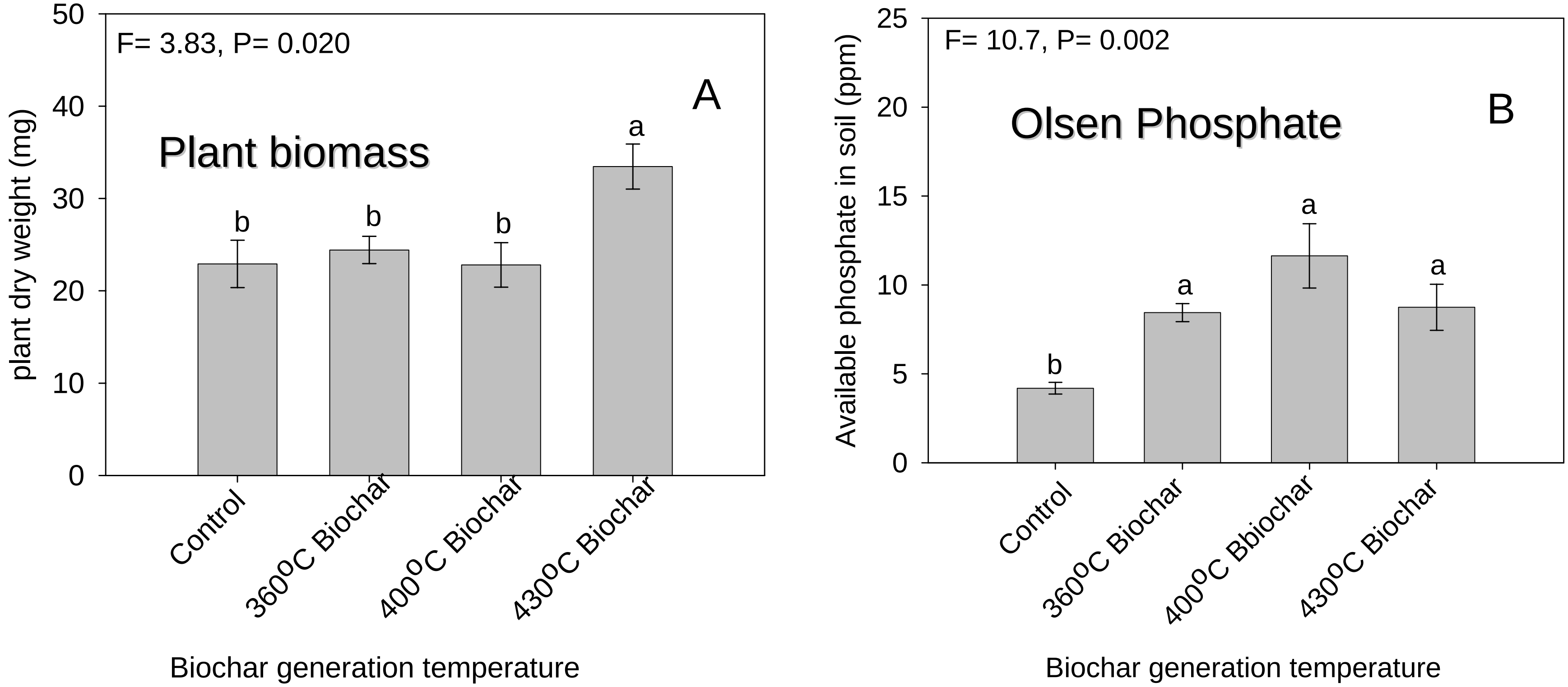
Experiment 2: different generation temperatures

