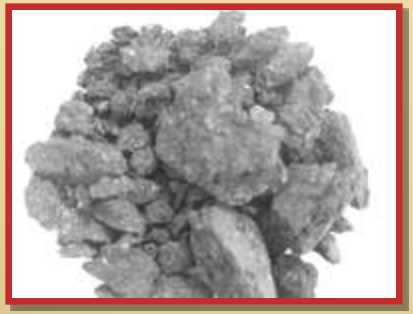
IMPACT OF BIOCHAR ON SPECIALTY CROPS

Kurt Spokas[1, 2] and Eric Nooker[2]

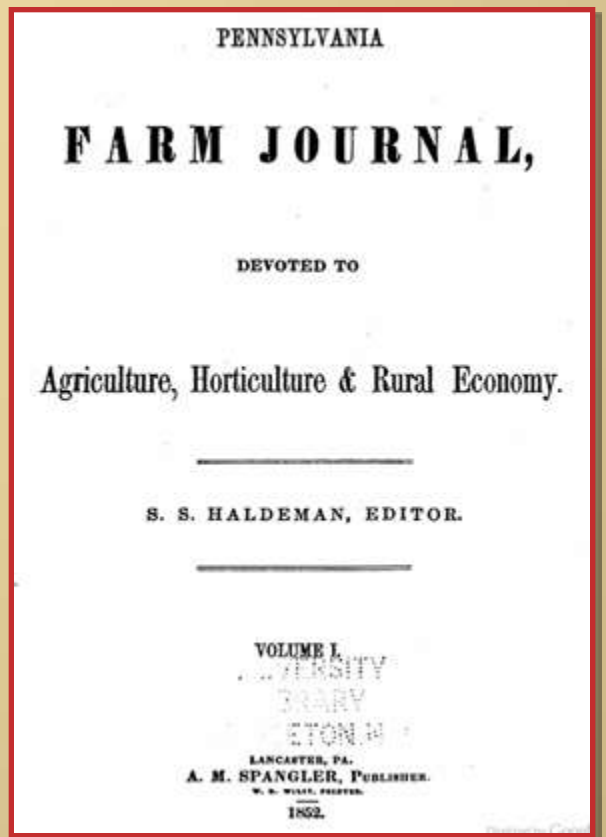
1 - USDA-ARS St. Paul, MN
2 - University of Minnesota Dept. of Soil, Water, and Climate

"The use of charcoal (*biochar*) as a fertilizer is not a new thing, though it is only within the few last years that agriculturists have taken much notice of it."




"The use of charcoal (*biochar*) as a fertilizer is not a new thing, though it is only within the few last years that agriculturists have taken much notice of it."

Pennsylvania Farm Journal (1852)
Editorial (Haldeman) Page 57


PENNSYLVANIA

FARM JOURNAL,

DEVOTED TO

Agriculture, Horticulture & Rural Economy.

S. S. HALDEMAN, EDITOR.

VOLUME I.

LANCASTER, PA.
A. M. SPANGLER, PUBLISHER.

1852.

BIOCHAR FOR SPECIALTY CROPS

History

- Biochar use in specialty crops production does date back to the start of modern science and earlier

BIOCHAR FOR SPECIALTY CROPS

History

1. Charcoal for food preservation -

Falck (1865) – Improves “ice chests” by including charcoal filled walls

Rideal (1903) - Produce (apples, pears, and lemons) can be kept well for long periods packed in charcoal powder

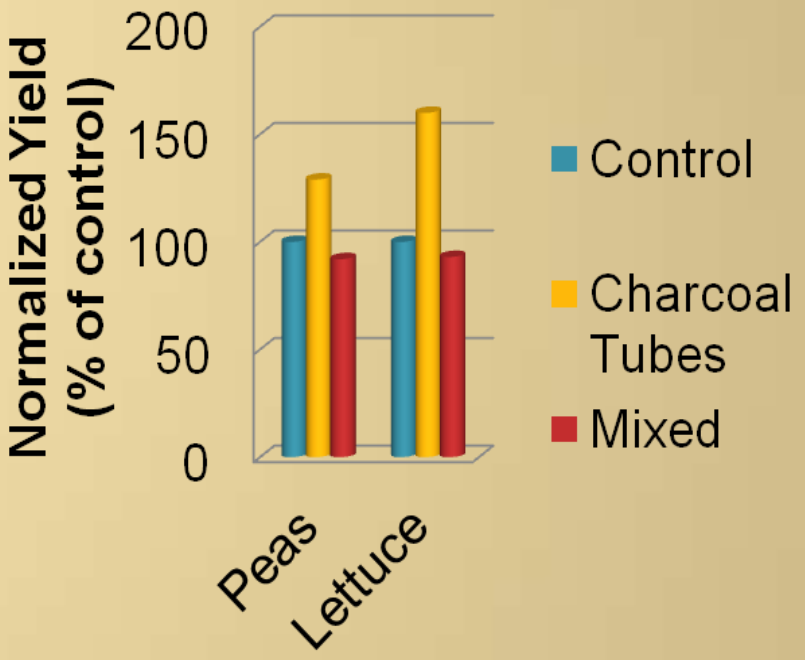
BIOCHAR FOR SPECIALTY CROPS

History

2. Charcoal used for disease prevention & non-target chemical protection

- **Skinner (1908)** –
  - Peas and lettuce in the presence of charcoal
  - Largest increases were in poor quality silty clay loam soils (70%)
  - Direct mixing of charcoal in soil did not result in significant increases

- **Hitz et al. (1953)**
  - Used activated charcoal for strawberry seedling protection from herbicides

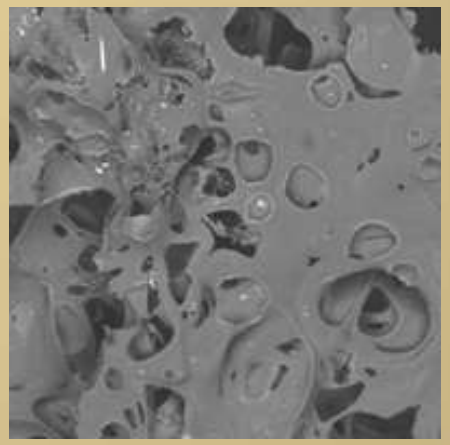


History

3. Actions of charcoal linked to sorptive properties

- **Turner (1955)**
  - Positive impacts linked to sorption of plant “putrids”
- **Weatherhead et al. (1978)**
  - Plant chemical inhibitors (auxin and cytokinin) sorbed by charcoal
- **Marimon et al. (2012)**
  - Biochar activation alters plant responses for eggplant
    - HNO_3 activated + cattle manure → Best yield + growth
    - H_2SO_4 activated → increased root density (below ground)

- Past studies have shown that charcoal can interactions with nitrate, nitrite, and ammonia

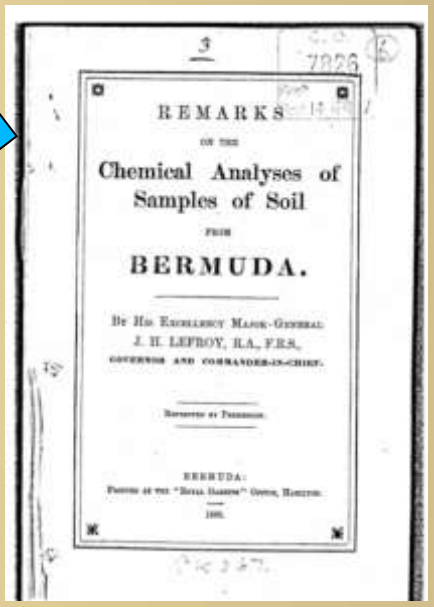


BIOCHAR FOR SPECIALTY CROPS

History

3. Charcoal was used as fertilizers (manures)

Ashes (see also *Potash*) "constitute an important class of manures, differing, however, in their effects according to the substance which has undergone the process of burning, and the manner in which the process has been accomplished. The ashes of all vegetable substances consist principally of those substances which plants require, as charcoal, lime, phosphoric acid, and alkaline salts. Of these charcoal or carbon is the most valuable, and hence to secure it in the greatest quantity the process of burning should be carried


3

REMARKS

ON THE

Chemical Analyses of Samples of Soil

FROM

BERMUDA.

