"There are but few who realize the value of charcoal applied to the soil"

-JH Waldon (1860)

BIOCHAR:
The Field Experience

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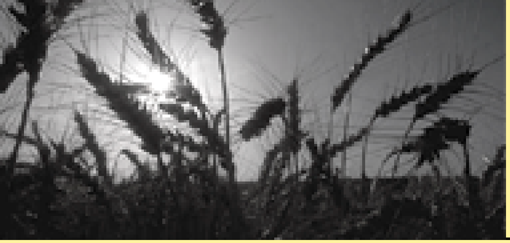
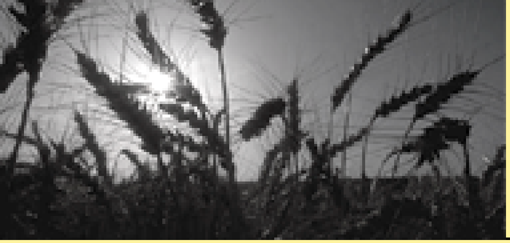


History

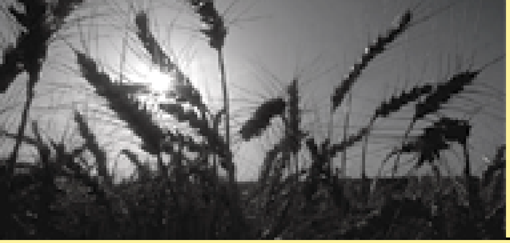
- 300+ years of biochar applications
  - 1700-1800's
    - Initial research into charcoal use
    - Focused on electrical conductivity, energy, and gunpowder production (Napier 1788, Proust 1811)
    - However, some agronomic research as well
    - Rothamsted Research Center (UK)



Soil Application

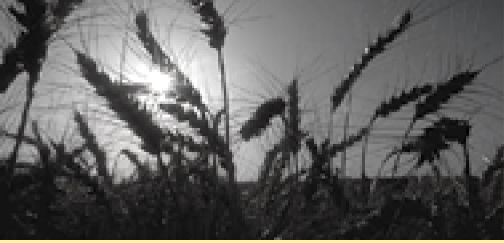
- Charcoal has been used for:
  - **Improving yields (peat charcoal)**
    - Oats – 2-fold increases reported
    - Grasses - improved growth & color
    - Potatoes – Improved yield 2-fold
    - Onions – Improved yields and growth
  - **Increasing soil temperature**
    - Earlier crop germination/emergence
  - **Charcoal mixed with manures**
    - "Improved fertilization action"
  - **Reducing plant pathogens**
    - Particularly for potatoes, peach trees

    "One handful of charcoal with each seed"
  - **Patents in the 1850's for "Antiseptic fertilizer"**
    - Charcoal + hydrocarbons



Charcoal + Fertilizer

- 90 bu ac^{-1} (5,649 kg ha^{-1}) corn grain yield following guano and charcoal additions



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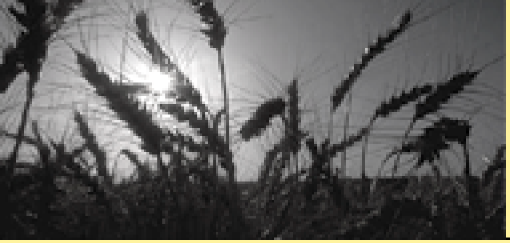
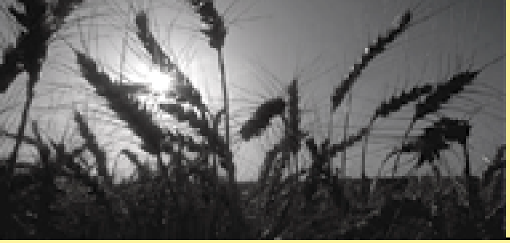


Charcoal + Fertilizer

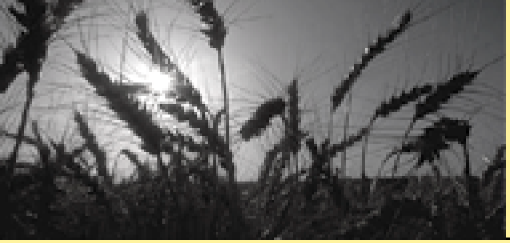
- 90 bu ac^{-1} (5,649 kg ha^{-1}) corn grain yield following guano and charcoal additions
- It was even stated that the yield was measured by his neighbors
- Average corn yields at the time were 45 bu ac^{-1} (2,825 kg ha^{-1}) (Voelker 1864, Robinson 1853)



