Biochar & Carbon Concerns in the Urban Forest

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Bartlett Tree Research Laboratories (West)

2015 Texas ISA

Tree-nectivity
Re-Connecting with the Environment

isa TEXAS Texas Chapter International Society of Arboriculture

BARTLETT Tree Research Laboratories
SCIENTIFIC TREE CARE SINCE 1907

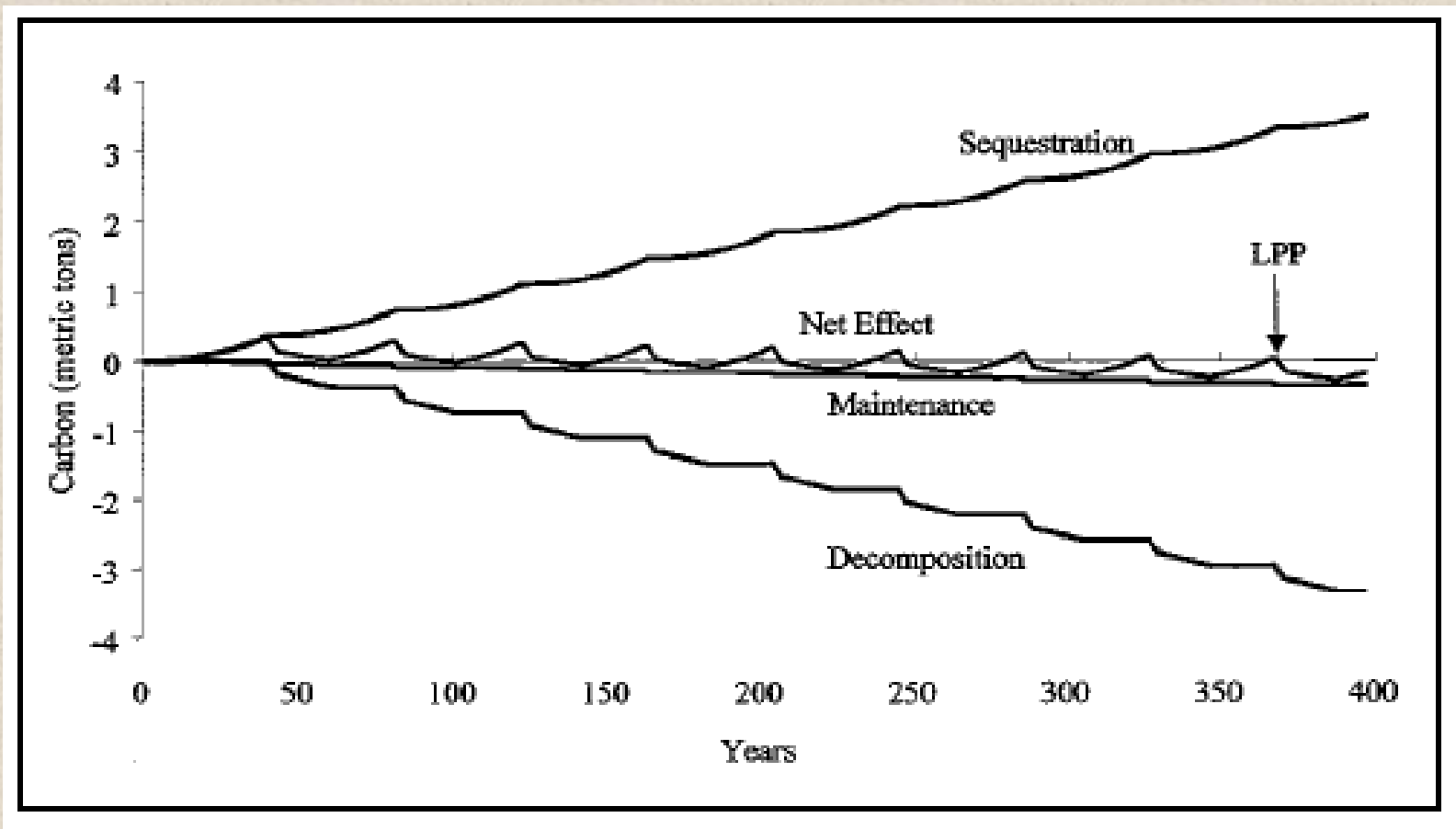
Biochar in Soil Management

- Landscape plants and climate change
- Biochar in landscape plant management
  - What is it?
  - What do we know about biochar and plants?
  - Current research on biochar and disease.

Can landscape plants help reduce atmospheric CO_2?

- Through direct **carbon sequestration**?
  - Probably not a major benefit
- Why not?
  - Decomposition releases CO_2 back into atmosphere
  - Maintenance related to tree also emits CO_2
    - Equipment, vehicles, manufacture of PHC materials

Carbon sequestration by urban trees



Nowack et. al. Journal of Arboriculture 28(3): May 2002

Factors that affect the Last Positive Point (LPP)

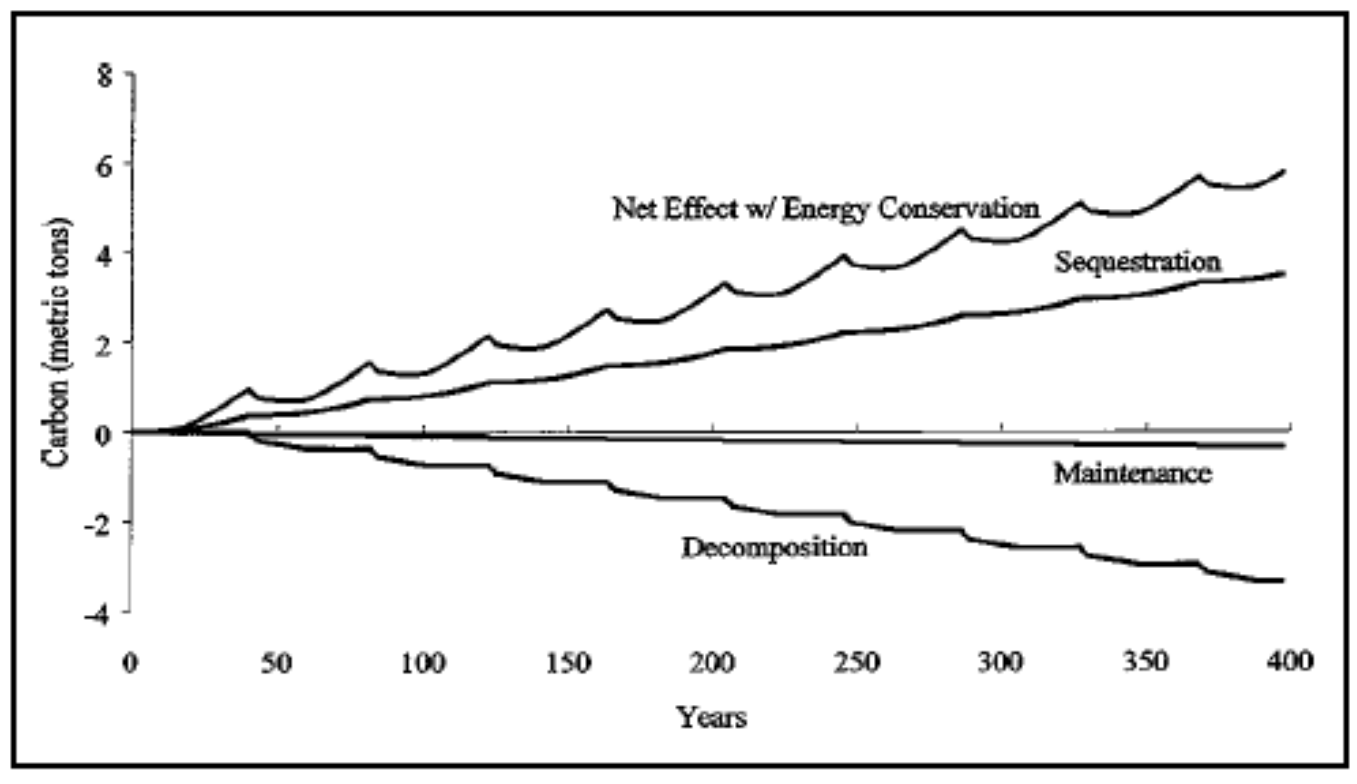
- Life span and size of tree species
  - Longer life-span reduces emissions from decomposition and tree replacement
- Fate of removed wood
  - Mulch, landfill, furniture?
- Maintenance intensity

	Last positive point	
Maintenance	No life span effect	Increased life span*
Minimal	680 years (17 generations)	100 years (5 generations)
Conservative	360 years (9 generations)	360 years (9 generations)
Intensive	240 years (6 generations)	540 years (9 generations)

*Minimal maintenance = 20-year life span; conservative maintenance = 40-year life span; intensive maintenance = 60-year life span.

Can landscape plants help reduce atmospheric CO_2?

- If not through sequestration, possibly through avoidance—*energy conservation*



Bottom line on Urban Forestry and Carbon Sequestration:

- Larger maturing trees will be most beneficial
- Extending lifespan will increase benefits
- Minimizing maintenance balanced with extending lifespan
- If possible, salvage wood for permanent uses
  - Furniture, biochar

Landscape professionals can help reduce carbon emissions

- Use lower emission vehicles, equipment
- More efficient scheduling, routing
- *'An ounce of prevention….'*
  - Proper planting practices
  - Soil management
  - Early structural pruning
  - IPM- monitor, diagnose, treat early
- **Or, possibly, add another factor to the equation…**

Incorporation of Biochar into soils

- Soil organic matter is already one of the largest pools of carbon, but is eventually decomposed to release CO_2
- Biochar is a stable form of carbon that will not be released for *hundreds or thousands of years*.

Biochar can help carbon picture in multiple ways

- Adds recalcitrant carbon to soil (long-term sequestration)
- Improves tree growth (size and age)
- Retains nutrients (reduced inputs)
- Increases disease resistance (reduced maintenance)

What is biochar?