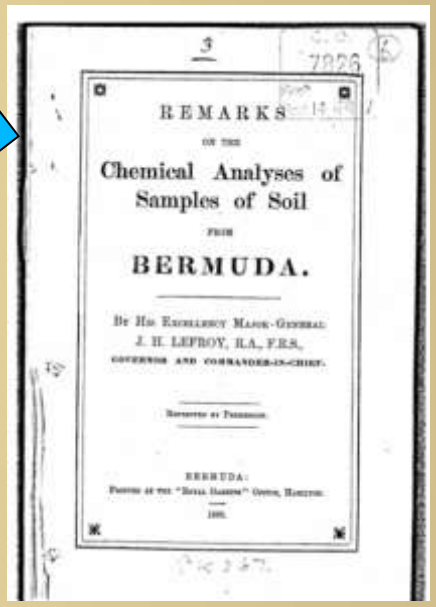
(John Henry LeFroy, 1883)

Quote is from a 1833 report

BIOCHAR FOR SPECIALTY CROPS

History

Ashes (see also *Potash*) "constitute an important class of manures, differing, however, in their effects according to the substance which has undergone the process of burning, and the manner in which the process has been accomplished. The ashes of all vegetable substances consist principally of those substances which plants require, as charcoal, lime, phosphoric acid, and alkaline salts. Of these charcoal or carbon is the most valuable, and hence to secure it in the greatest quantity the process of burning should be carried on as slowly as possible, and this is best effected by covering up the mass while burning and admitting no more air than just sufficient to keep up a smouldering fire. The ashes of all vegetables contain almost the same constituent parts, and are found useful in all soils and to the majority of crops. They should always be applied when newly burned, as they lose much of their value by keeping even although kept under cover. A medium quantity of ashes may be taken as 1 lb. weight to the square yard."* Coal ashes finely screened are also useful as manure, but less so than wood ashes. The ashes of sea weed, known in England as kelp, contain carbonate of soda and salts of potash, and are much used



3

REMARKS

ON THE

Chemical Analyses of Samples of Soil

FROM

BERMUDA.

(John Henry LeFroy, 1883)

Quote is from a 1833 report

Application rate
≈5000 lb/ac
(5500 kg/ha)

BIOCHAR FOR SPECIALTY CROPS

History

3. **Charcoal has been used as fertilizers (manures)**

“The best manures for onions are said to be sea weed and charcoal dust.”

Fressendeen (1834) – American Farmer Journal

BIOCHAR FOR SPECIALTY CROPS

History

no doubt the guano added very largely to it. With an improved corn planter the guano in a mixture of 3½ parts to one part of charcoal or wood ashes, can be dropped in the hill and covered an inch deep with soil, the same machine at the same time dropping the corn. With hills 3 1-2 feet apart each way it would apply at the rate of a spoonful of guano to a teaspoonful of charcoal or ashes, and as the guano is covered with soil, the seed does not come in contact with it.

Robinson (1853) Guano: A Treatise of Practical Information for Farmers

BIOCHAR FOR SPECIALTY CROPS

History

However:

“On stiff clay soils it will produce an increase of vegetation, but not sufficient to pay the expense of the manure (charcoal).”

Maryland State Agricultural Society (1822) p. 410

BIOCHAR FOR SPECIALTY CROPS

Research Data

1. **Germination and Seedling Growth**

   12 biochars x 12 specialty crops x 6 soils

2. **Bioaccumulation of PAH Compounds from Biochar Amended Soils**

BIOCHAR FOR SPECIALTY CROPS

Research Data

1. **Germination and Seedling Growth**
   - Observed spectrum of behaviors – increases, decreases, and no effects
   - Most interesting – Subsequent tests in same soil