Biochar – Initial Findings

- Charcoals made from the same wood feedstock under the exact same production conditions, did not always produce charcoal with identical properties (Priestley 1770, Mitchell 1748)

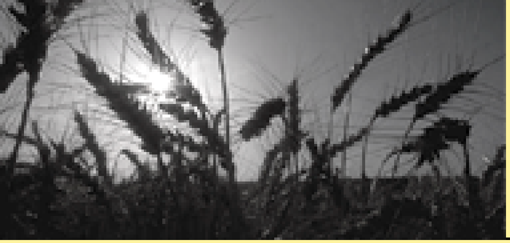
- Initial hypothesis:
  – Charcoal's benefits linked to "carbonic acid" addition to the soil (Bradley 1727)



Biochar: Historic Hurdle

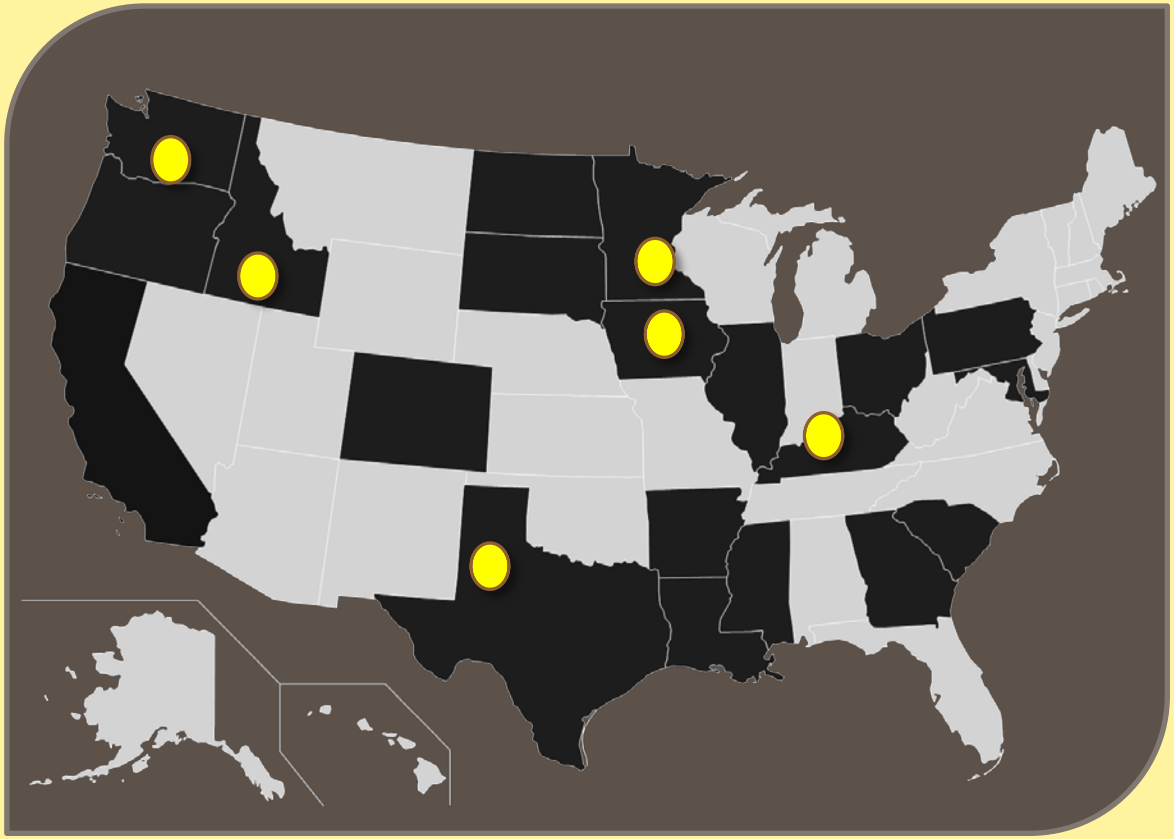
- Profitable use of charcoal was limited by the high charcoal price that was the result of additional uses for charcoal ranging from iron production, energy source, and gunpowder manufacturing

(Tucker 1756, Kirwan 1793, Dundonald 1795b, Sneyd et al. 1798).