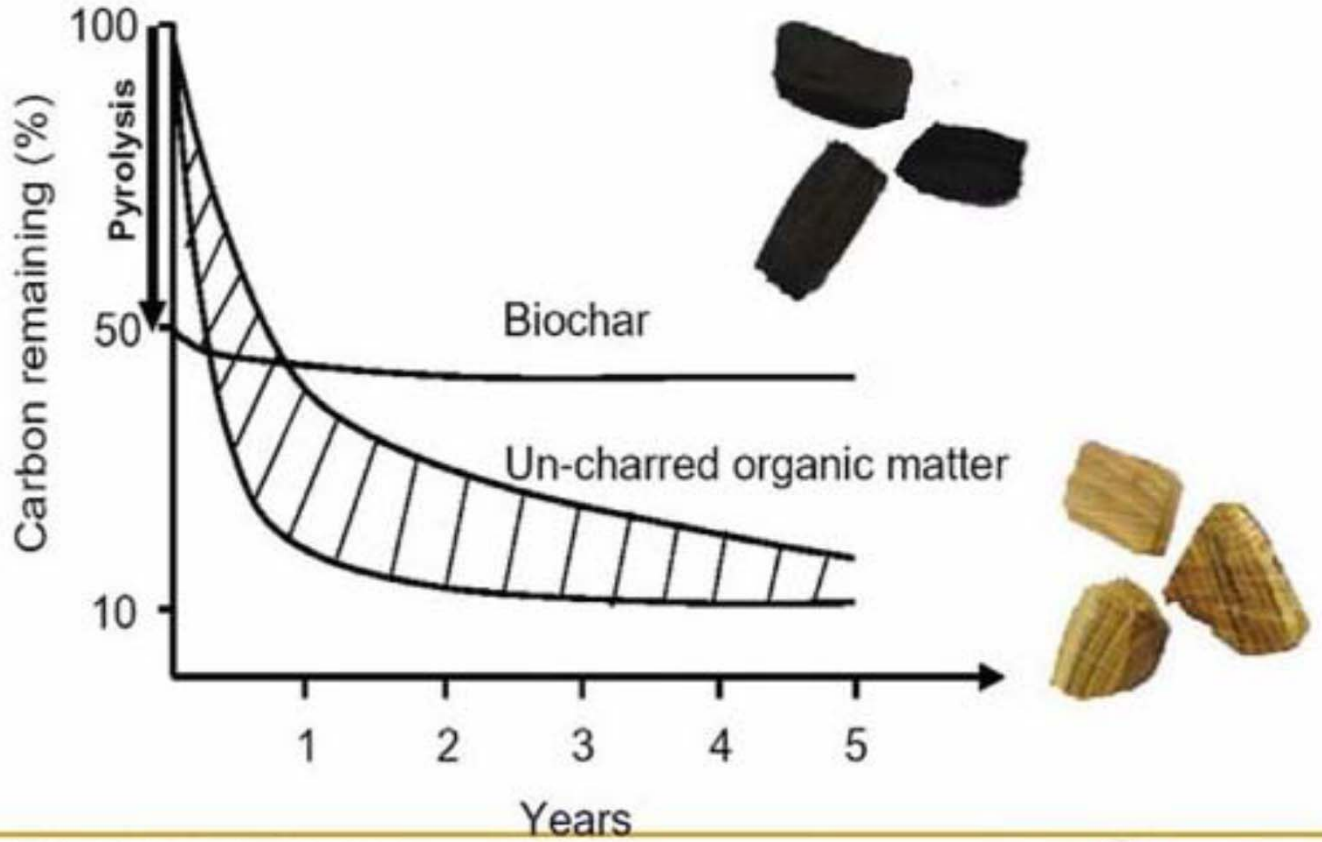
- Product of pyrolysis of organic matter
  - Source of energy from exothermic heat
  - Oils and gasses collected and used as fuel
- Mimics ancient practices discovered in nutrient poor tropical soils.
  - Terra preta soils (Dark earth), 2,000+ years

Ancient cultures burned organic waste and buried ‘biochar’

- Small patches of fertile soil in otherwise low-productive areas
- Linked to soil content of “black carbon” or biochar particles

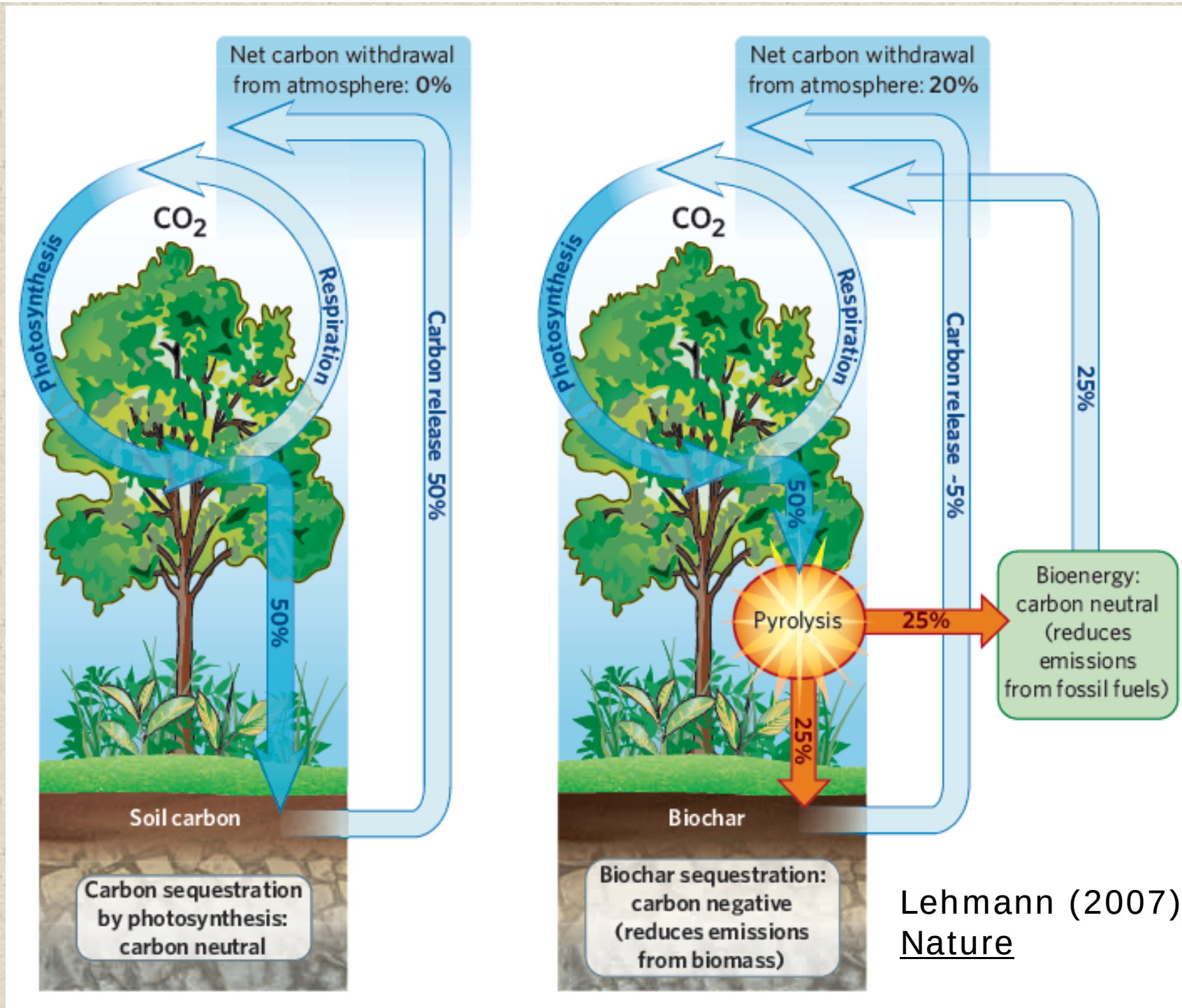
www.biochar-international.org/biochar/soils

The essential stability of biochar



Lehmann et al., 2006, *Mitigation and Adaptation Strategies for Global Change* 11, 403-427

Cornell University



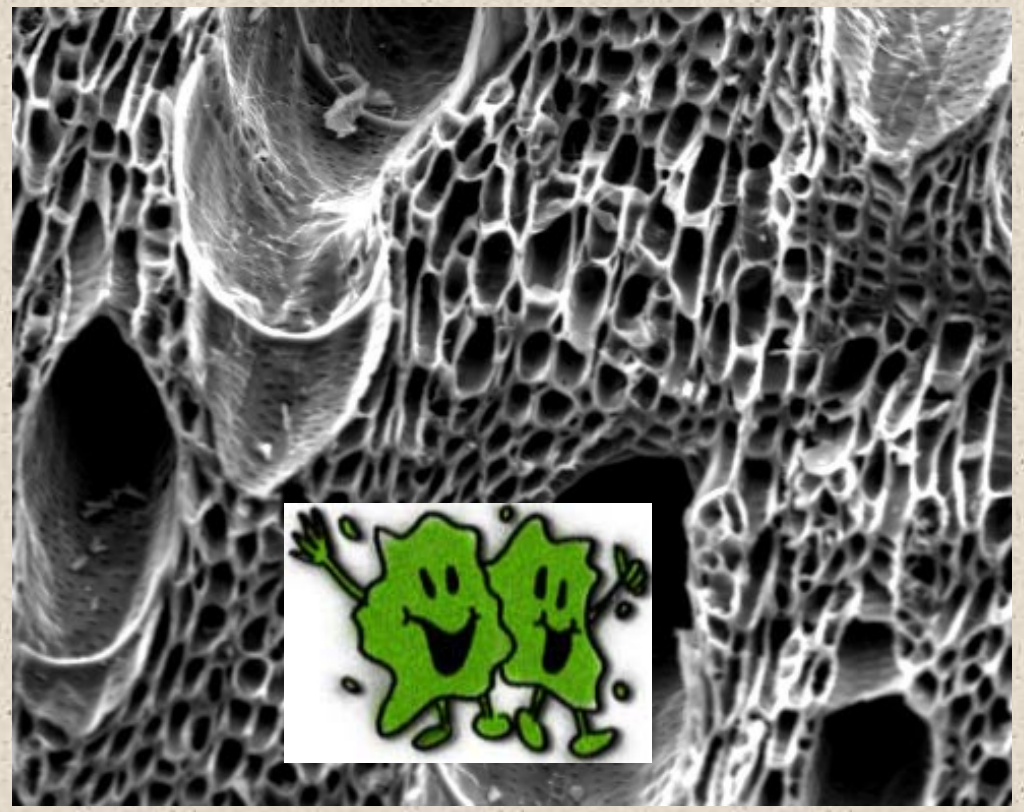
Lehmann (2007) Nature

Properties of Biochar will vary depending on...

- Parent Material
  - Forestry slash, crop residue, chicken waste
- Cooking Temp and Duration
  - Remaining volatiles
  - Ash content

www.biocharproject.org
www.biochar-international.org/biochar/soils

Variable surface texture and high porosity are two key attributes



Habitat for beneficial microbes

Plenty of research exists regarding biochar, soils, and agriculture

- Both biochar and charcoal amendments to soil have been practiced for millennia and studied for decades.

❖Agronomy, food security
❖Soil quality
❖Water quality, run-off
❖Climate Change

www.biochar-international.org/biochar/soils

An incomplete list of potential benefits....