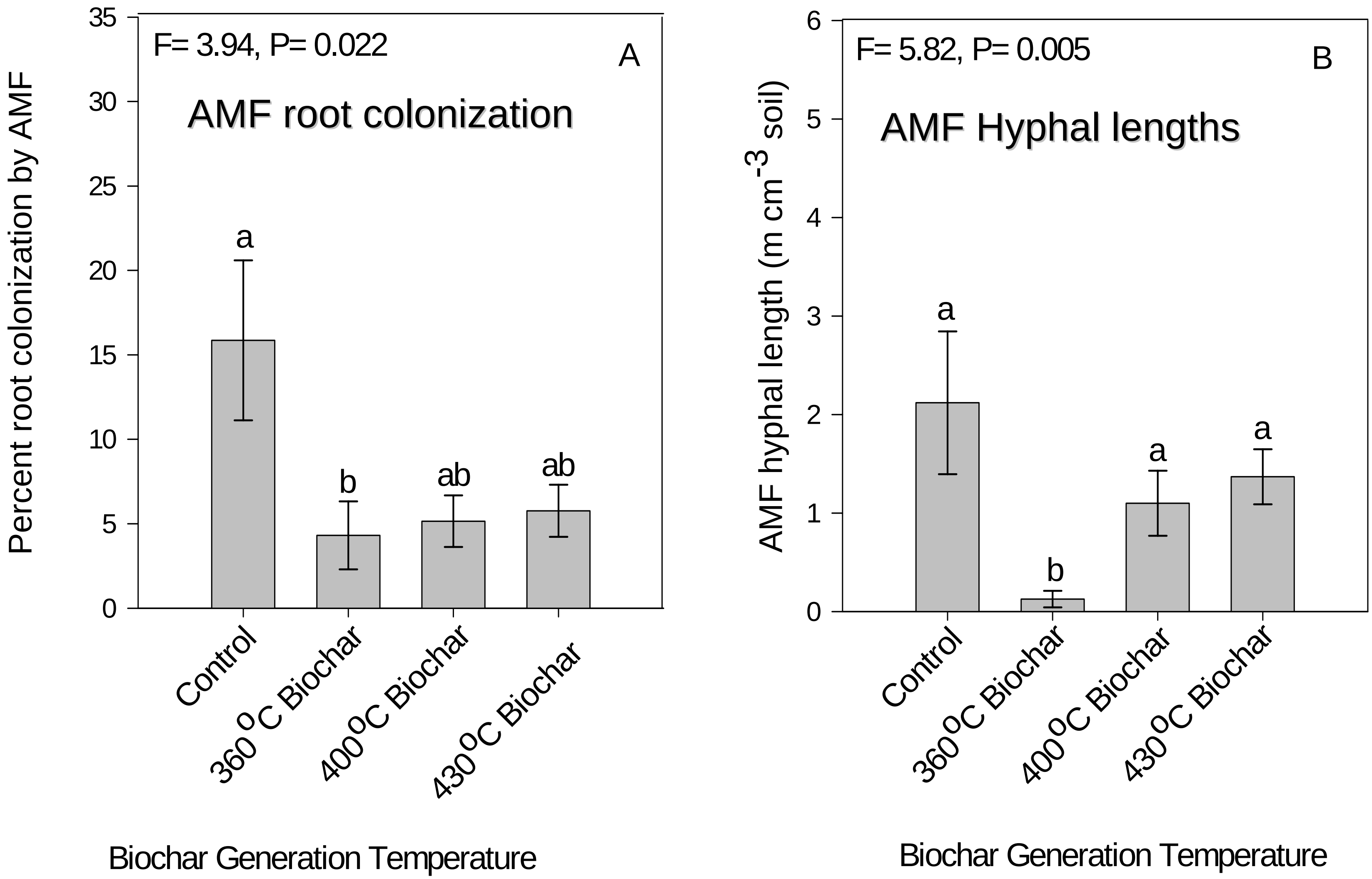
- Added 360^{o} C, 400^{o} C and 430^{o} C Peanut shell BCs to Nyack river soil at a rate of 10% by soil volume
  - MIP low in this soil



- *Plantago lanceolata* grew in the BC-treated soils for 30 days in growth chamber

Results: Different BC generation temperatures





F= 3.94, P= 0.022
A
AMF root colonization
Percent root colonization by AMF
35
30
25
20
15
10
5
0
a
b
ab
ab
Control
360 °C Biochar
400 °C Biochar
430 °C Biochar
Biochar Generation Temperature
F= 5.82, P= 0.005
B
AMF Hyphal lengths
AMF hyphal length (m cm-3 soil)
6
5
4
3
2
1
0
a
b
a
a
Control
360 °C Biochar
400 °C Biochar
430 °C Biochar
Biochar Generation Temperature