BIOCHAR RESEARCH

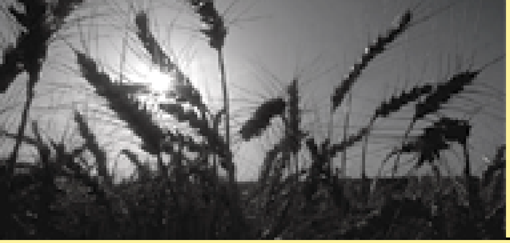
USDA-ARS Biochar and Pyrolysis Initiative (CHARNet)



- Over 20 Locations – 6 Coordinated field plot locations

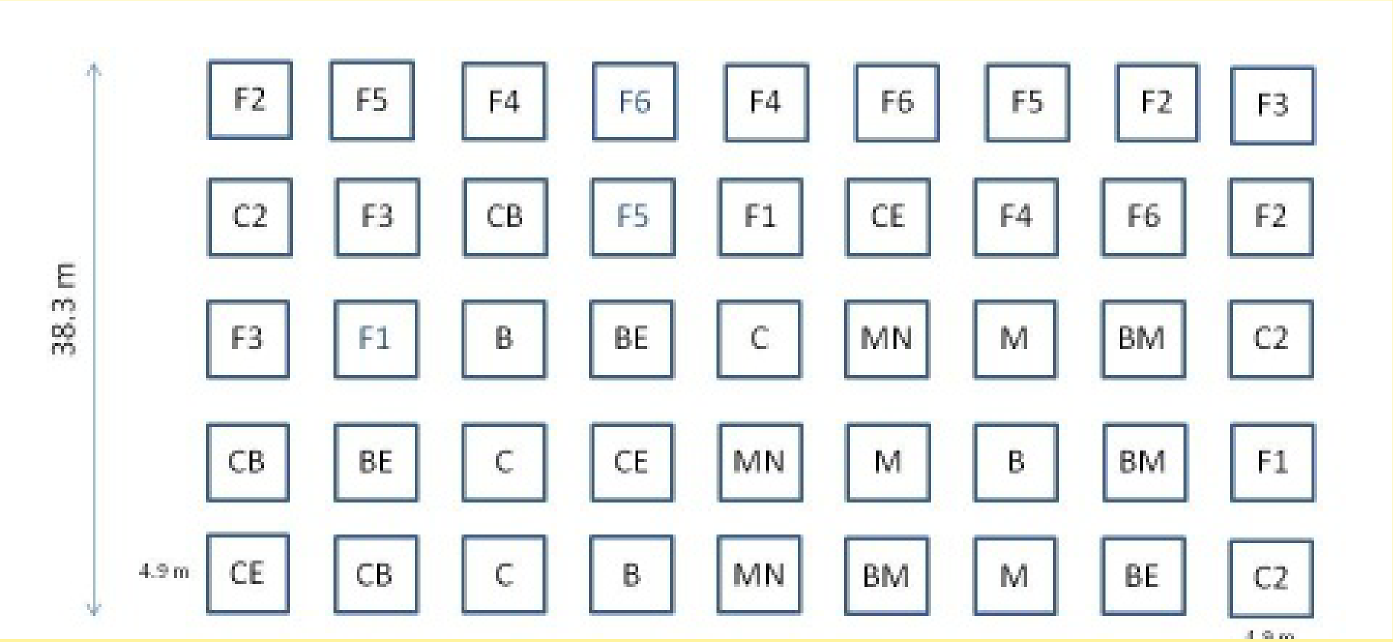
USDA

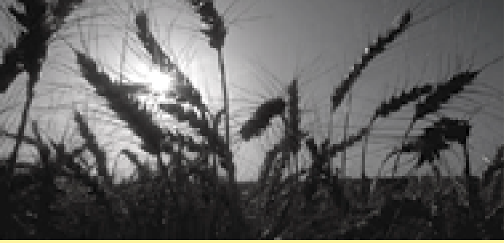
Agricultural Research Service



Rosemount, MN: Biochar Plots