- ↑ Overall plant growth
- ↑ Nutrient retention
- ↑ Cation Exchange
- ↑ Soil drainage (heavy)
- ↑ Water holding (sand)
- ↑ Beneficial bacteria
- ↑ Mycorrhizal assoc.
- ↑ Carbon sequestration
- ↑ Disease Resistance

- ↓ Nutrient run-off
- ↓ Pesticide run-off
- ↓ Chemical input
- ↓ Soil bulk density
- ↓ Atmospheric CO_2
- ↓ Other GHG's
- ↓ Pest Management

Lot's of research on field crops, not as much on trees

- Important Tree-Related Findings
  - Increases overall growth
  - Increased survival and growth of seedlings
  - Decreased nitrate leaching
  - Increased mycorrhizal colonization of roots
  - Shift in microbial population to beneficials
  - Reduced impact of *Phytophthora*

Current / Recent research on Biochar and landscape plants

- Planting, survival and growth
- Street tree soil amendment
- Simulated “tree pit” experiments
- Disease resistance (systemic)
- Niche uses:
  - Bare root planting, rain gardens, green-roof substrate

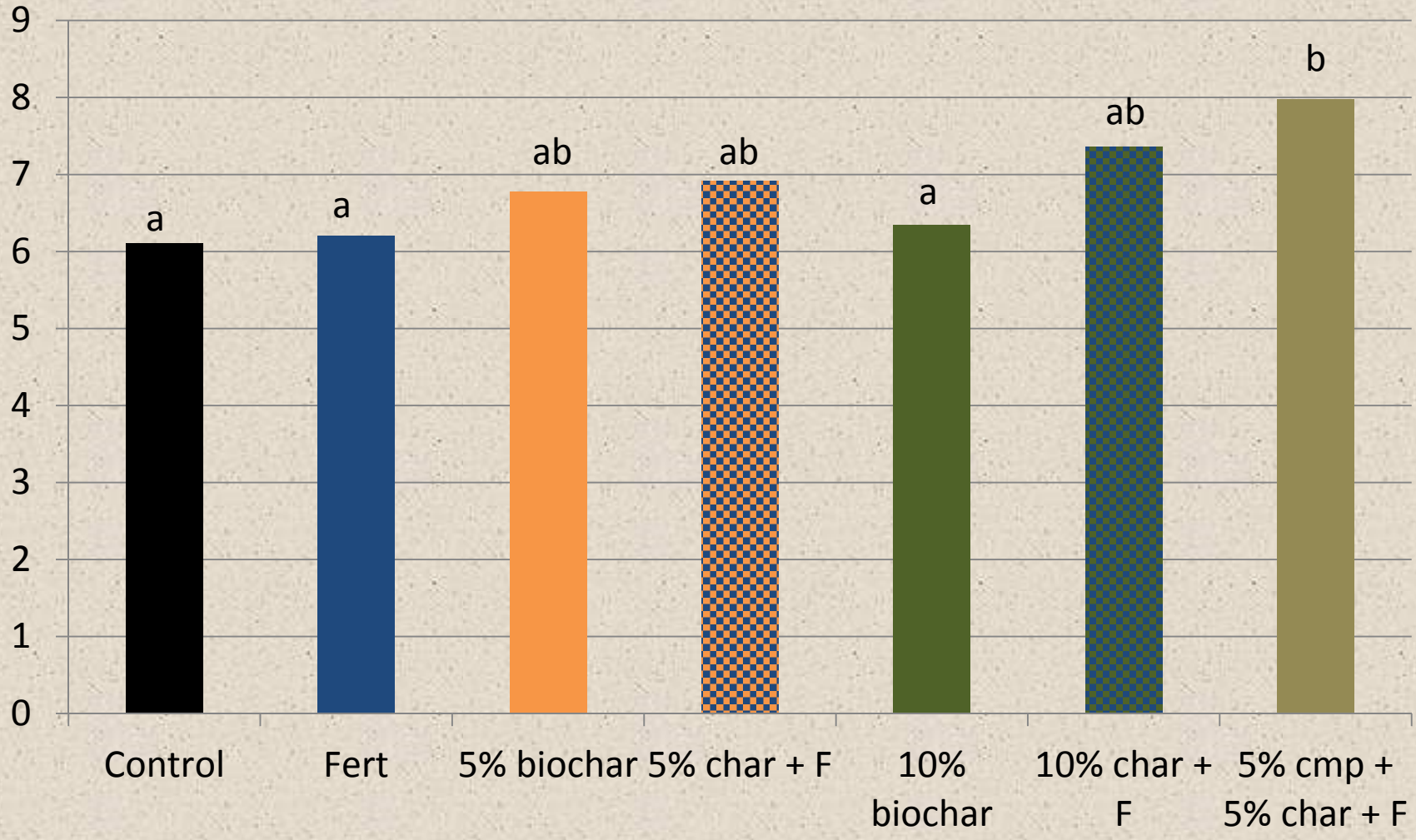
Biochar trials at Bartlett Research Labs Charlotte, NC

Simulated planting pits of approx. 144 cu ft. – cherry, azalea, sneezeweed.

Early benefits seen in soil nutrient retention

No major growth or condition differences after two years.

CEC highest in char+compost+fert



UK Research- Planting Trials

Horse Chestnut Trial: plot after ground preparation and biochar application

Planting

After planting

Year 1 results

Treatment	Application rate (kg/m²)	Crown Coverage
Grow char	0.25	4.5cd
Grow char	0.5	4.3bc
Grow char	1	4.0b
Bamboo biochar	0.25	4.7d
Bamboo biochar	0.5	3.3a
Bamboo biochar	1	3.3a
Control	0	3.5a

Biochar

Control

PEAR TRANSPLANT TRIAL (PYRUS COMMUNIS 'CONFERENCE')

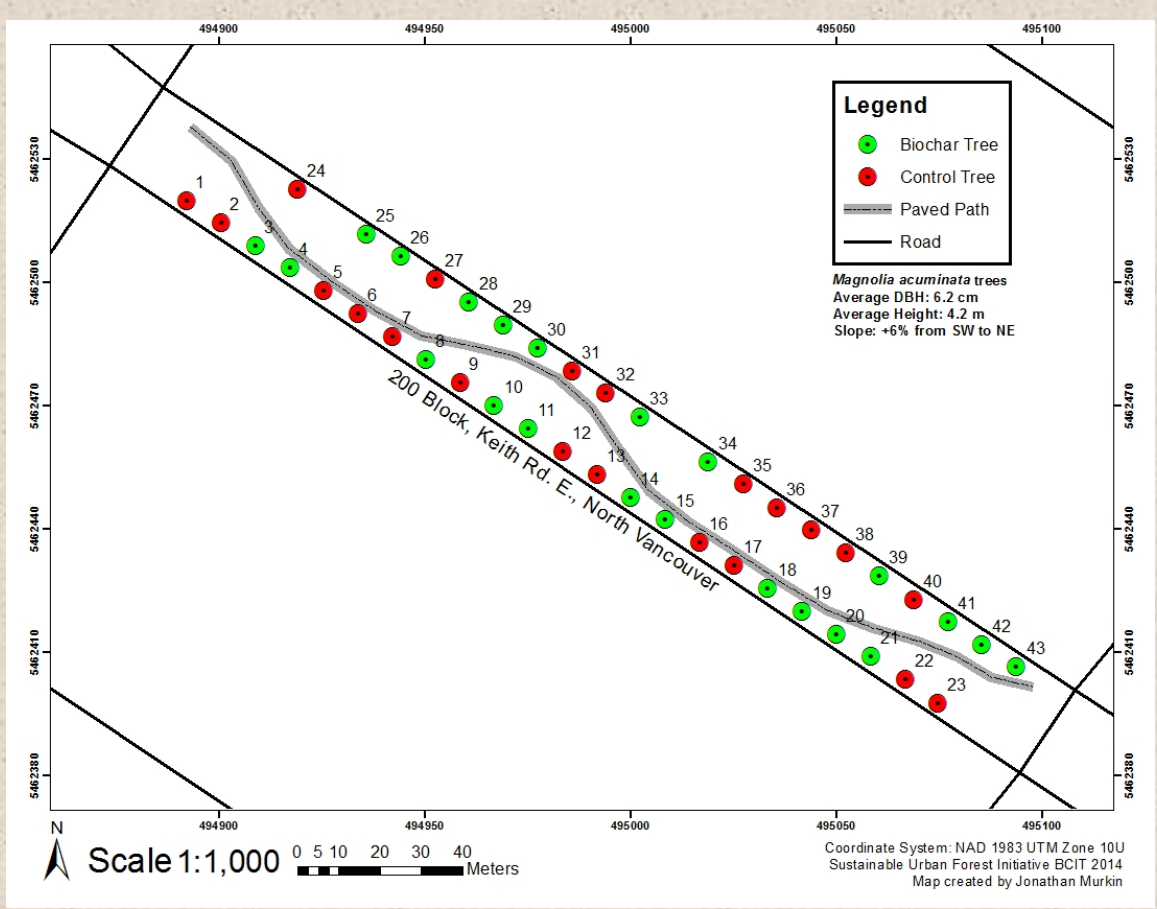
TREATMENT	SPAD	PI	Mortality
Control (No Amendment)	38.7	6.2	20%
Molasses Pellets	42.3	7.1	0
Biochar	44.5	8.2*	0
Molasses Pellets + Biochar	49.9*	7.2	0
Organic BOOST	50.3*	11.1*	0
Organic BOOST + Biochar	50.1*	10.0*	0

Street Tree Trials in Vancouver B.C.

- Boulevard Magnolia trees with or without biochar amendment
  - Soil injected suspension in water

2 years in:

- SPAD measures taken this summer (leaf 'greenness')
- Biochar trees were 'greener' on average
  - Too much variation for significance at this time.



Another on-going study with real tree pits in Chicago

The Morton Arboretum

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TREE FUND
Tree Research & Education Endowment Fund

Hyland Johns grant

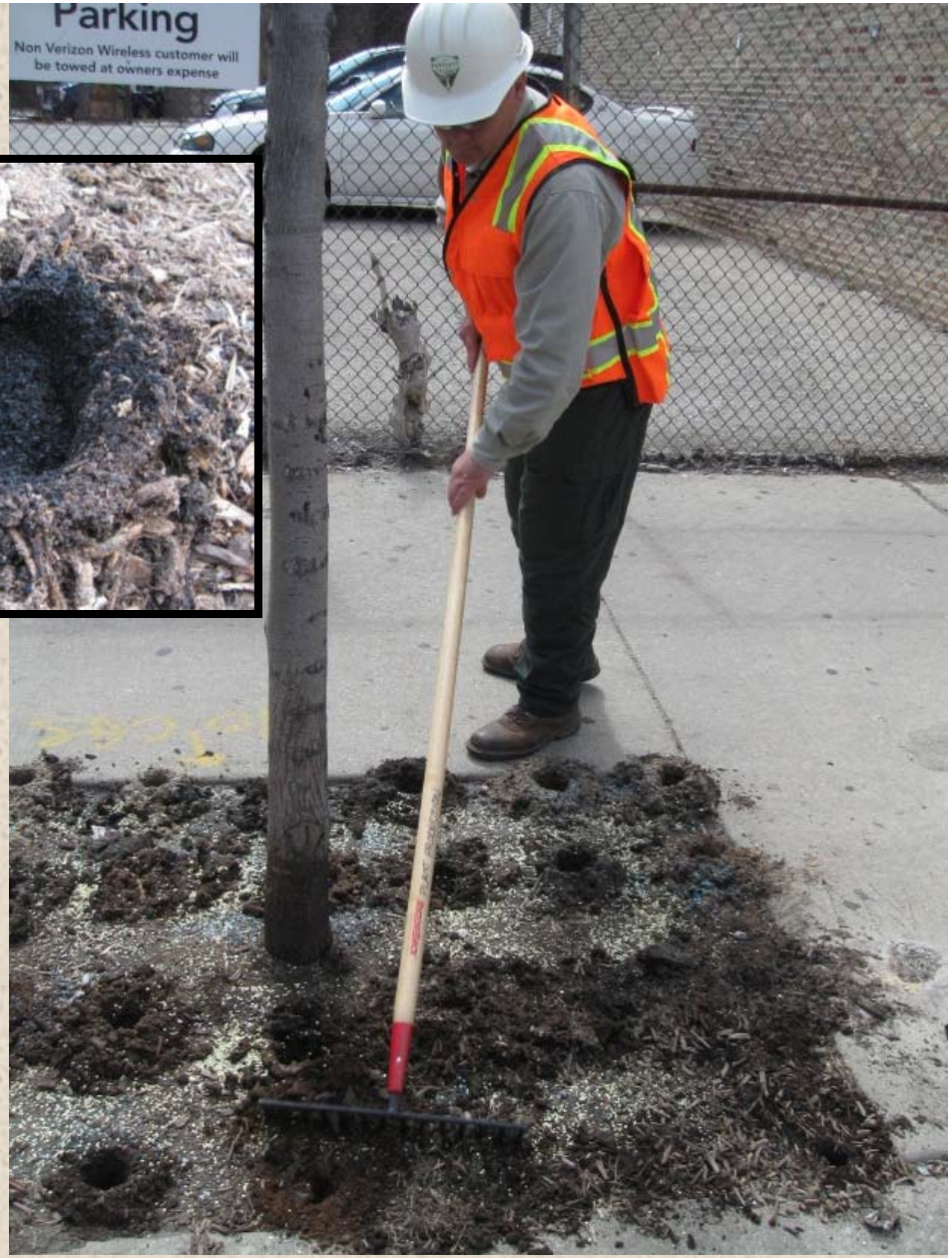
Urban site: City tree pits in Bucktown neighborhood in Chicago

BIOCHAR BUCKTOWN SOIL (0-20 CM) ON 04/04/11

1319 to 1643 N. Milwaukee Avenue, Chicago IL (Wicker Park)

- Auger used to drill holes for amendment.