1st cropping

Control BC

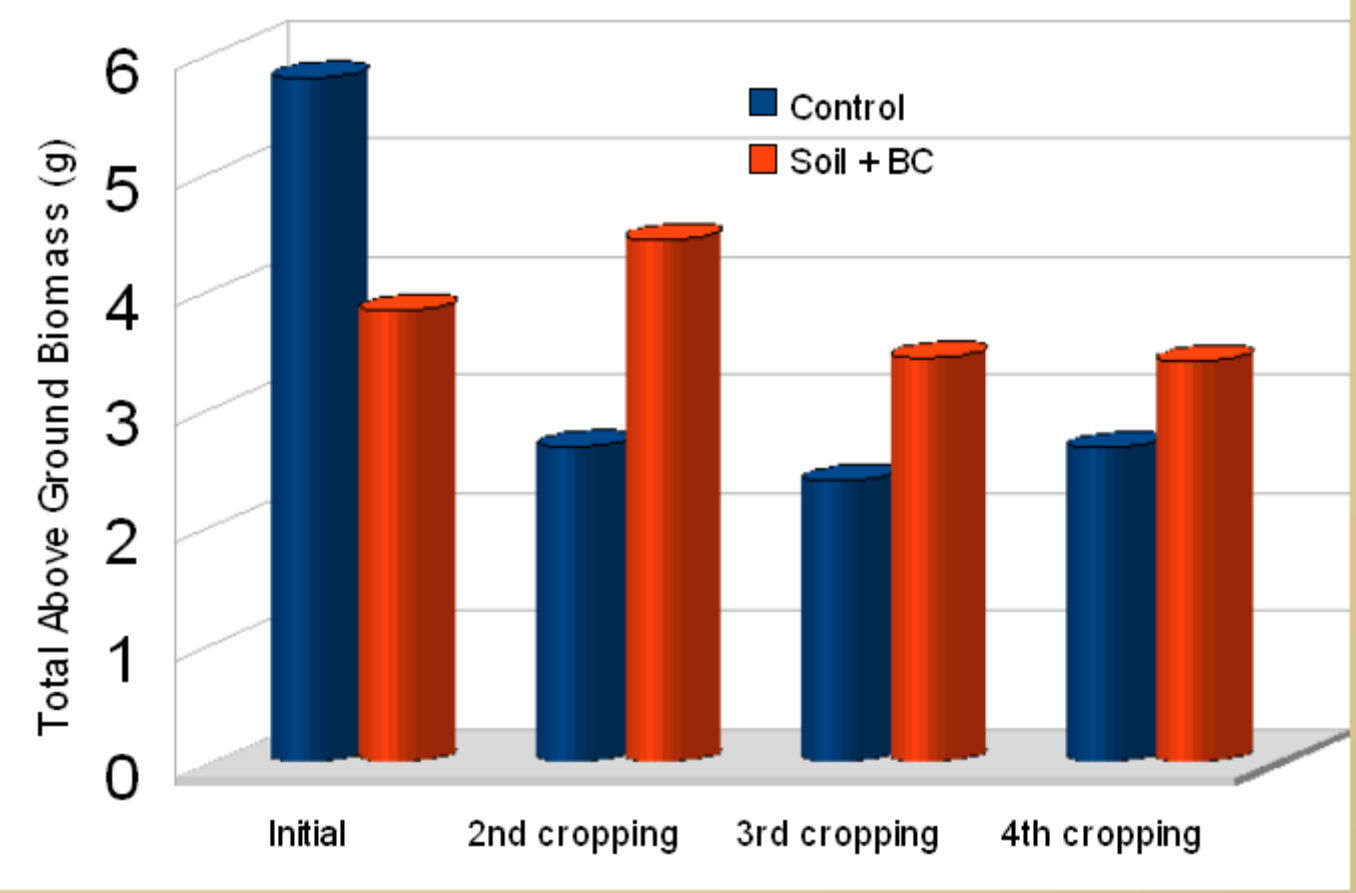
3rd cropping

Control BC

BIOCHAR FOR SPECIALTY CROPS

Research Data

1. Germination and Seedling Growth

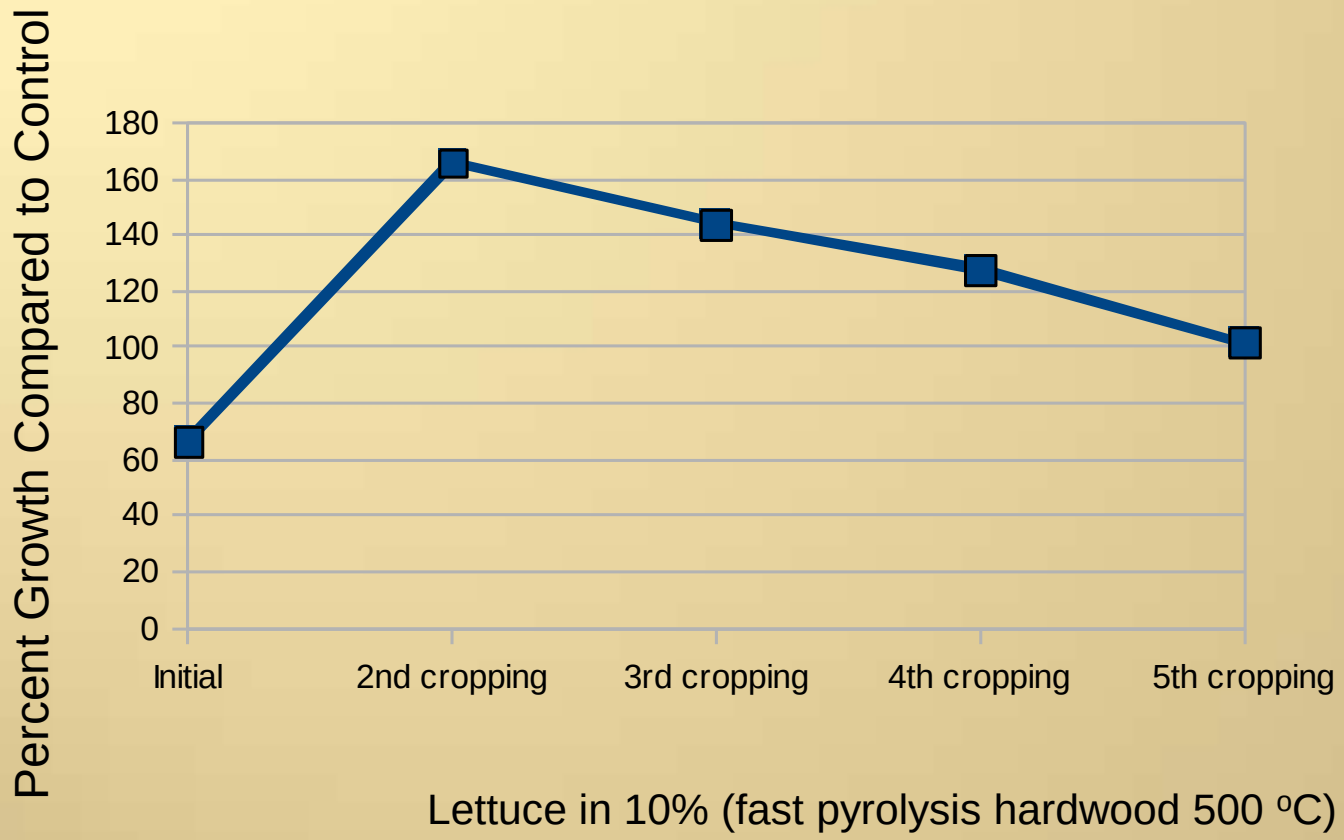


Spinach in 1% biochar (fast pyrolysis macadamia nut shell)

