Biochar:
Impacts on Soil Microbes and the Nitrogen Cycle

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Biochar

Properties of Biochar

Stable (resident times 100 to 10,000 yrs)
High carbon content
Mechanism to “lock” atmospheric carbon in soil

Gaining significant attention

>Carbon Storage (Climate Change)
Biochar can store atmospheric carbon, potentially providing a mechanism for reduction in atmospheric CO_2 levels

>Soil Improvements
Improves water quality, plant growth, water infiltration
Improves soil fertility/nutrient cycling
Reduces GHG emissions (N_2O, CH_4)

>Bio-energy Source (Renewable energy source)

ARS Biochar Research

- Part of new ARS multi-location:

Biochar and Pyrolysis Initiative

- 6 ARS locations:

  Ames, IA; Kimberly, ID; St. Paul, MN;

  Big Spring, TX; Florence, SC; Prosser, WA.

  +additional sites in the near future

- Biochar used in replicated field plots
- Continuous corn (same crop for comparison)
- In addition to following crop yield and soil carbon:
  - ✓ Soil gas concentrations and trace gas fluxes
  - ✓ Seedling Emergence/Initial seedling growth rates

USDA

Agricultural Research Service

Biochar Impacts on Soil Microbes & N Cycling

- 26 different biochars evaluated
- 11 different biomass parent materials
  - Hardwood, softwood, corn stover, corn cob, macadamia nut, peanut shell, sawdust, algae, coconut shell, turkey manure, distillers grain
- Represents a cross-sectional sampling of available “biochars”
  - C content 1 to 84 %
  - N content 0.1 to 2.7 %
  - Production Temperatures 350 to 850 ^{o}C
  - Variety of pyrolysis processes
    - Fast, slow, hydrothermal, gasification




“Biochar” Alone

Corn (Stover,Cob,DG)

Pine

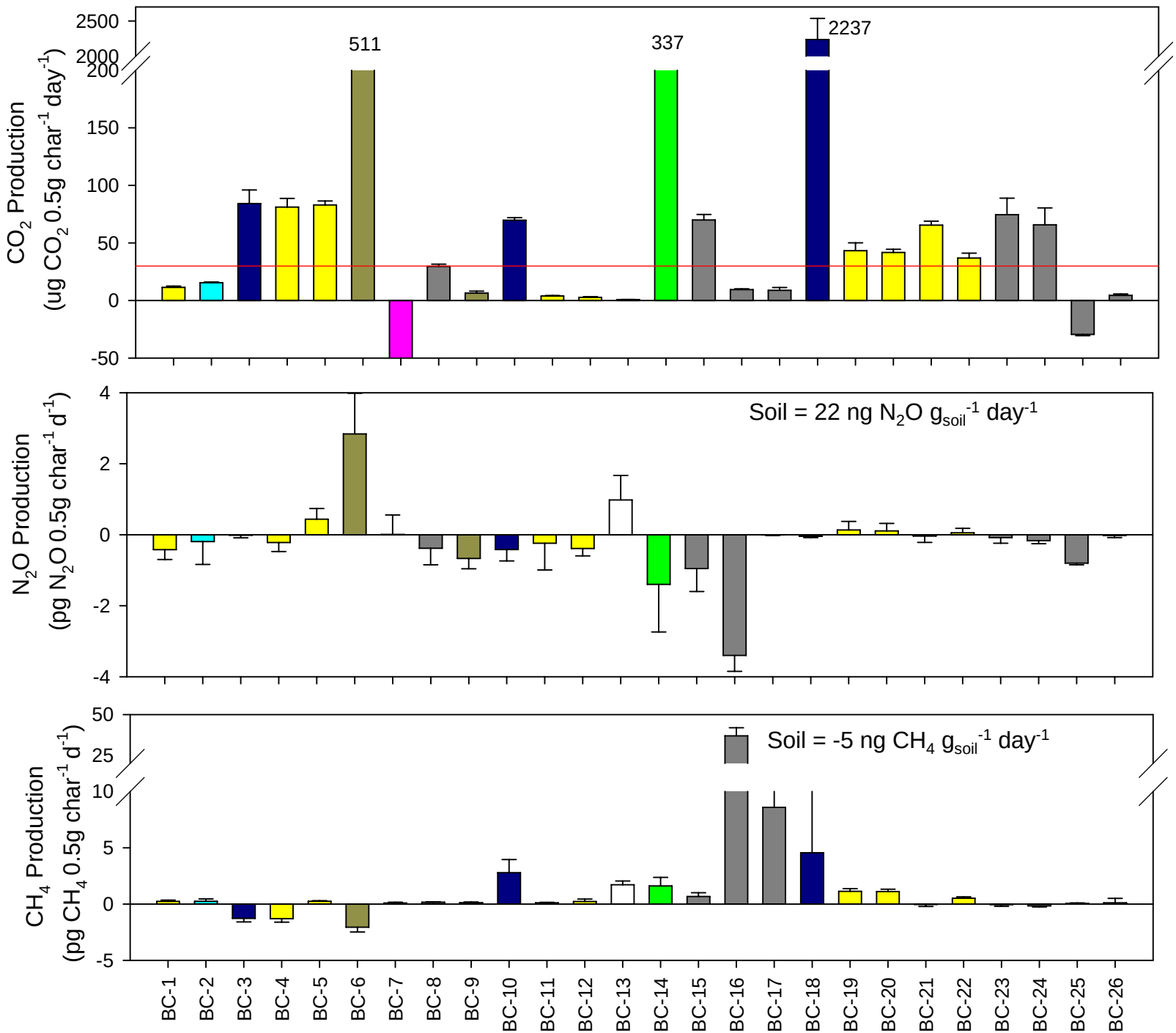
Shells (peanut/mac)