(312) 440-7000


Parking
Non Verizon Wireless customer will
be towed at owners expense

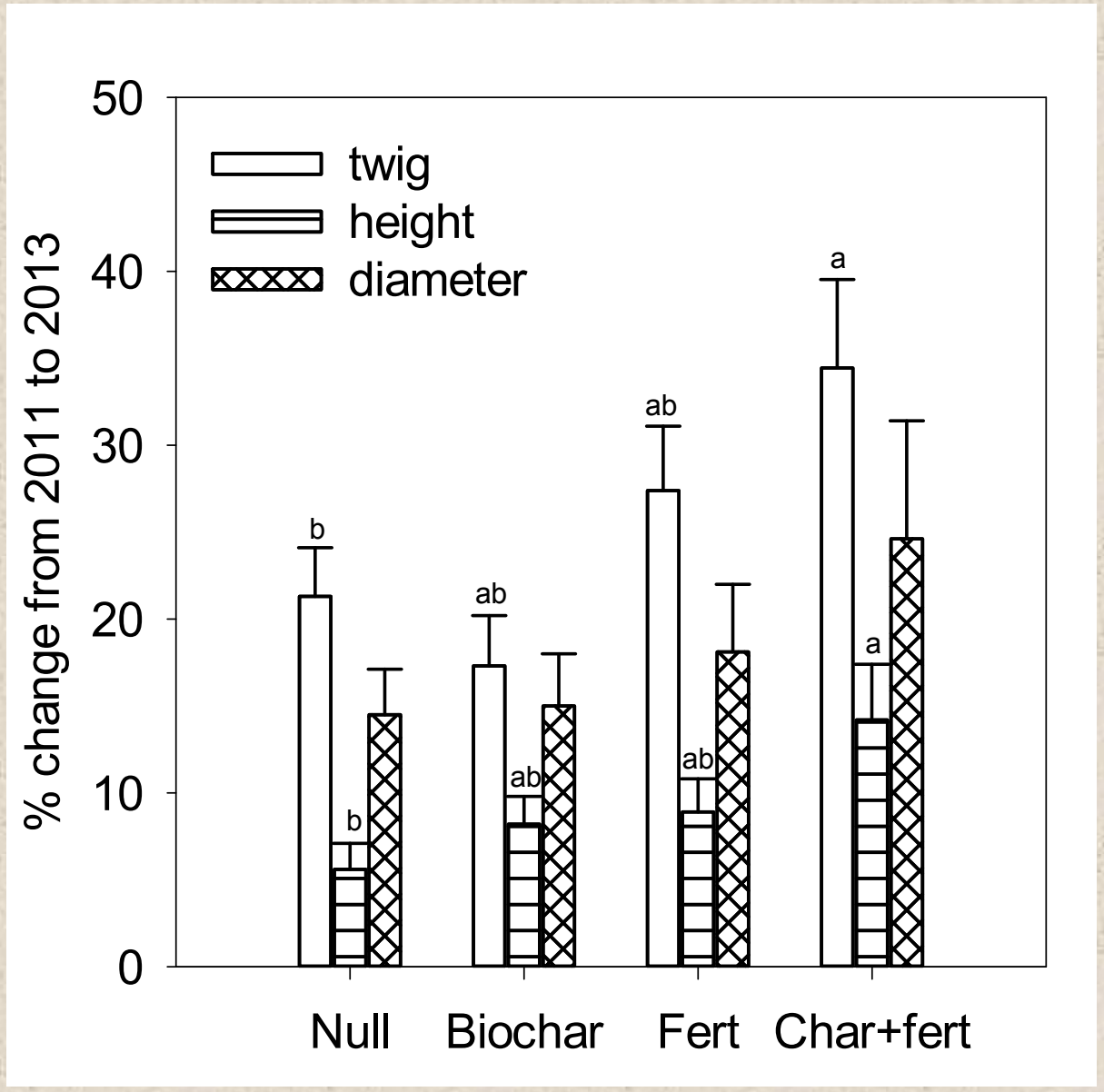
Tree growth

24-months following treatments (2013)

Twig (*P*=0.0118):
Char+fert > Null

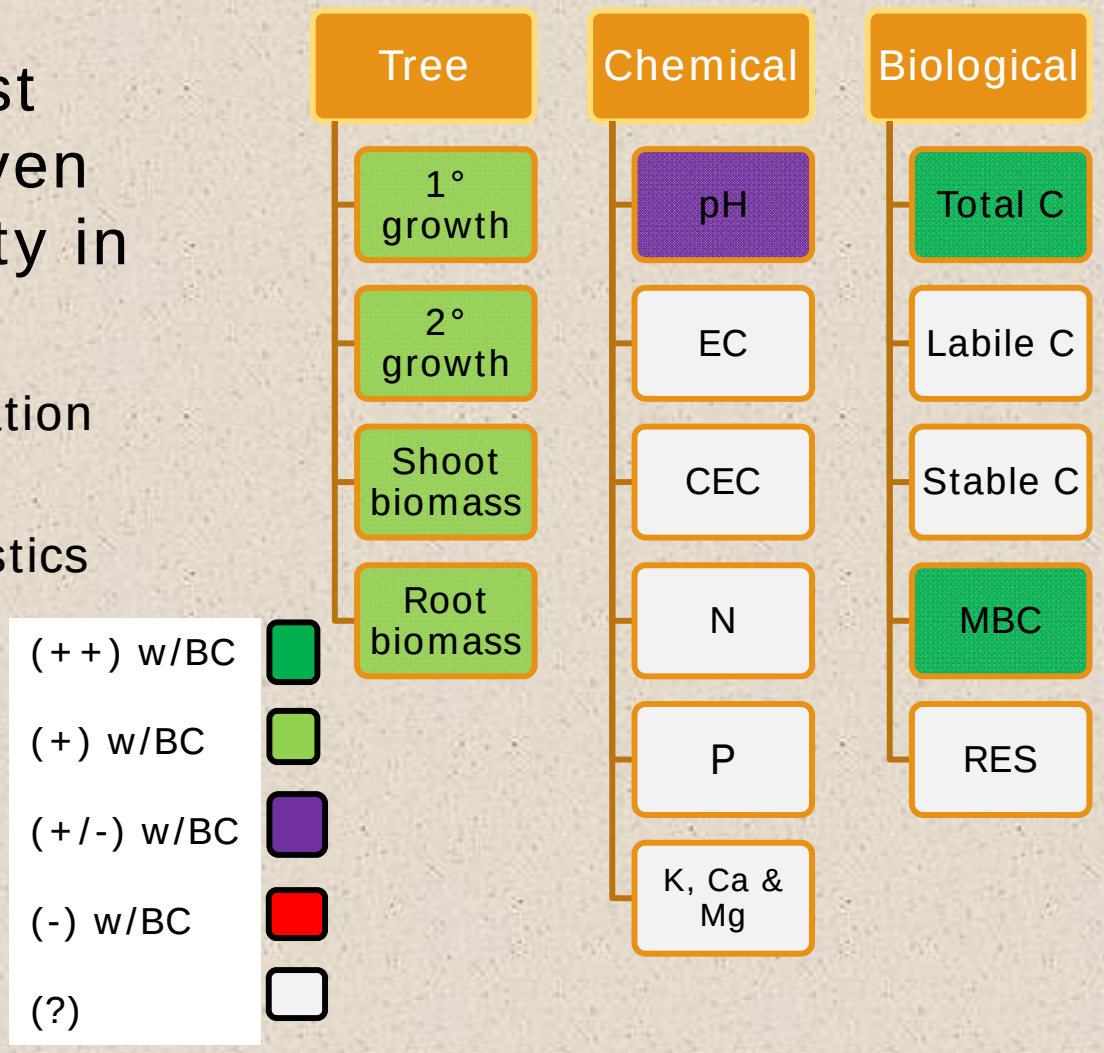
Height (*P*=0.0416):
Char+fert > Null

Diameter (*P*=0.3448)