BIOCHAR FOR SPECIALTY CROPS

Research Data

1. Germination and Seedling Growth

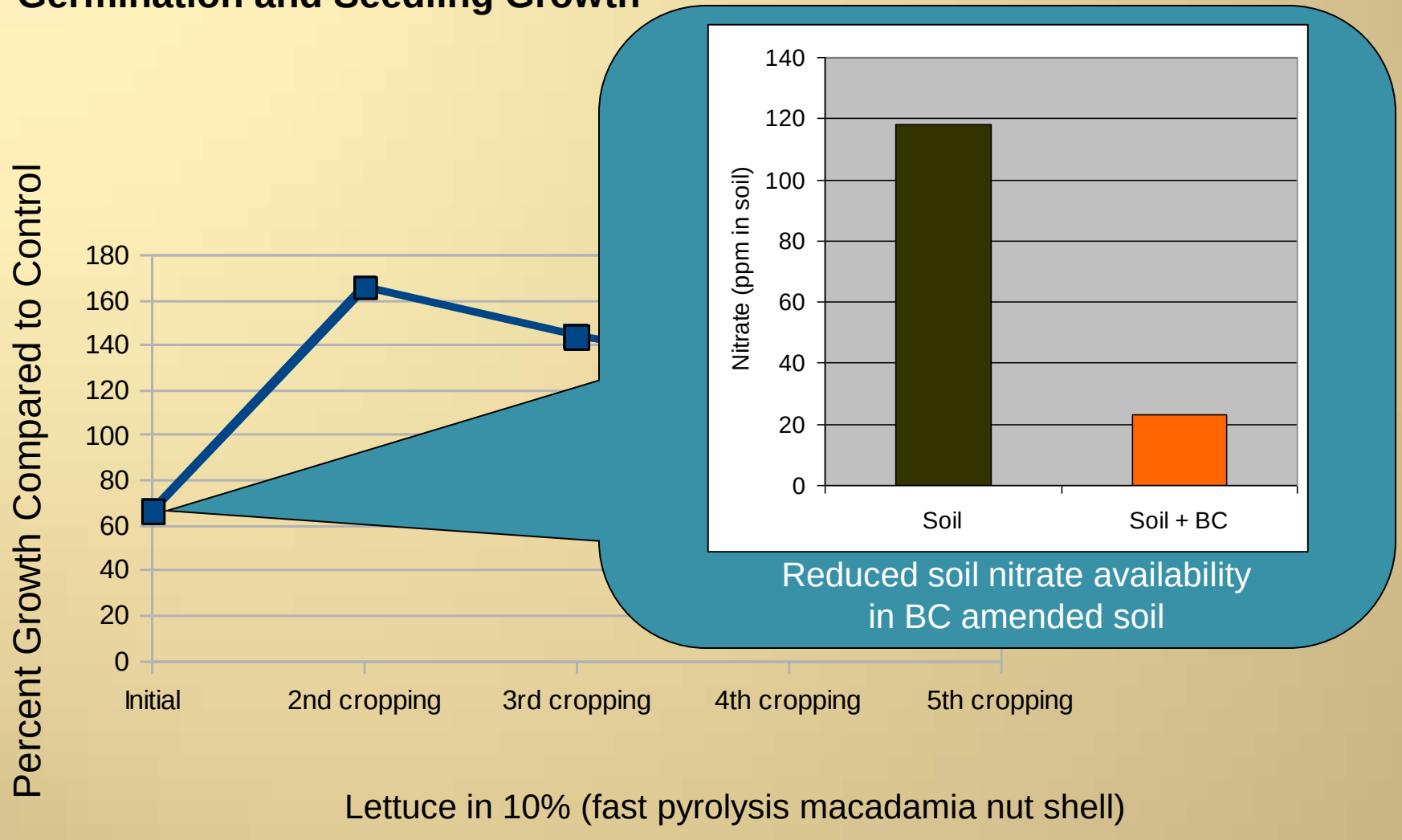


Lettuce in 10% (fast pyrolysis hardwood 500 ^{o}C)

BIOCHAR FOR SPECIALTY CROPS

Research Data

1. Germination and Seedling Growth

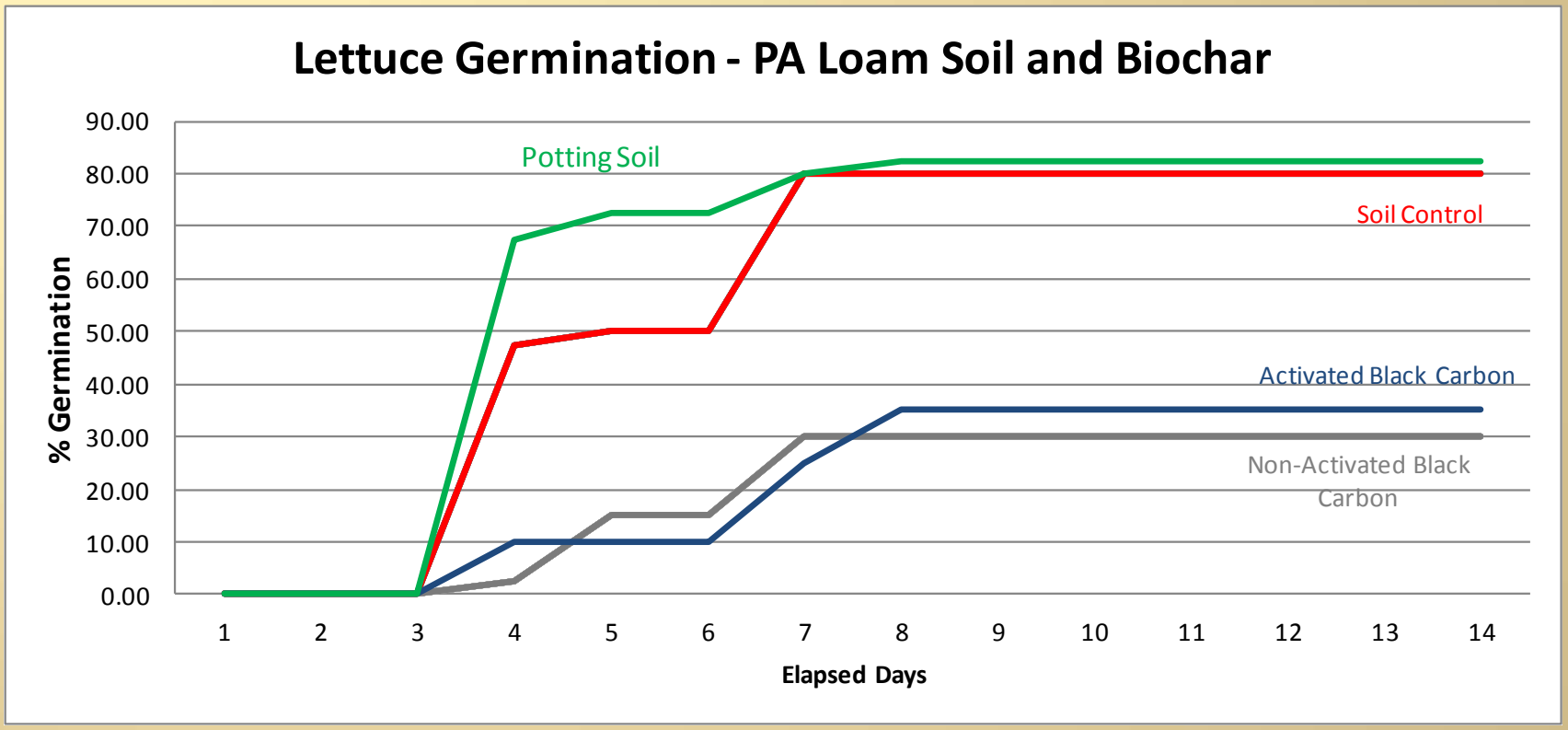


Lettuce in 10% (fast pyrolysis macadamia nut shell)