Materials and Methods

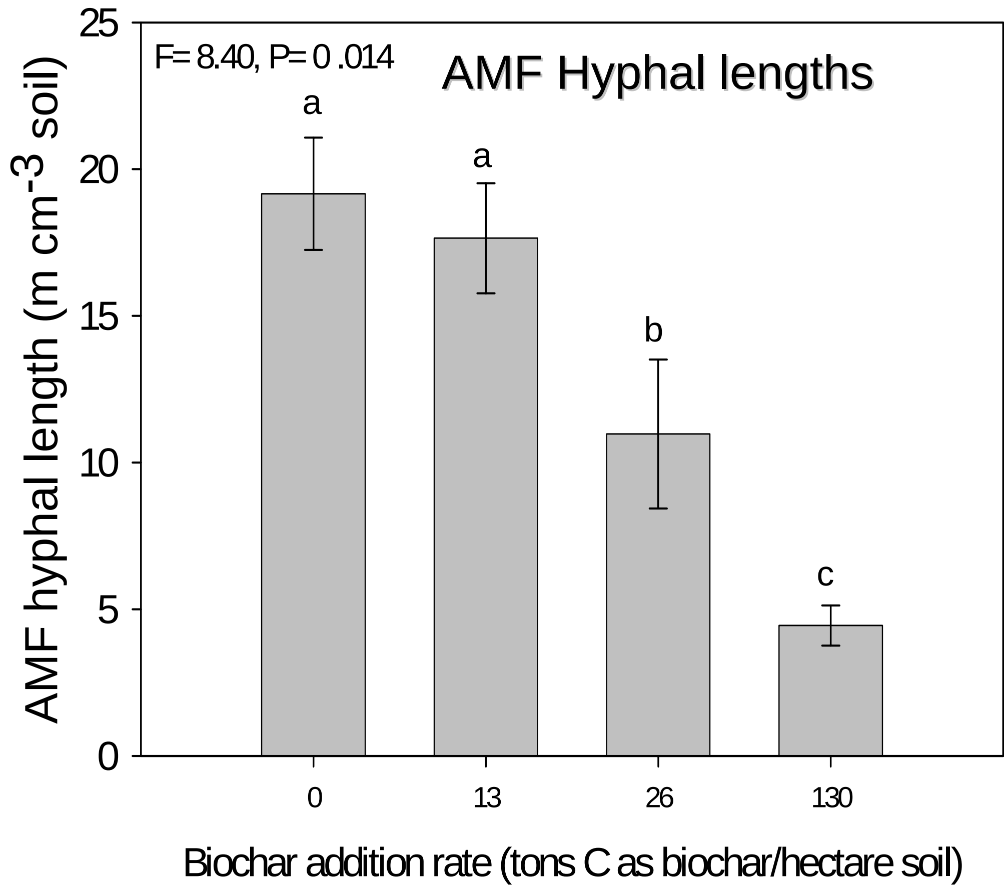
Experiment 3: Colombian Field Experiment