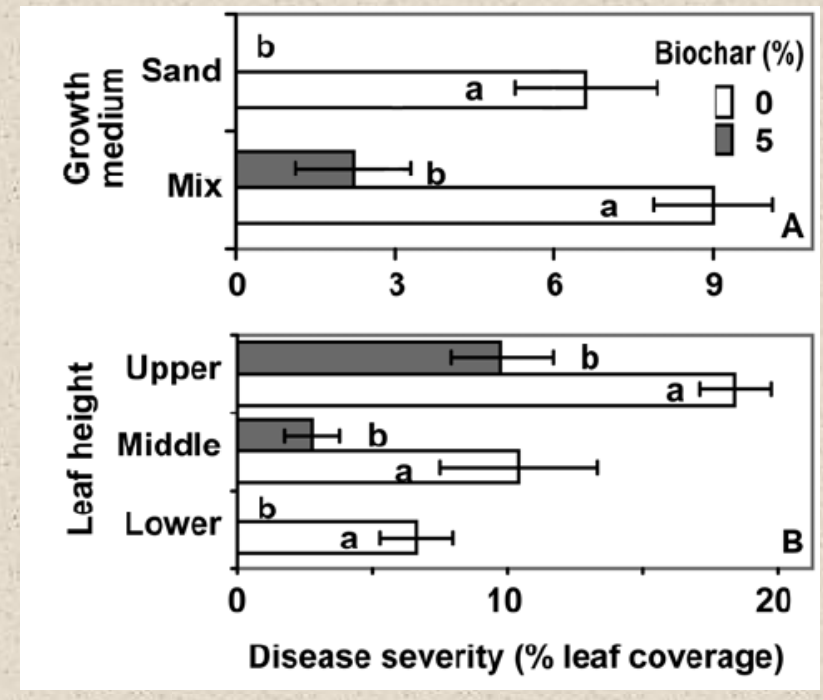
Results from Dr. Bryant Scharenbroch

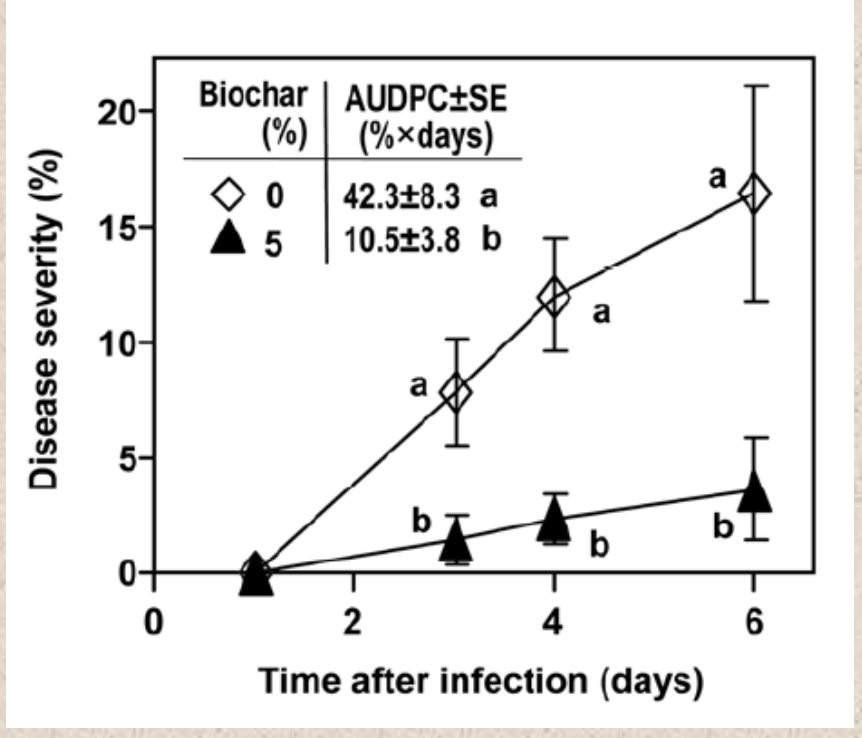
- Early results suggest improved growth even with major variability in samples
  - height and twig elongation improved
  - Several soil characteristics also improved
- Data collection ongoing



Biochar and plant disease

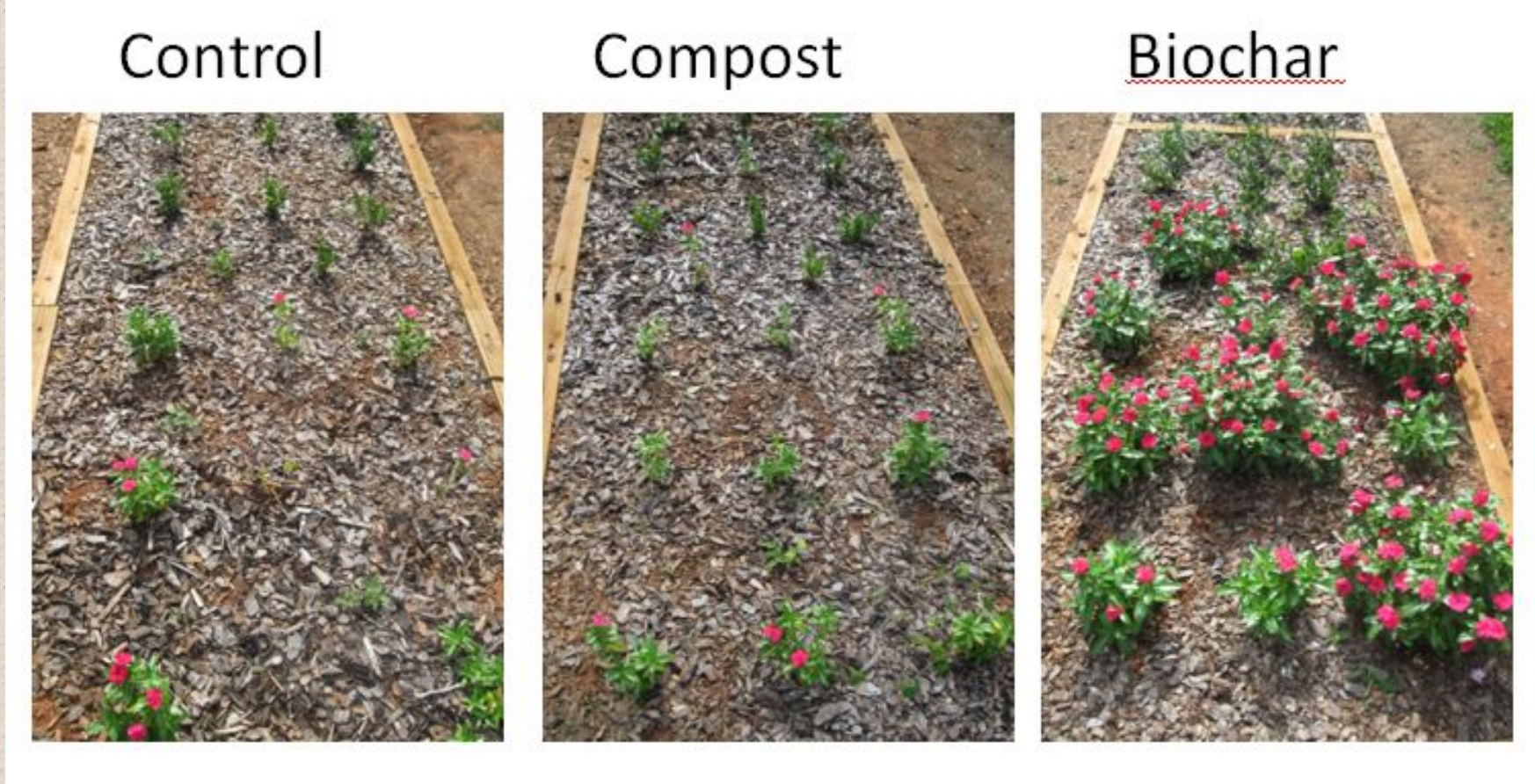
- Soil amendment has been shown to reduce disease in several situations
- Follow-up study showed important shift in soil microbial populations