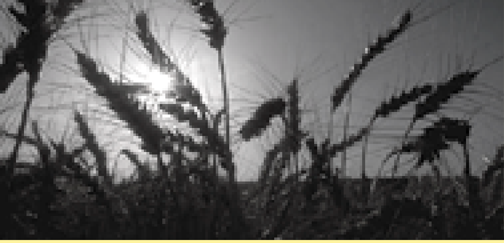
- Triplicate 16’ x 16’ plots (4.9 x 4.9 m)
- 20,000 lb/ac (22,450 kg/ha) application rate
- 0-15 cm incorporation
- Established Fall 2008





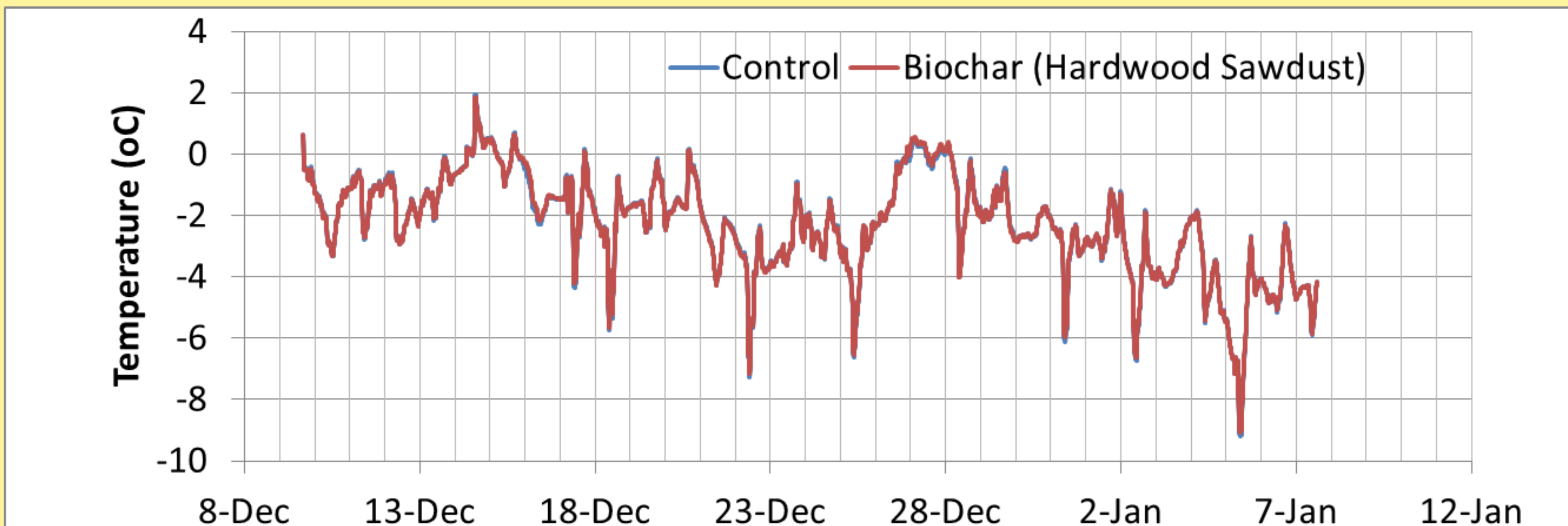
Rosemount, MN Field Plots

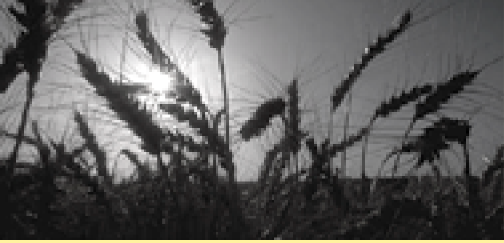
- Biochar increases soil albedo and thus increases soil warming.