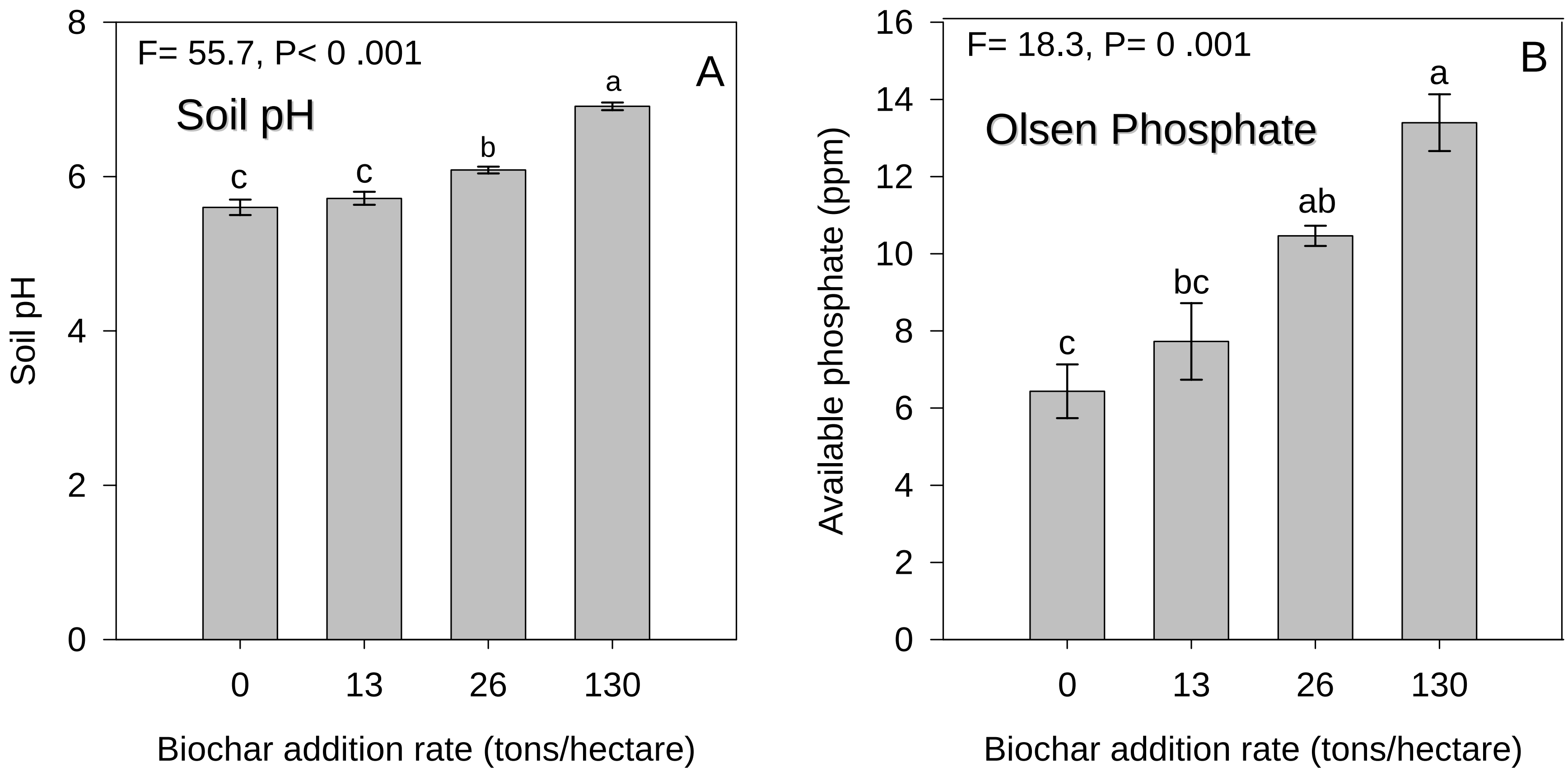
- BC made from local Mango (*Mangifera indica*) wood was tilled into a Colombian tropical savannah soil at 3 different rates
  - BC applied in December 2004

- Soil samples taken in August 2005

(Julie Major)

Results: Colombia field experiment




F= 55.7, P< 0 .001
A
Soil pH
Soil pH
Biochar addition rate (tons/hectare)
0
13
26
130
0
2
4
6
8
c
c
b
a
F= 18.3, P= 0 .001
B
Olsen Phosphate
Available phosphate (ppm)
Biochar addition rate (tons/hectare)
0
2
4
6
8
10
12
14
16
c
bc
ab
a

Conclusions

- Results show multiple BCs have a strong ability to influence AMF hyphal production in soils
  - Do not know if influences are direct or indirect
- Effects on other AMF and plant response parameters are less conclusive
  - Generally neutral root colonization responses in first experiment
  - Largely neutral plant growth responses in first two experiments

- Results demonstrate importance of choice when attempting to use BCs to stimulate AMF activity
  - Choices include generation temperature, application rate and parent material

- BCs can negatively affect AMF abundance, while leading to increases plant biomass production
  - BC influences on soil may reduce plant dependence on AMF, thus their abundances decline

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