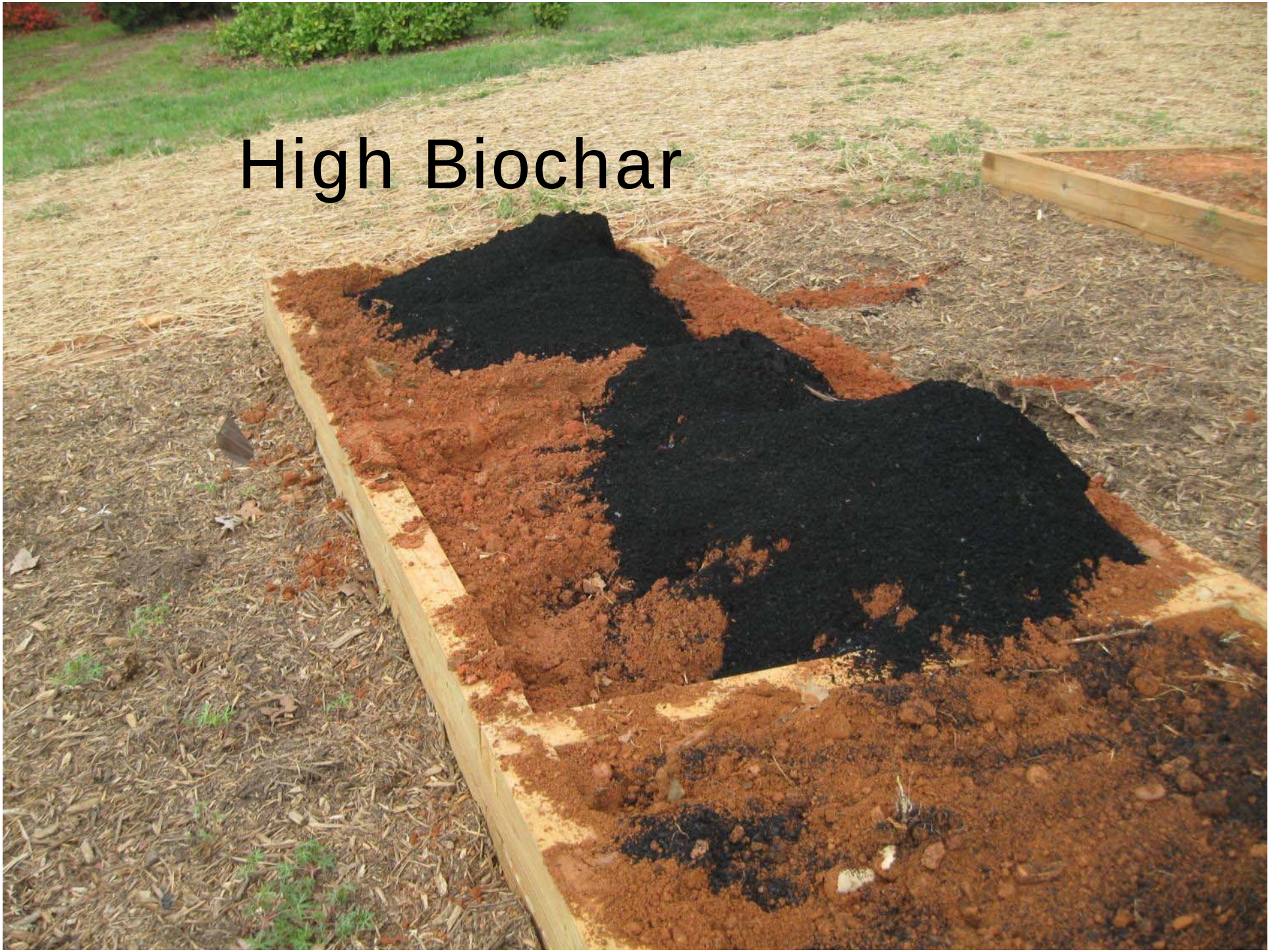




Elad et al (2010) Phytophathology

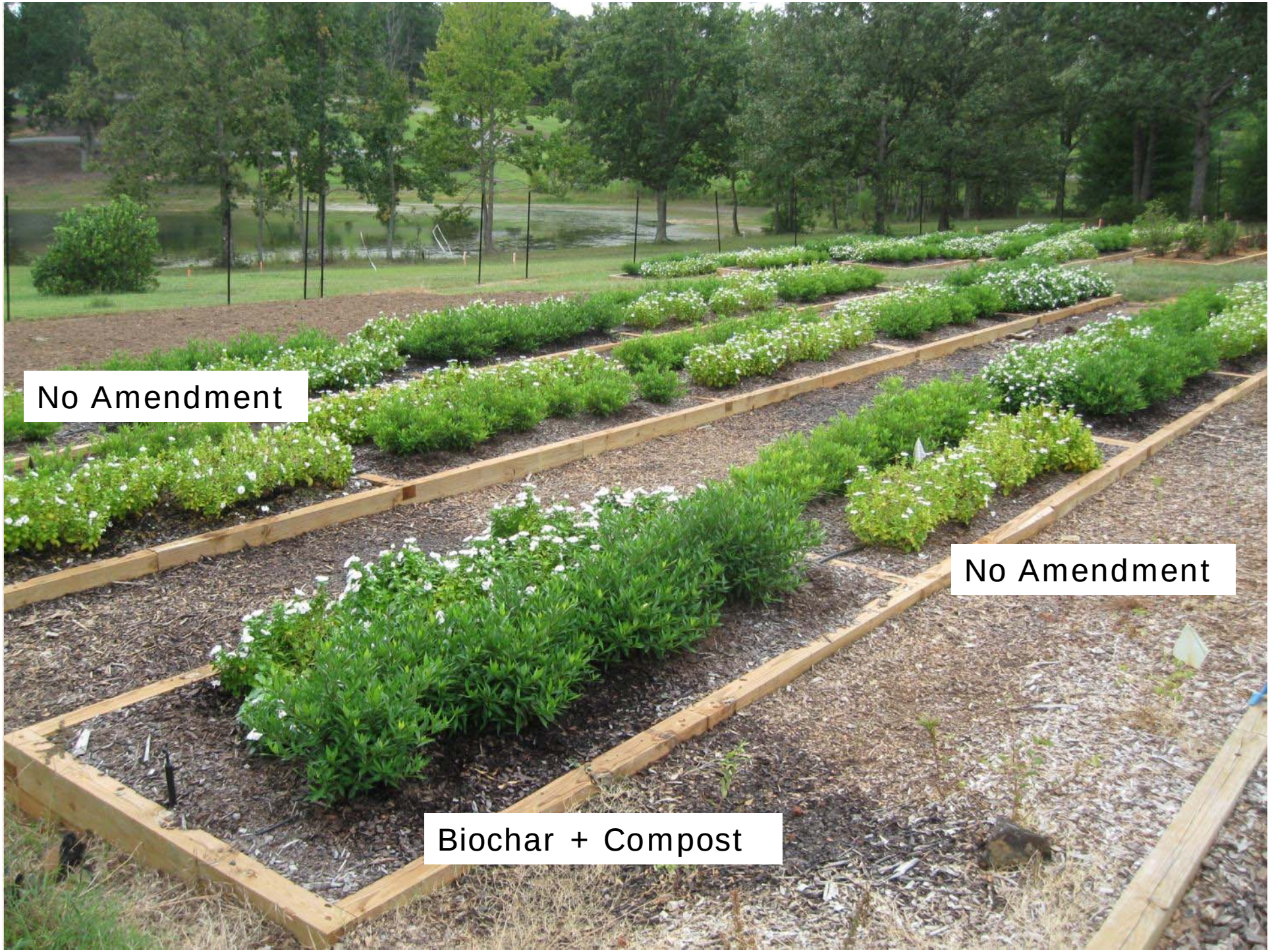
Biochar amendment appears to be helping in field trials w/ *Phytophthora*




High Biochar

After tilling

Biochar
No Amendment


No Amendment
No Amendment
Biochar + Compost

Biochar and Disease Resistance

- Controlled research: *Can biochar amendment reduce Phytophthora cankers on landscape tree species?*

- Oak Trial: *P. cinnamomi* on Red Oak
- Maple Trial: *P. cactorum* on Red Maple

Experimental procedure

- Tree seedlings planted in soilless potting mix with:
  - 0, 5, 10, or 20% biochar by *volume*, stem inoculated
  - 0% biochar + Agrifos® at drench rates, stem inoculated
  - 0% biochar, mock inoculation (control).
- Irrigated and Fertilized regularly to eliminate differences in nutrient retention, drainage and water holding capacity

Experimental Procedure

- Pathogen Inoculation:
  - Wound-inoculation
  - Site wrapped in moist sterile gauze, parafilm, aluminum foil.
  - Pathogen isolated from ‘bleeding’ canker of mature oak or maple

Results: Can biochar reduce disease progression or effects on physiology?

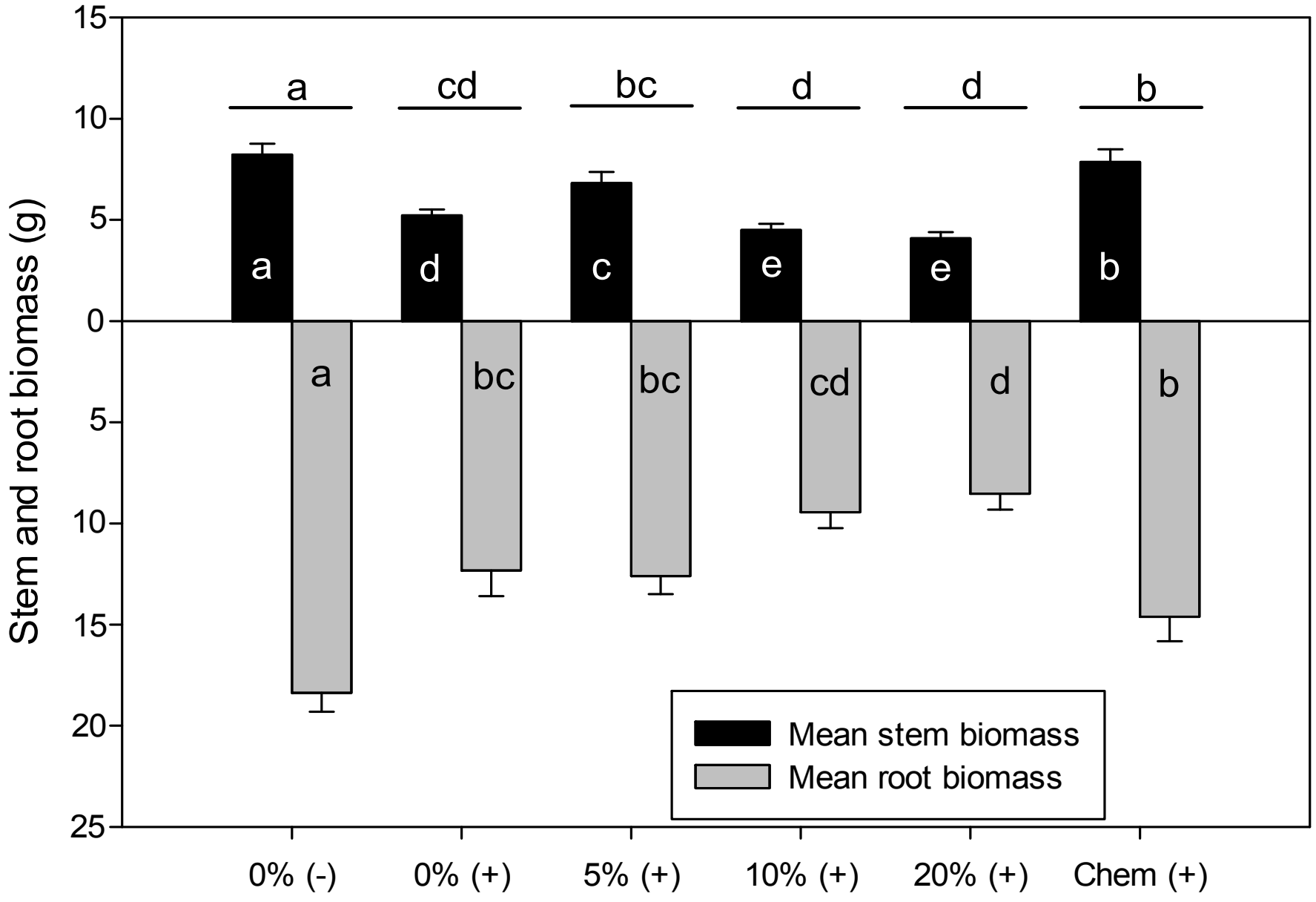
HortScience 47(12):1–5. 2012.

Biochar Amendment Increases Resistance to Stem Lesions Caused by *Phytophthora* spp. in Tree Seedlings

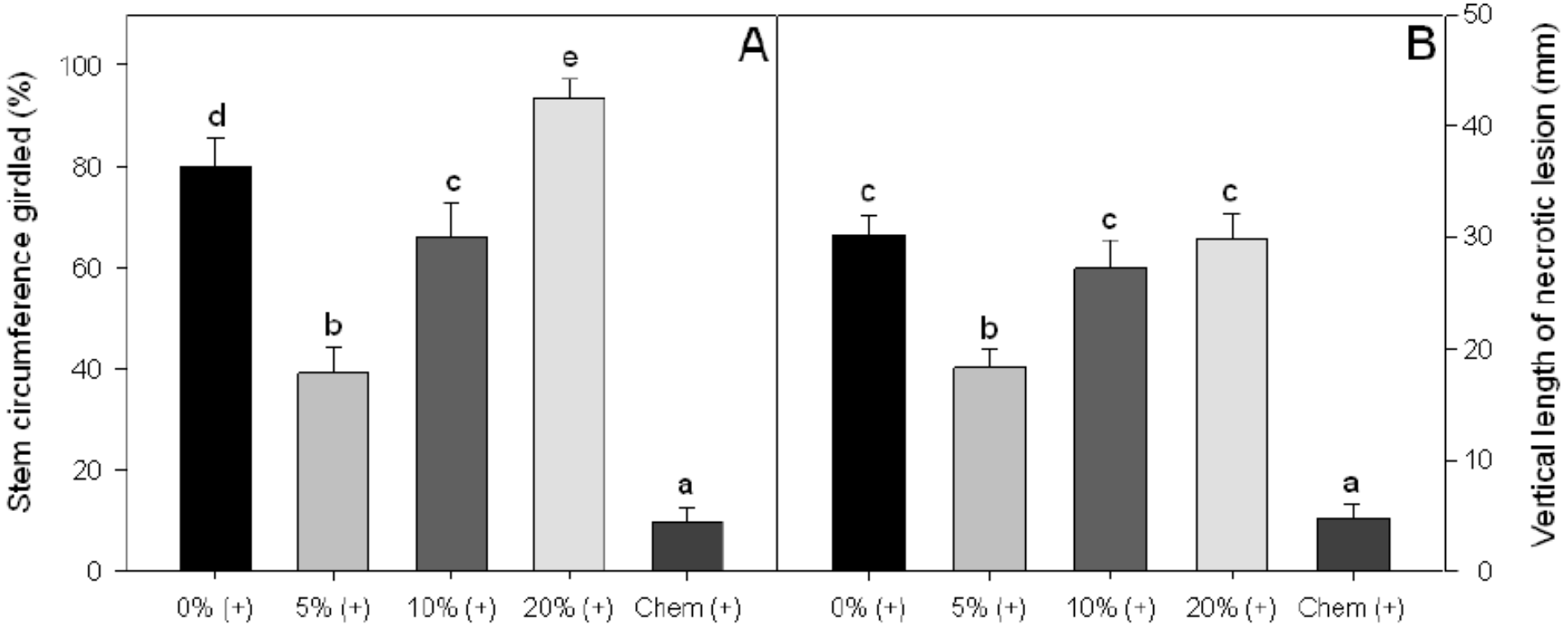
Drew C. Zwart and Soo-Hyung Kim[1]
Center for Urban Horticulture, School of Environmental and Forest Sciences, College of the Environment, University of Washington, 3501 NE 41st Street, Box 354115, Seattle, WA 98195