BIOCHAR FOR SPECIALTY CROPS

Research Data

1. Germination and Seedling Growth



BIOCHAR FOR SPECIALTY CROPS

Research Data

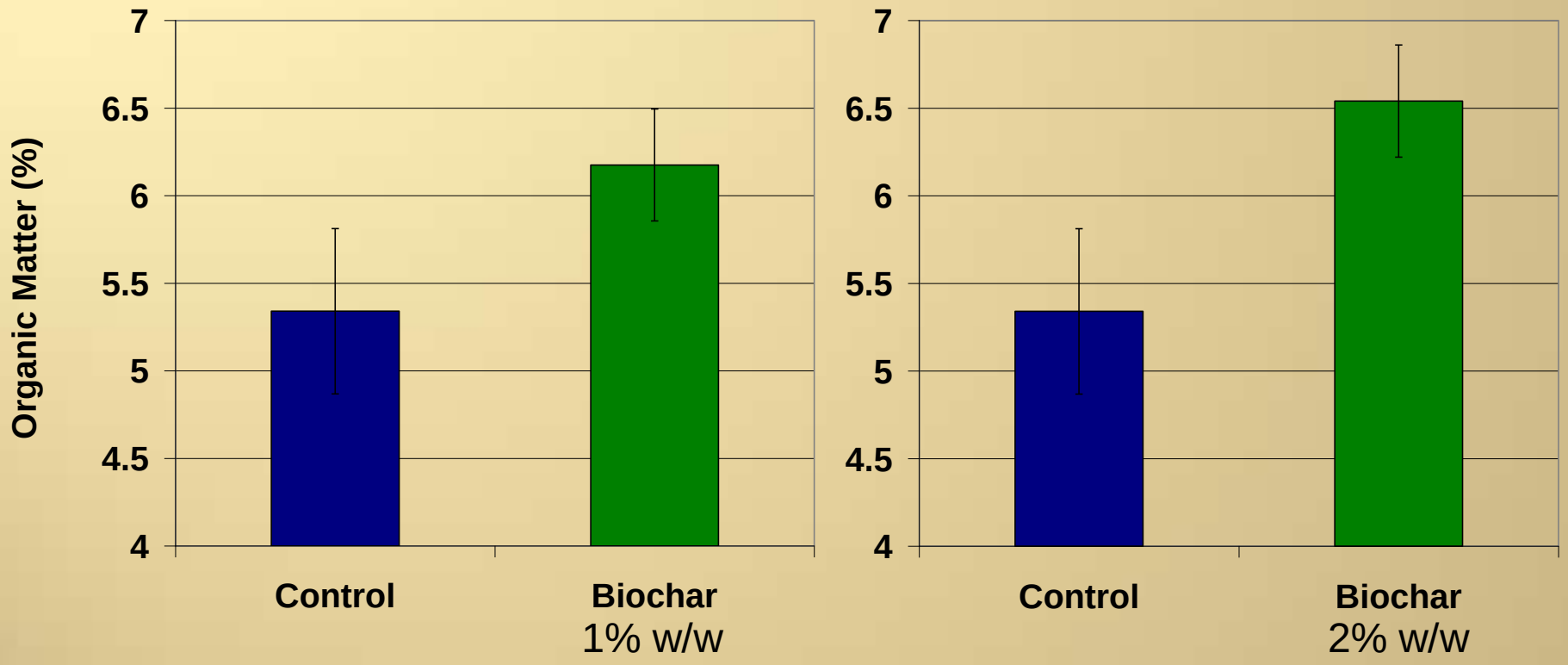
- What are the consistent trends observed ?

BIOCHAR FOR SPECIALTY CROPS

Research Data

- What are the consistent trends observed ?

  - **Organic Matter (Soil C) <u>is increased</u>**
    - Usually, statistically significant after 1% (w/w)



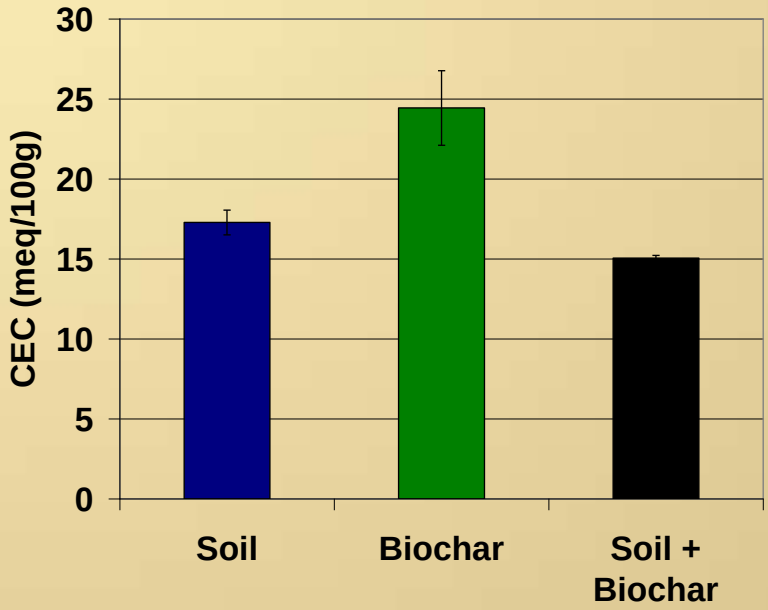
Hardwood slow pyrolysis biochar (550 ^{o}C)

BIOCHAR FOR SPECIALTY CROPS

Research Data

- **CEC**
  - Variable response observed
    - Both in initial mixing and post-growth sequences

  - Majority increases – But there are some decreases observed
    ~ 30% of soil *x* biochar combinations



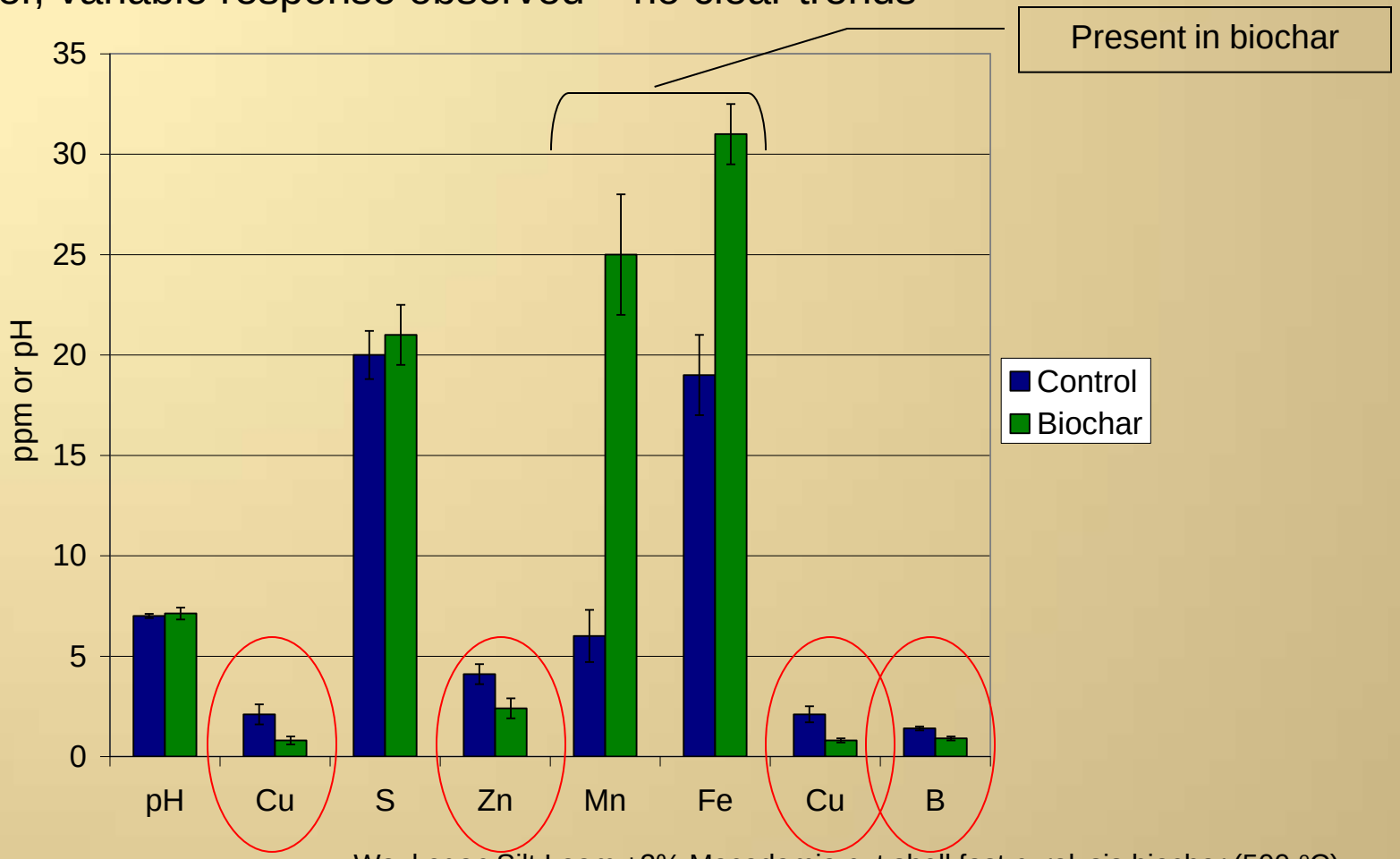
Waukegan Silt Loam +Hardwood slow pyrolysis biochar (550 ^{o}C)