Rosemount, MN Field Plots

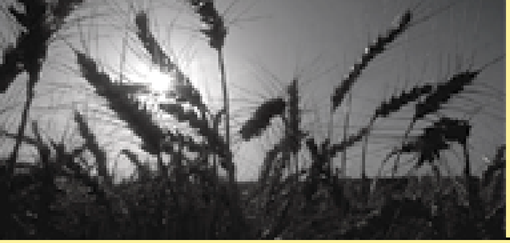
- *Biochar increases soil albedo and thus increases soil warming.*
- Minnesota soil
  - – No significant difference in soil temperatures
    - Within +/- 0.10 ^{o}C





GHG Emissions

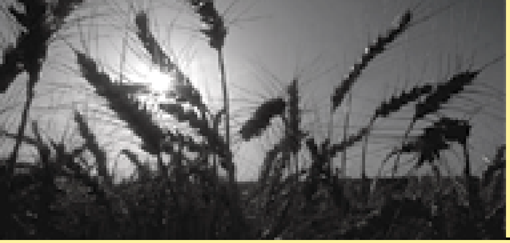
- Biochar reduces GHG emissions following incorporation



GHG Emissions

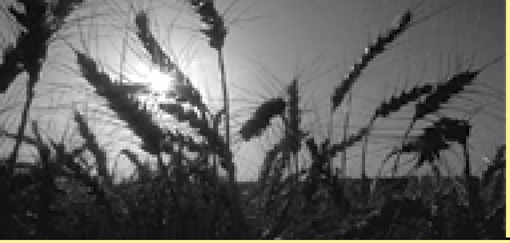
- Assessing field GHG emission for 5 years
- Initial year :
  - Periodic differences in CH_4, CO_2 and N_2O
  - Disappeared after 1st growing season
  - Lower soil nitrate in current biochar plots
  - High spatial-temporal variability