Maple

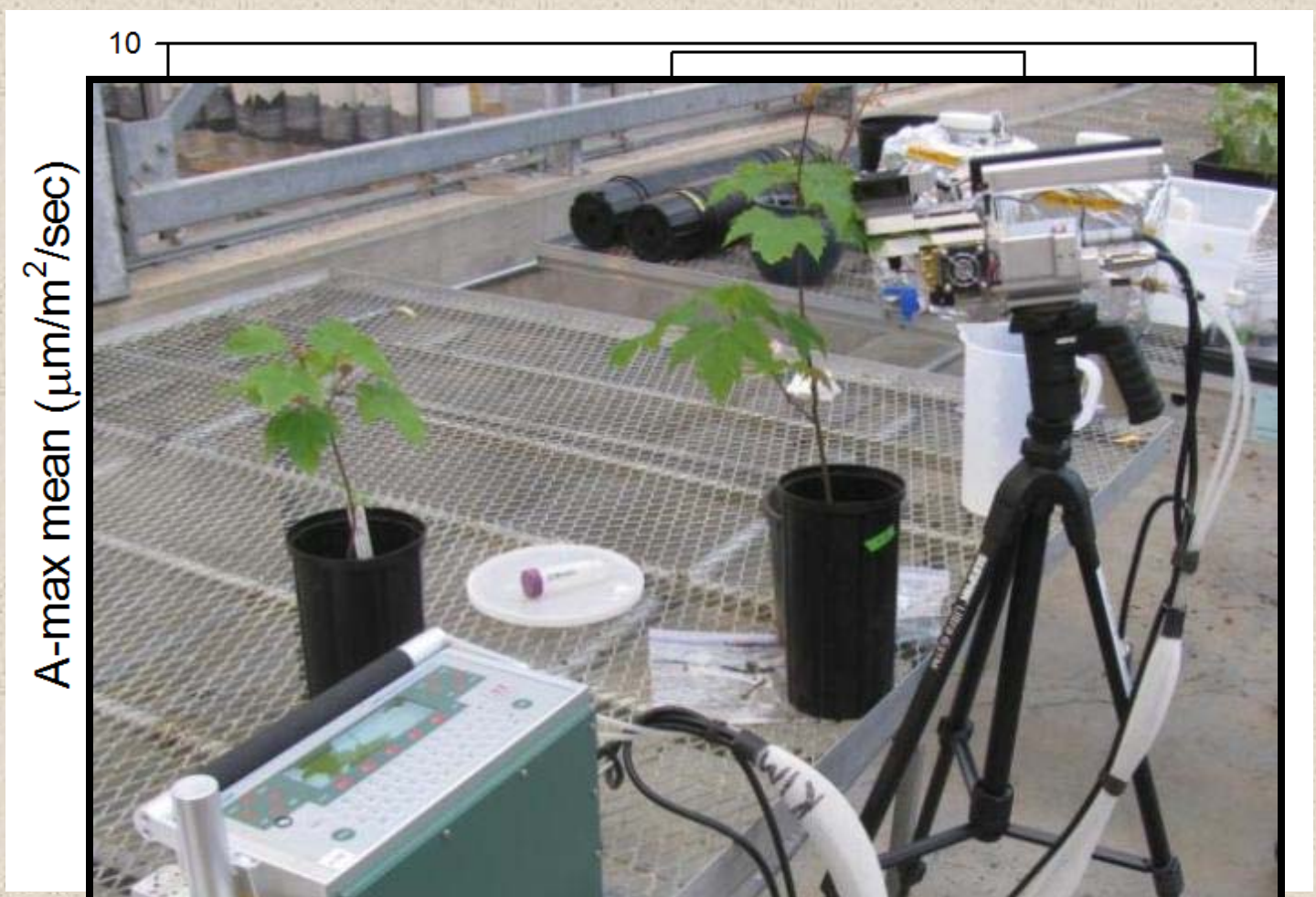
- Biomass:
  - Control > Chem. > 5 % > Inoc. > 10 + 20 %
- Lesion size:
  - Vertical growth: Chem. > 5 % > 10 %, 20 %, 0 %
  - Horizontal growth (girdling %): same


Stem and root biomass (g)
15
10
5
0
5
10
15
20
25
a
cd
bc
d
d
b
a
d
c
e
e
b
a
bc
bc
cd
d
b
Mean stem biomass
Mean root biomass
0% (-)
0% (+)
5% (+)
10% (+)
20% (+)
Chem (+)

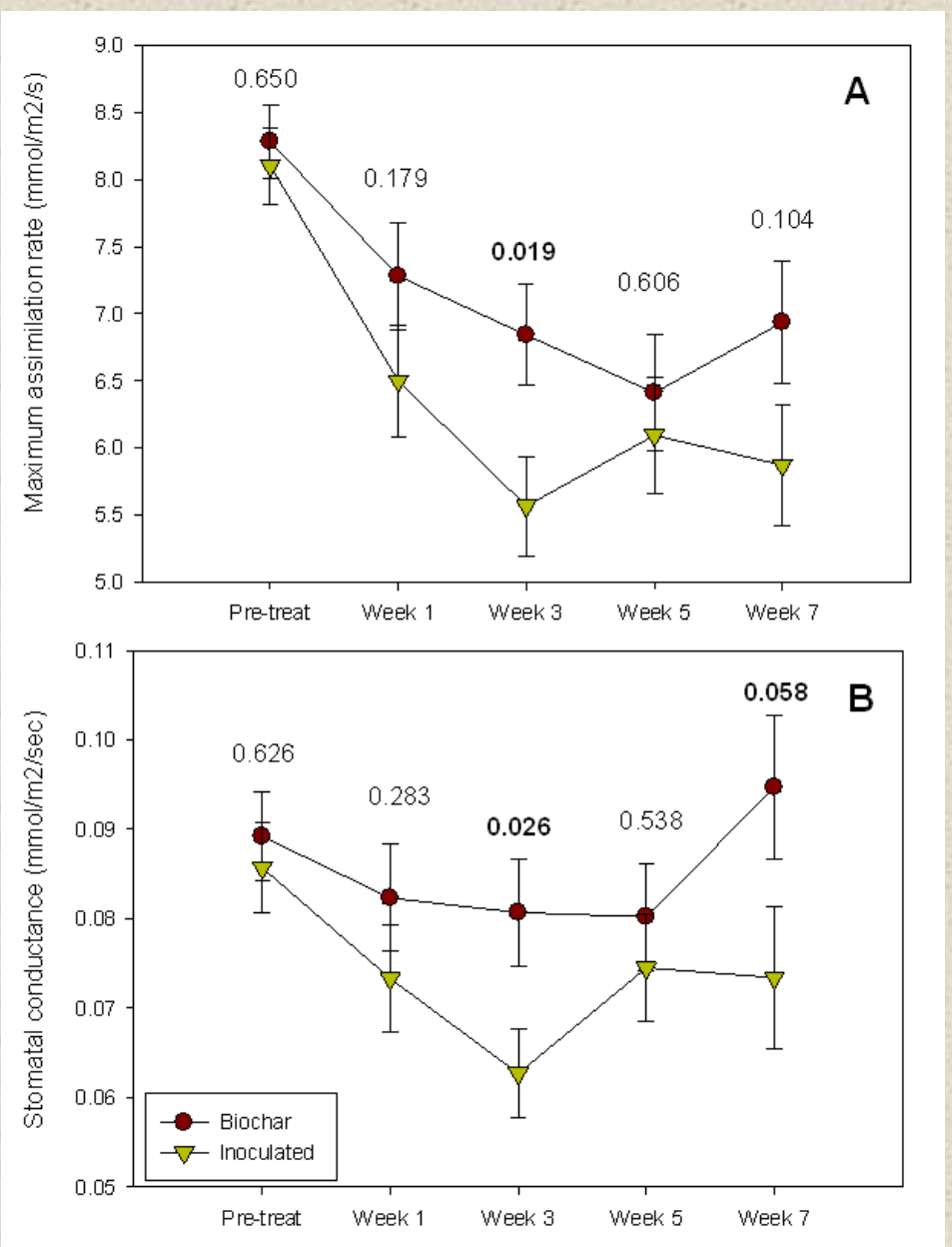
Girdling % and total vertical length were reduced by biochar compared to non-amended treatment



- Biochar did not reduce lesions as much as industry standard SIR material (Agrifos®, salts of phosphous acid)



- Photosy… …%
  Biocha…
  control

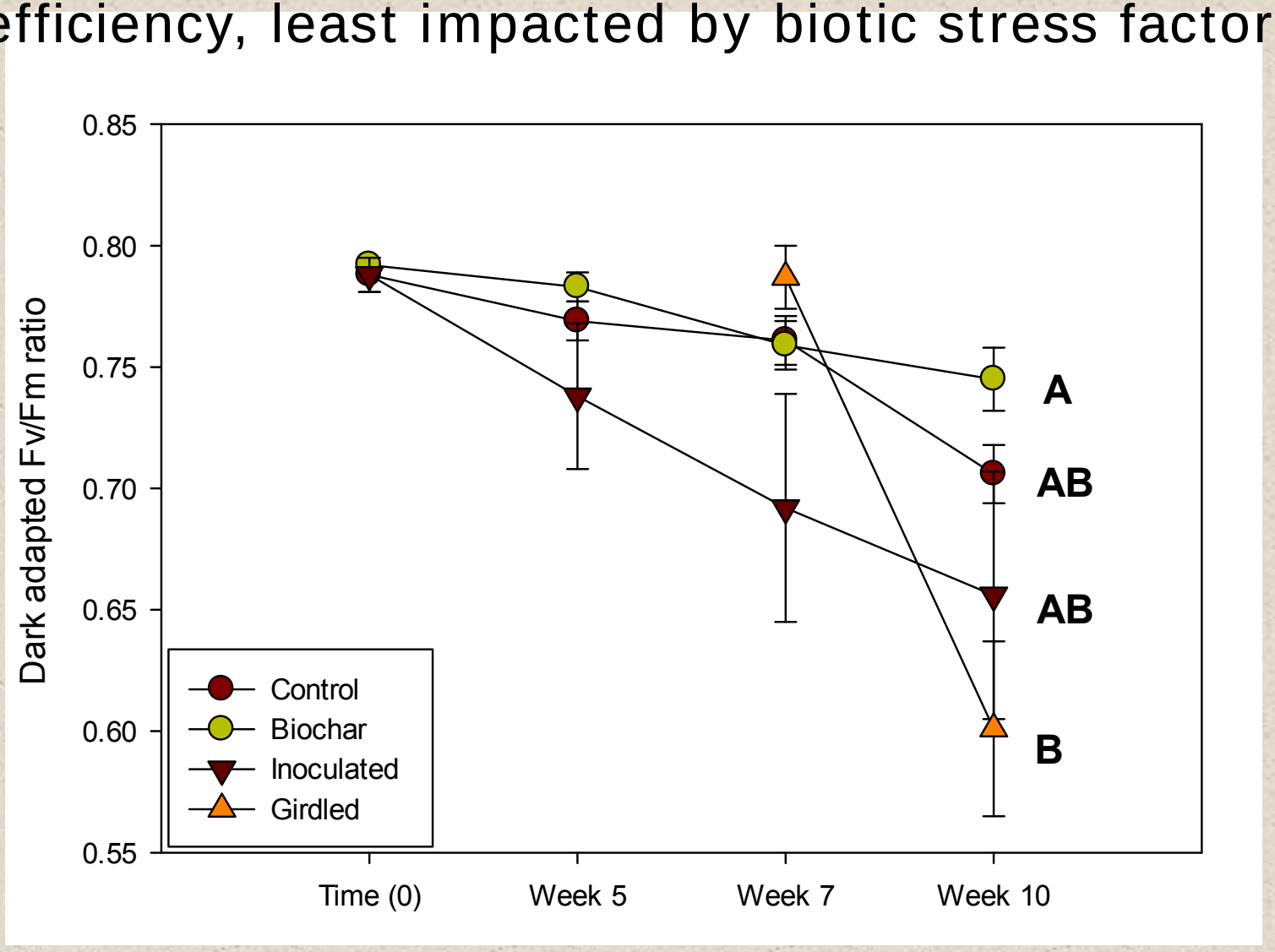


Two years combined data:

- Same treatment, species, and conditions in **Biochar** and **Inoculated** groups.
  - 2-way ANOVA accounts for experiment year and treatment
- Clear trends in Assimilation and Conductance
- Photosynthetic performance in inoculated plants is **Improved** by **5 % Biochar** amendment of potting media

Chlorophyll Fluorescence data:

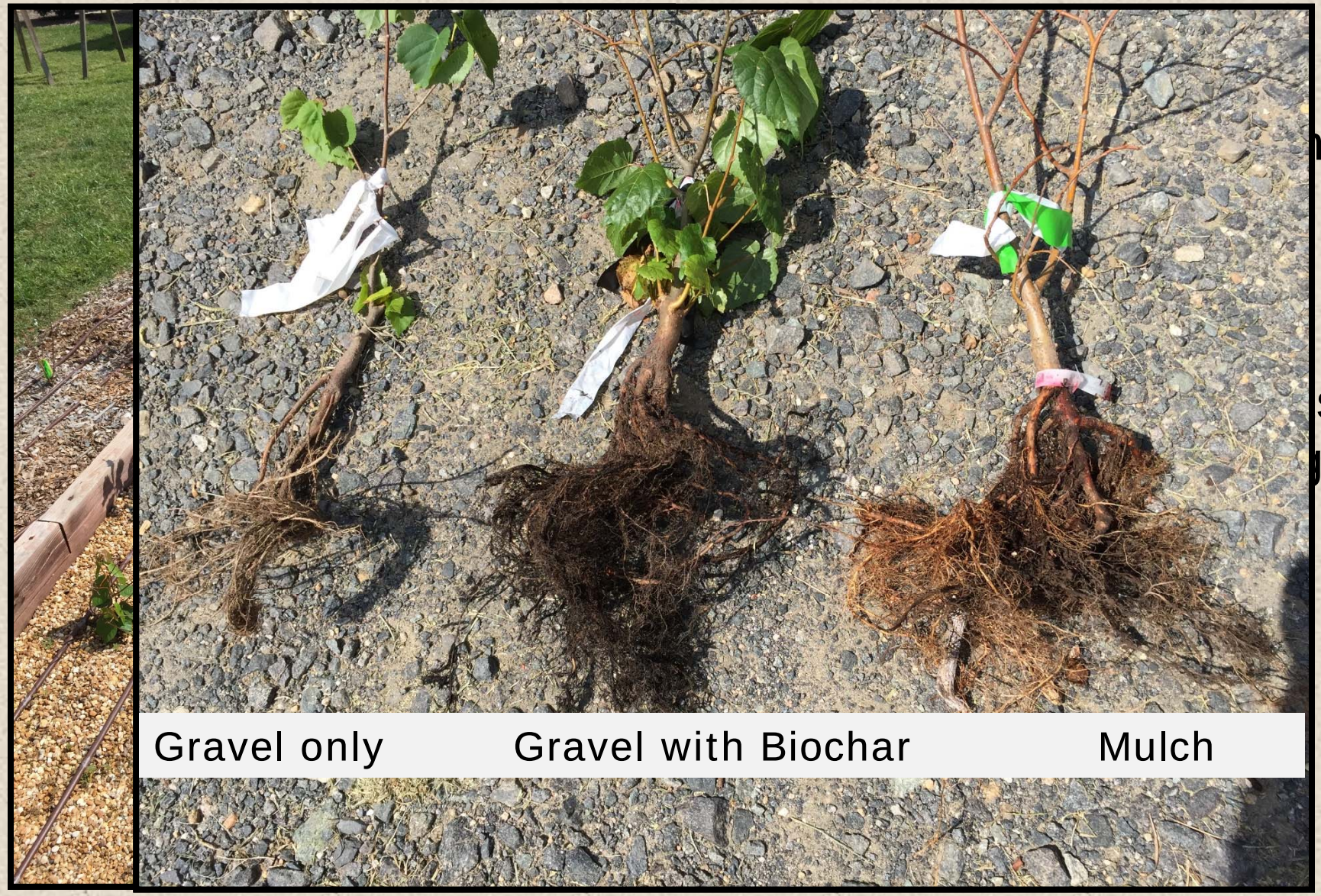
- **Biochar** group had highest photosynthetic efficiency, least impacted by biotic stress factor



Oak- stem water potential

- **5 % biochar** reduced girdling growth of pathogen
- **5 % biochar** amendment resulted in least negative stem water potential
- No difference in biomass

Niche uses: Missouri gravel beds



Niche uses: rain gardens

Niche uses: Green-roof research

- Focused primarily on nutrient retention and run-off water quality.

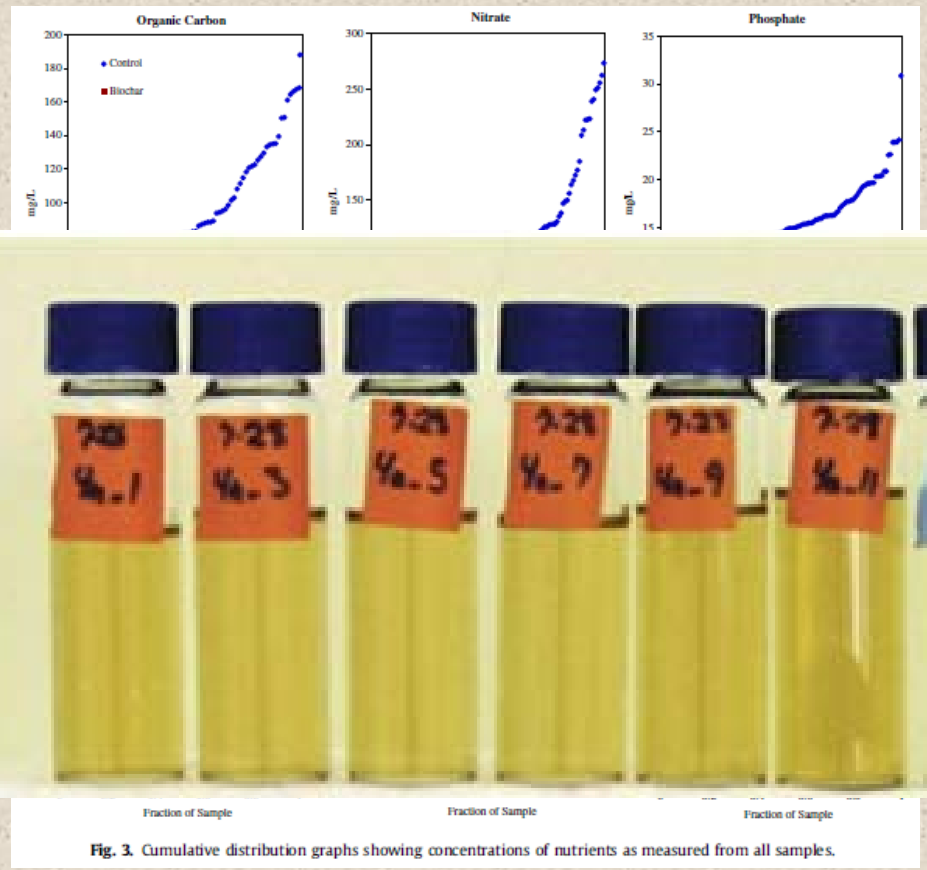


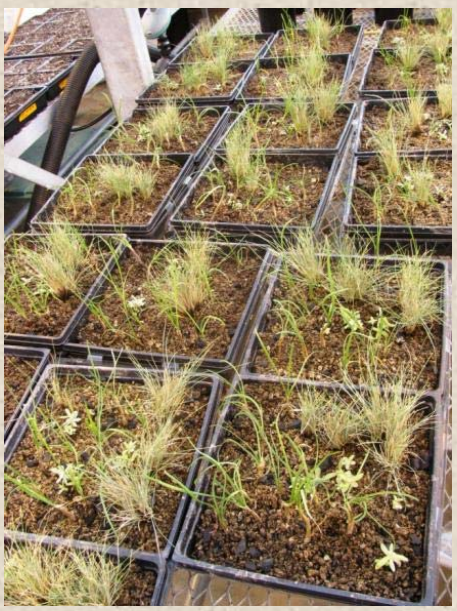
Fig. 3. Cumulative distribution graphs showing concentrations of nutrients as measured from all samples.

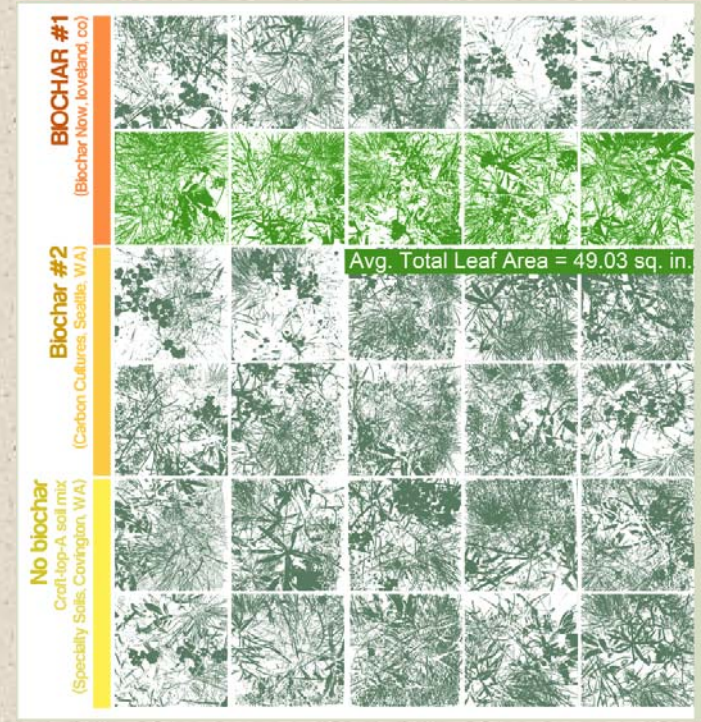
Leaching reduced by 500%

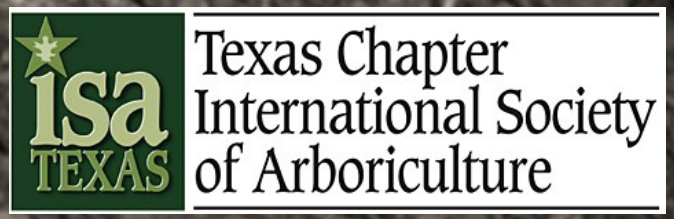
Beck et. al. (2011). Environmental Pollution 159: 2111-2118

Project at U.W. (Gar-yun Ho)

- Comparing 2 different biochars with 3 plant species and bare soil.
  - Looking at nutrient retention and water holding
- **Results:**
  - Reduced EC of leachate (fertilizer retained in media)
  - Increased plant leaf area





Summary

- Results with woody plants are promising
- We are seeing positive responses at 5% v/v
  - Soil factors
  - Woody plant response will be slower
  - Disease resistance
- MUST be mixed with compost if OM is less than 5%