BIOCHAR FOR SPECIALTY CROPS

Research Data

- Micronutrients… Occasional reduction in availability post biochar additions

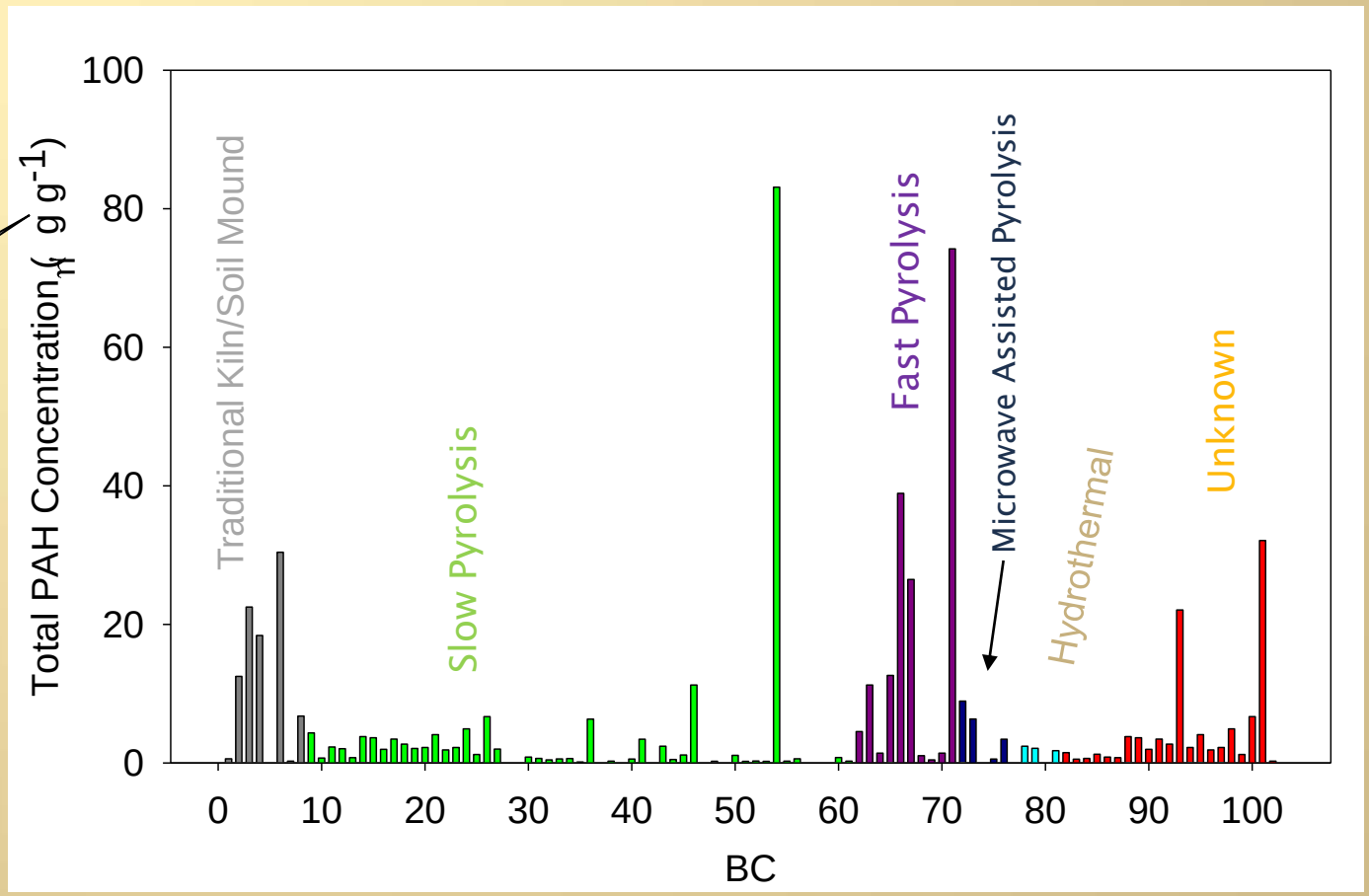
  - However, variable response observed – no clear trends



Waukegan Silt Loam +2% Macadamia nut shell fast pyrolysis biochar (500 ^{o}C)