- Higher CO_2 Emissions
  - uncharred additions



Soil Microbial Biomass

- Biochar – Increases SMB numbers ?
- Samples taken in Fall 2012



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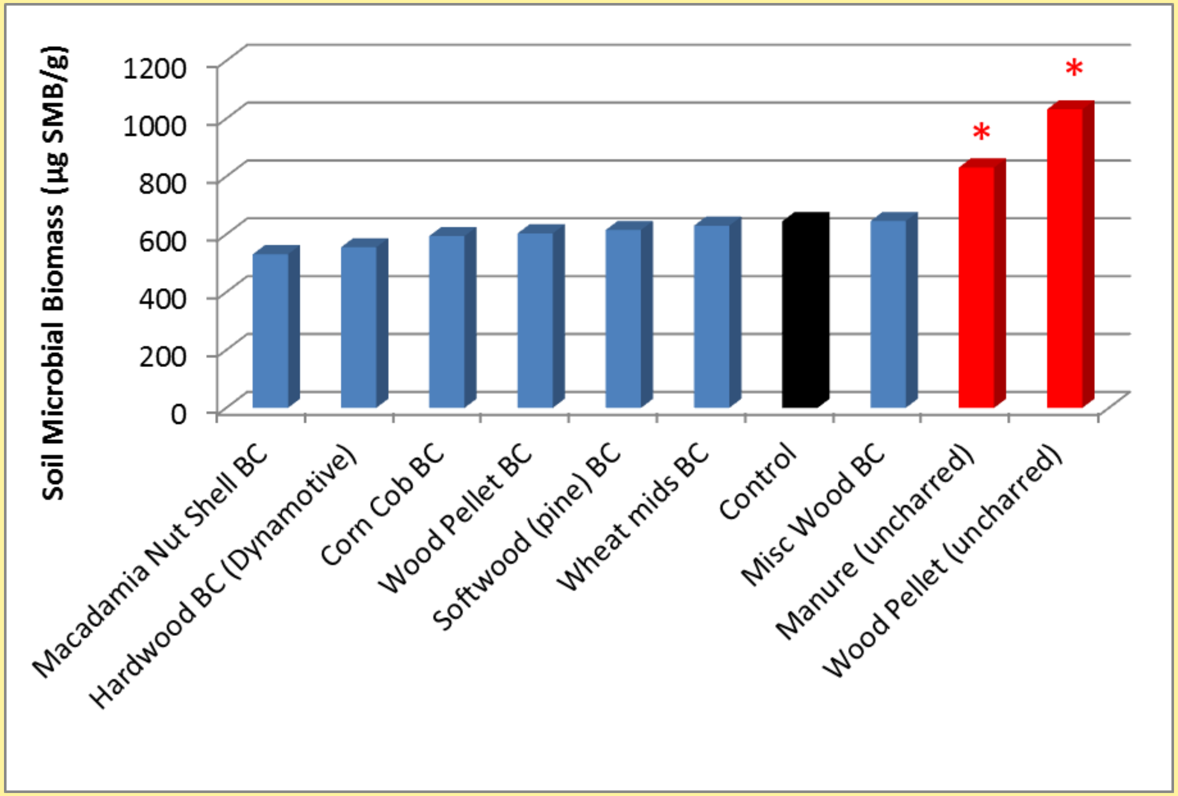
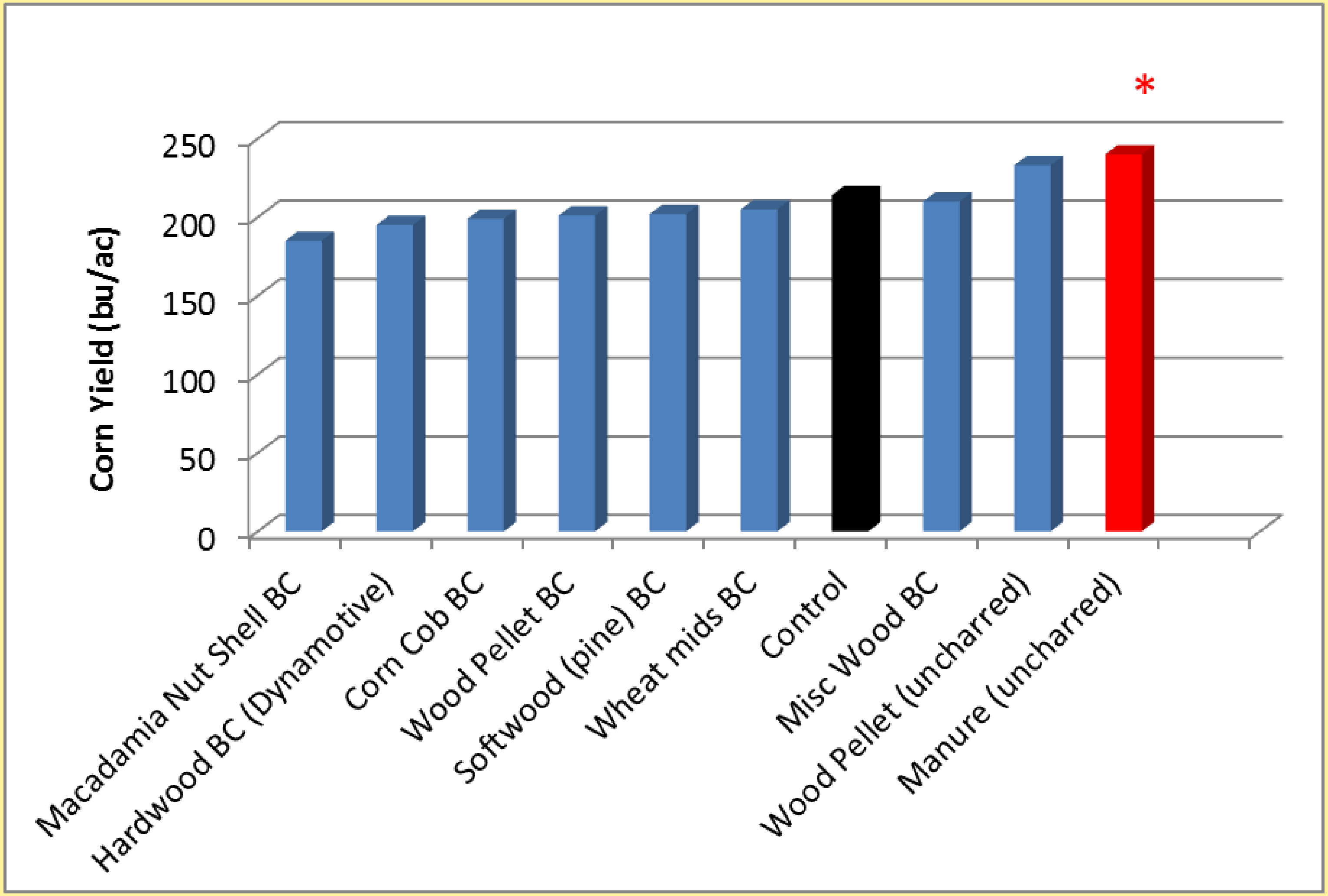
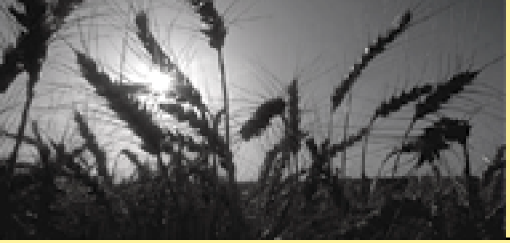