Sorbed PAH on Biochar

- Sum of total PAH range from 0.01 to 83 µg g^{-1}



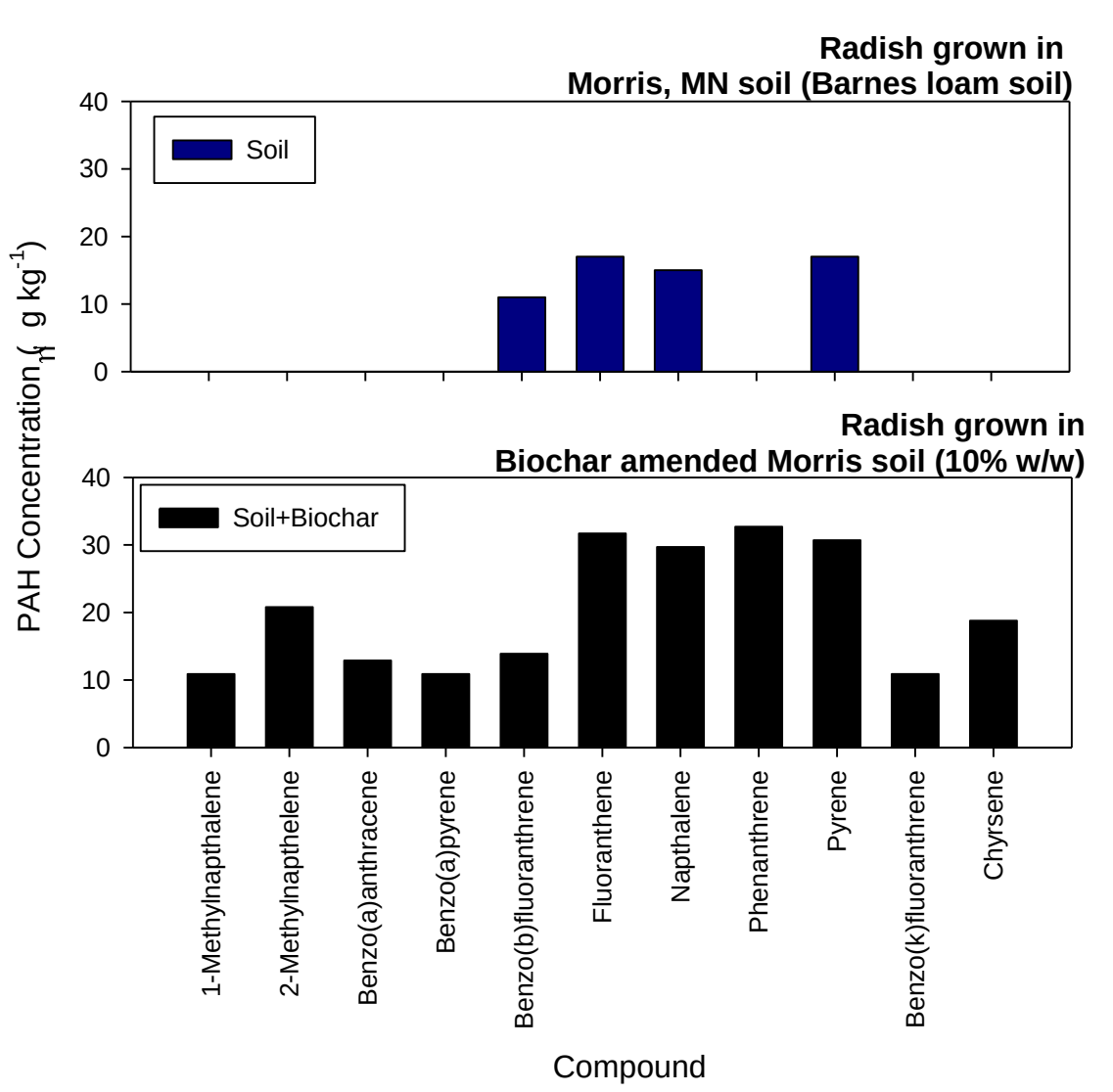
ppm

BIOCHAR FOR SPECIALTY CROPS

PAH Uptake

2. **Some specialty crops grown in biochar amended soils bio-accumulate PAH compounds**

   - Levels are variable as a function of soil type and biochar



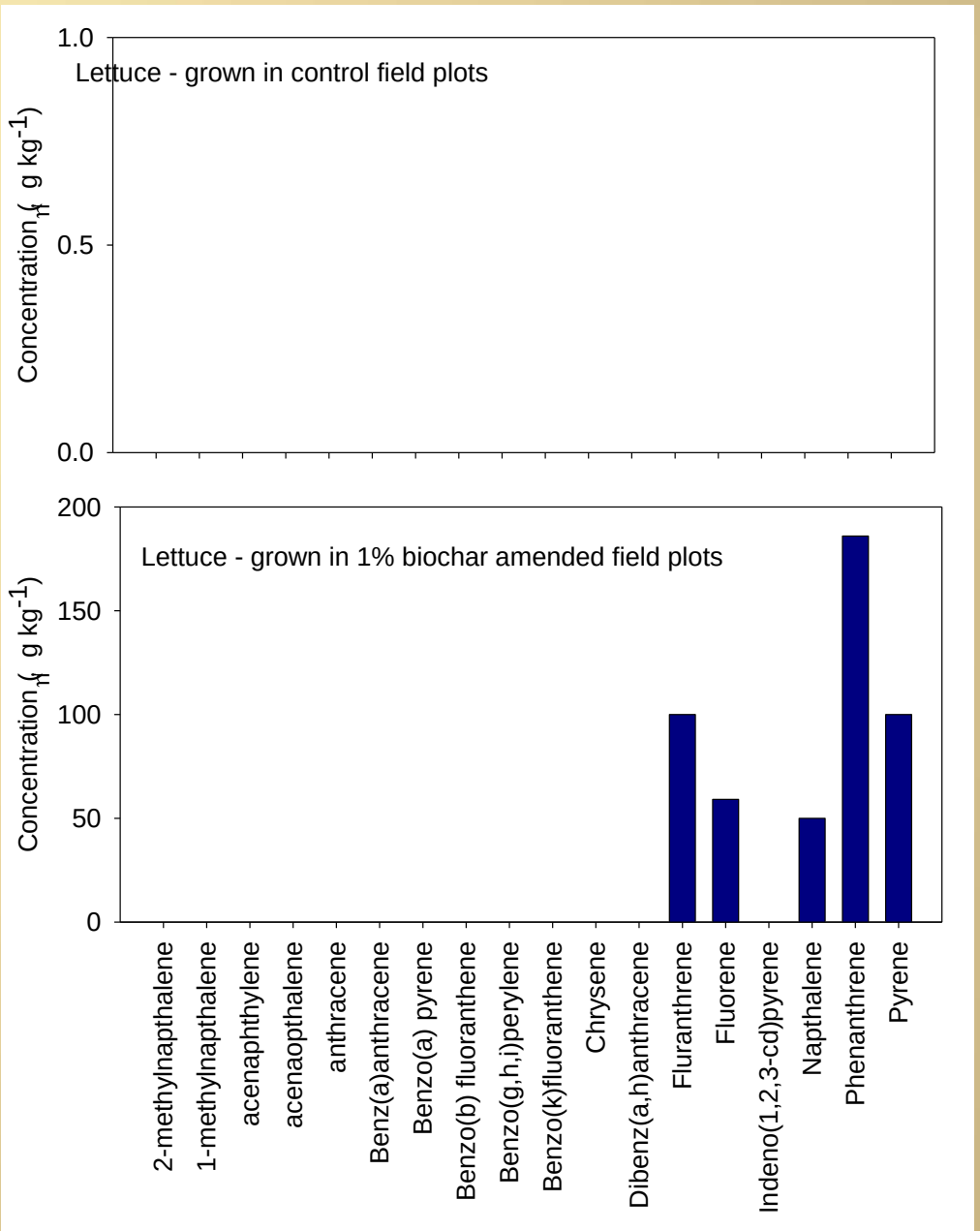
BIOCHAR FOR SPECIALTY CROPS

PAH Uptake

Field Plots -- Rosemount, MN

Approx. 1 % w/w

- Could be contaminated from rainwater splash of BC-soils



BIOC

PAH Up

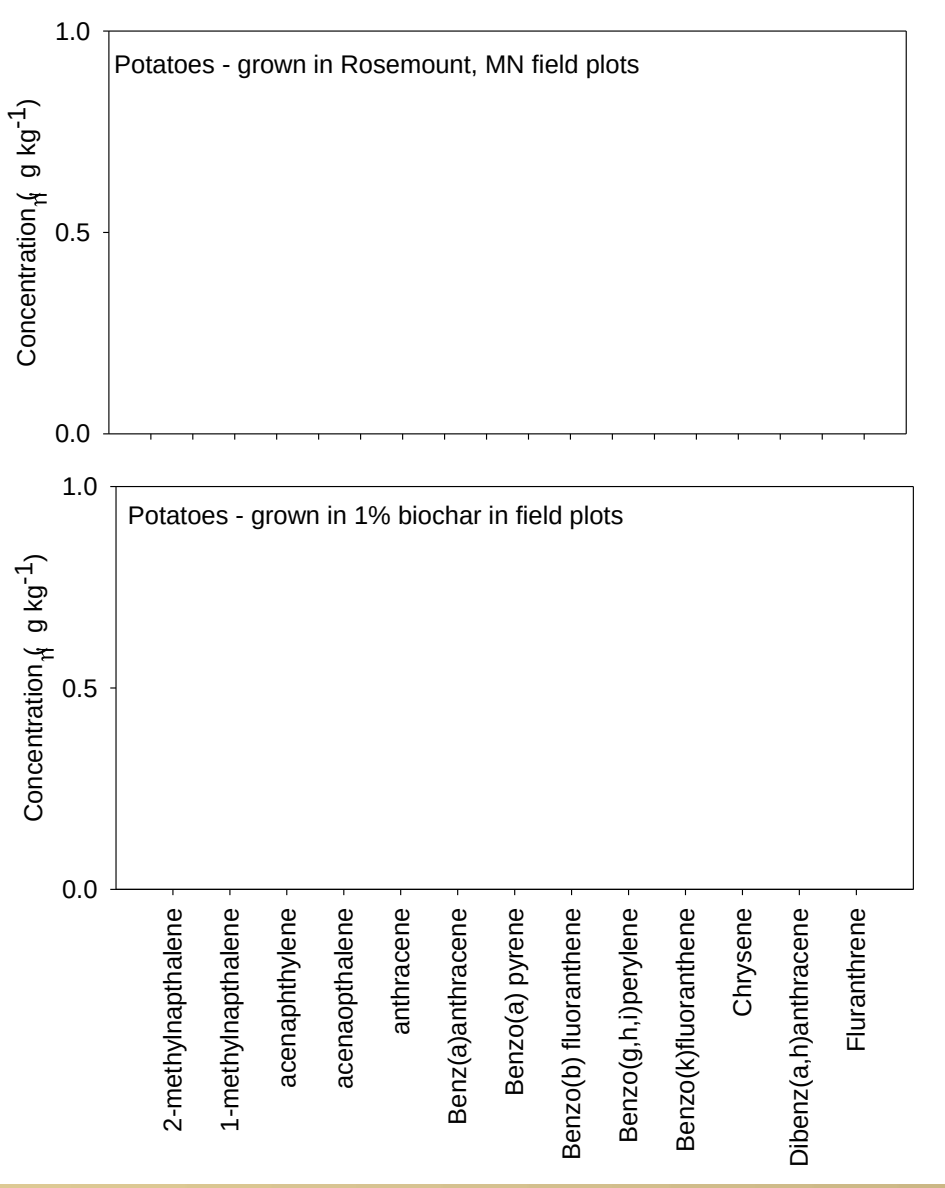
Spec
bio
bio
cor

- C
co
fr
sp

BIOCHAR FOR SPECIALTY CROPS

PAH Uptake

3. Specialty crops grown in biochar amended soils bio-accumulate PAH compounds

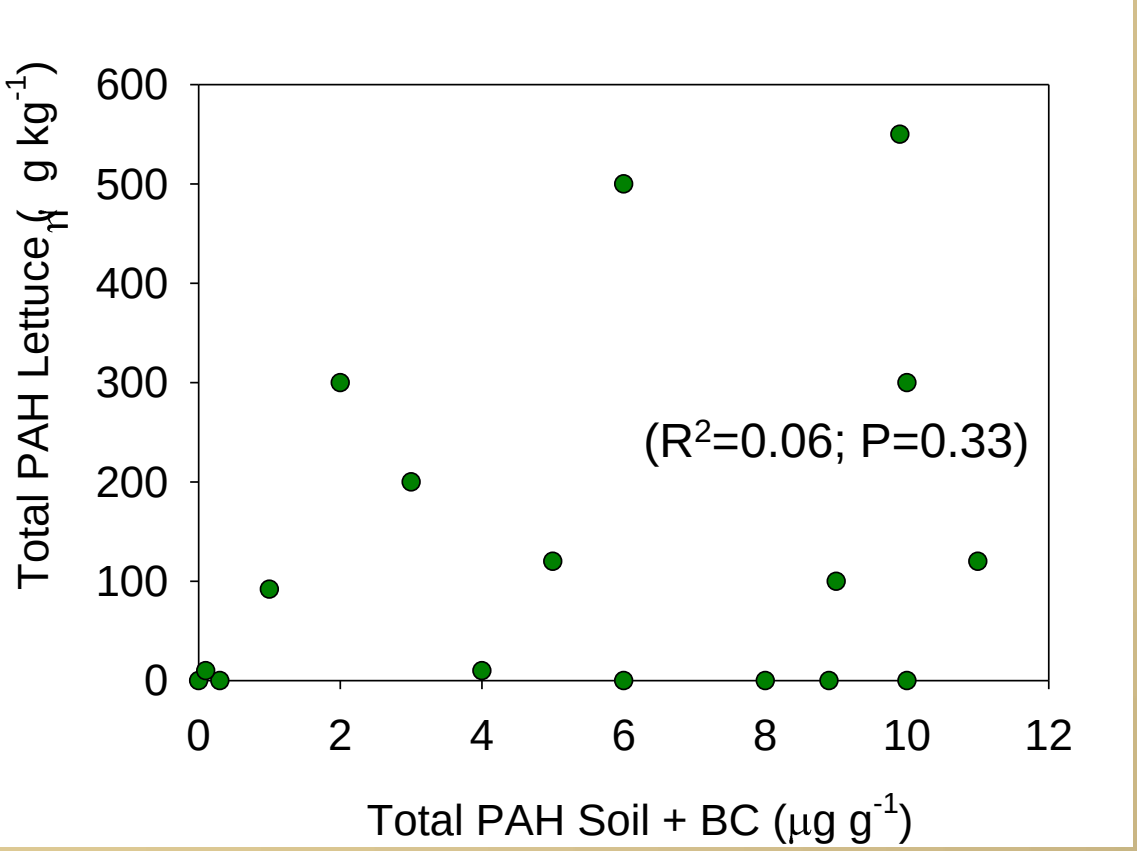


BIOCHAR FOR SPECIALTY CROPS

PAH Uptake

3. Lack of correlation with soil and bio-accumulated PAH amounts

Agrees with literature on the bio-accumulation of PAH compounds in contaminated soils.



BIOCHAR FOR SPECIALTY CROPS

PAH Uptake

Additional research is needed in relation to:

- Variable bio-availability
- Weathering effects ?
- Wood ash has been observed to be a slow release source of PAH compounds – but the time is unknown

Conclusions

- Differences observed in the response to specialty crops

  >> Function of both biochar and soil

- Results to date agree with literature on plants grown in PAH contaminated soils

  > No direct correlation between soil and plant concentrations

Acknowledgements

- **MN DEPARTMENT OF AGRICULTURE**
  Funding through MN Specialty Crop Block Grant

- MN Master Gardeners
  - Growing various combination of soil x biochar combinations

- Penn State University
  - Comparison of different black carbon
  - Examining impact of activation

- Lac Courte Oreilles Ojibwa Community College
  - Community garden bed research

Acknowledgements

- **Dynamotive Energy Systems**
- **Best Energies**
- **Sylva Corp.**
- **Northern Tilth**
- **Avello Bioenergy**
- **Acala Partners, LLC**
- **Minnesota Biomass Exchange**
- **NC Farm Center for Innovation and Sustainability**
- **National Council for Air and Stream Improvement (NCASI)**
- **Illinois Sustainable Technology Center (ISTC) [Univ. of Illinois]**
- **Biochar Brokers**
- **Chip Energy**
- **AECOM**
- **ICM, Inc.**

- **Technical Support : Martin duSaire**
- **Students:**
  - **Tia Phan, Lindsey Watson, Lianne Endo, Amanda Bidwell, Kia Yang, Michael Ottman, Ed Colosky, Vang Yang, Tara Phan, Abby Anderson, and Rena Weiss**