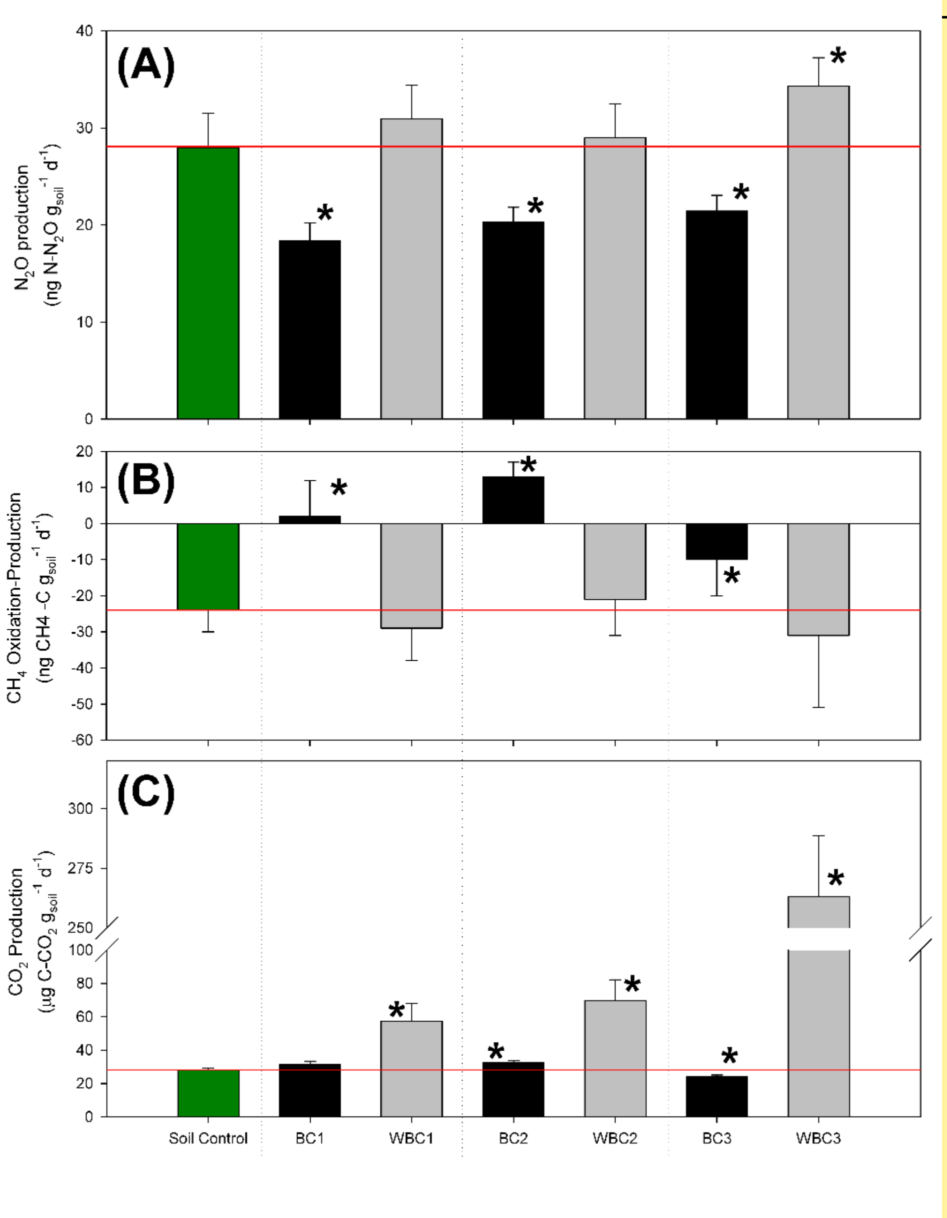
Corn Yield - 2012

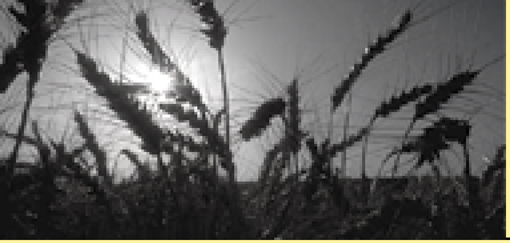




Aged Biochar

- Weathering alters soil GHG responses





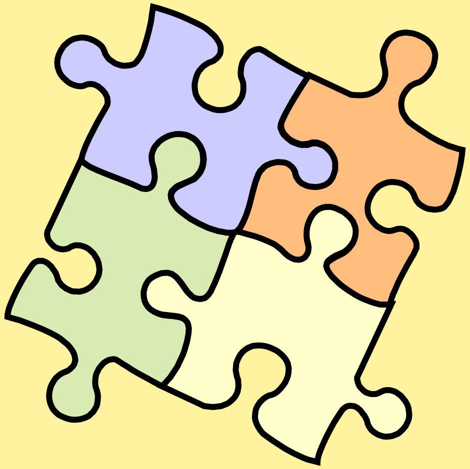
Biochar could be a piece of the solution

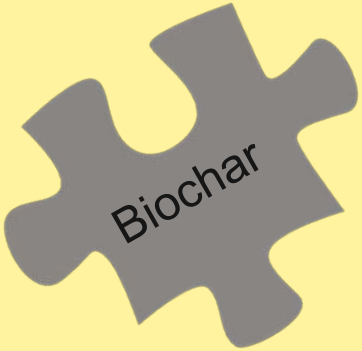
Just as the climate issues did not arise from a single source;

the solution to the problem will not be a **single solution**

Soil C sequestration can be one piece of the solution, but

multiple avenues should be utilized





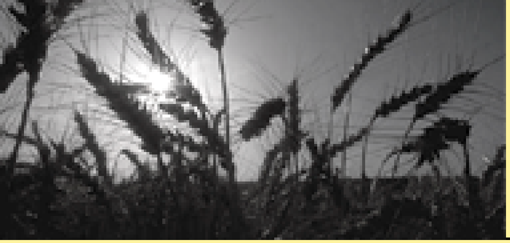
"The nation that destroys its soil destroys itself."

--Franklin D. Roosevelt

Conclusions

- Biochars are complex heterogeneous materials on many levels
  - Surface chemistries
  - Responses in the soil environment
- We need to understand biochar’s mechanisms
  - Fully utilize the chemical, physical, and microbial properties of biochar to obtain the anticipated function.

  In other words, to optimize for a particular use or “designer biochar” (Novak, 2009)



Acknowledgements

Minnesota Department of Agriculture – Specialty Block Grant Program

Minnesota Corn Growers Association

- Dynamotive Energy Systems
    - Fast pyrloysis char (CQuest™) through non-funded CRADA agreement
- Best Energies
    - Slow pyrolysis char through a non-funded CRADA agreement
- Northern Tilth
- 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
- Penn State
- University of Bonn (Germany)
- Laboratorio di Scienze Ambientali R.Sartori - C.I.R.S.A. (University of Bologna, Italy)
- IRNAS-CSIC (Spain)
- USDA-ARS Biochar and Pyrolysis Initiative

- Technical Support : Martin duSaire
- Graduate Students: Ed Colosky and Eric Nooker
- Undergraduate Students: Tia Phan, Lindsey Watson, Lianne Endo, Amanda Bidwell, Kia Yang, Michael Ottman, Lafu Yang, and Vang Yang

Summer High School Students: Rena Weis, Abby Anderson, and Tara Phan