Pine + Compost

Turkey manure

Wood

Algae



Correction for Biochar production

$$\mathrm{CO_2\,Production\ Rate\ Corrrected} = \frac{\left(CO_2^{\,biochar+soil} - CO_2^{\,biochar}\right)}{5g_{soil}(\mathrm{t}_d)},$$

$CO_2^{\,biochar+soil}$ is the total CO_2 production from the soil + biochar + water incubation (µg CO_2) at time t_d

$CO_2^{\,biochar}$ is the total CO_2 production (µg) at time t_d for the biochar + water incubation

t_d is the time of sampling (days)

Soil + Biochar

Corn (Stover,Cob,DG)

Pine

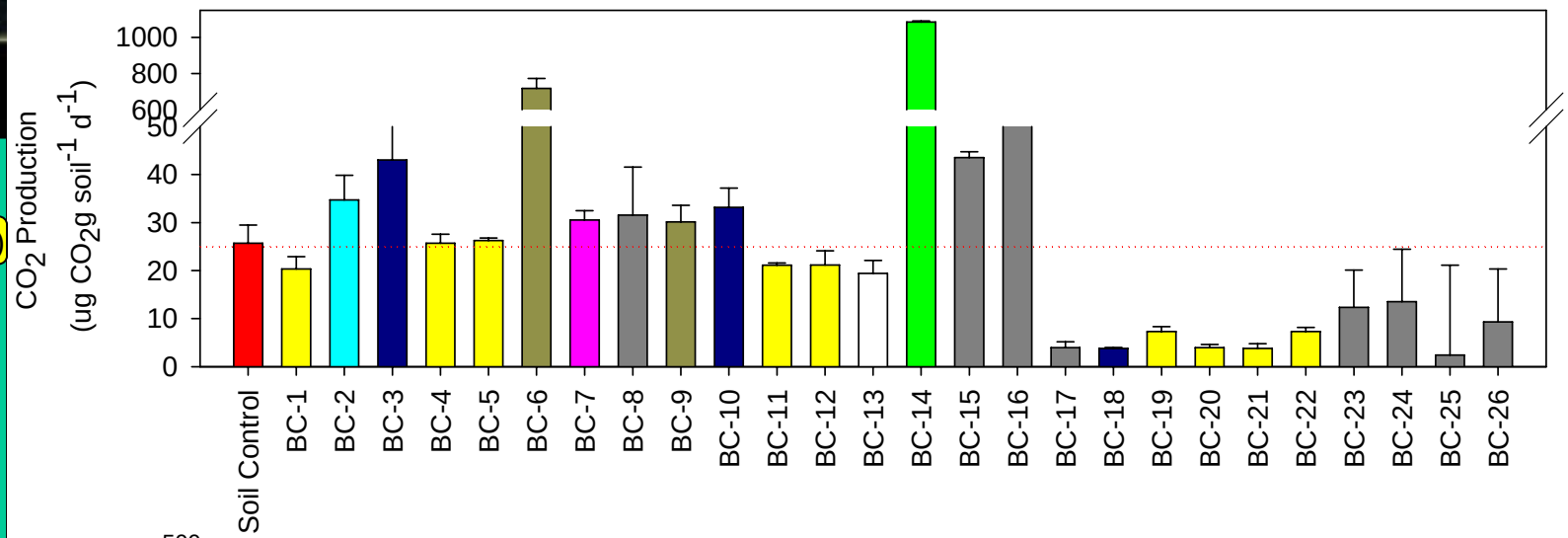
Shells (peanut/mac)

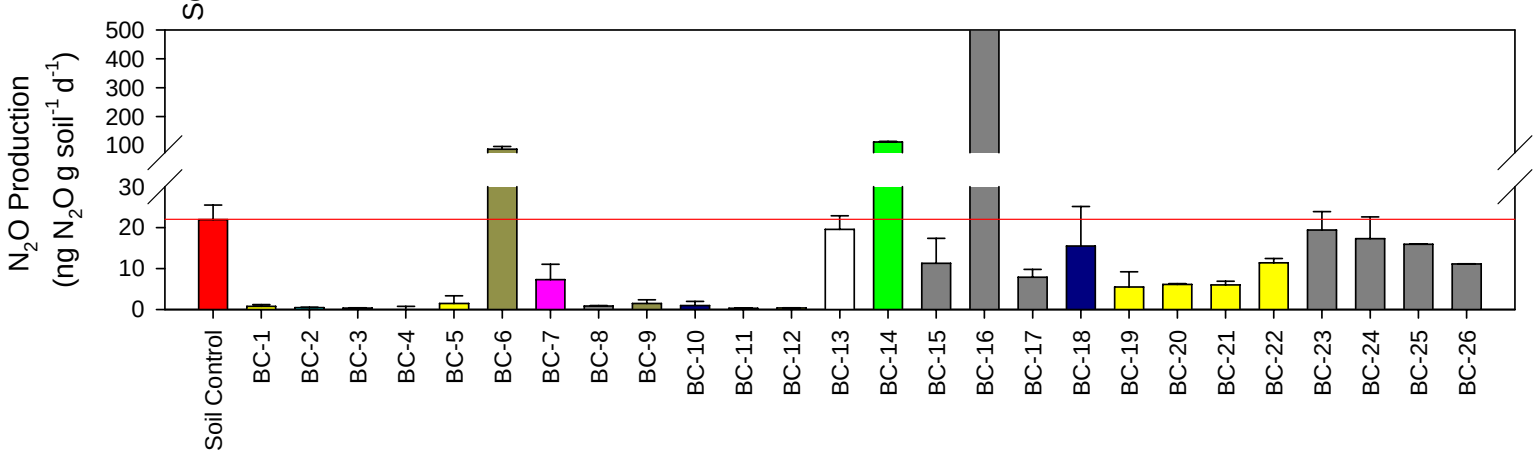
Pine+Compost

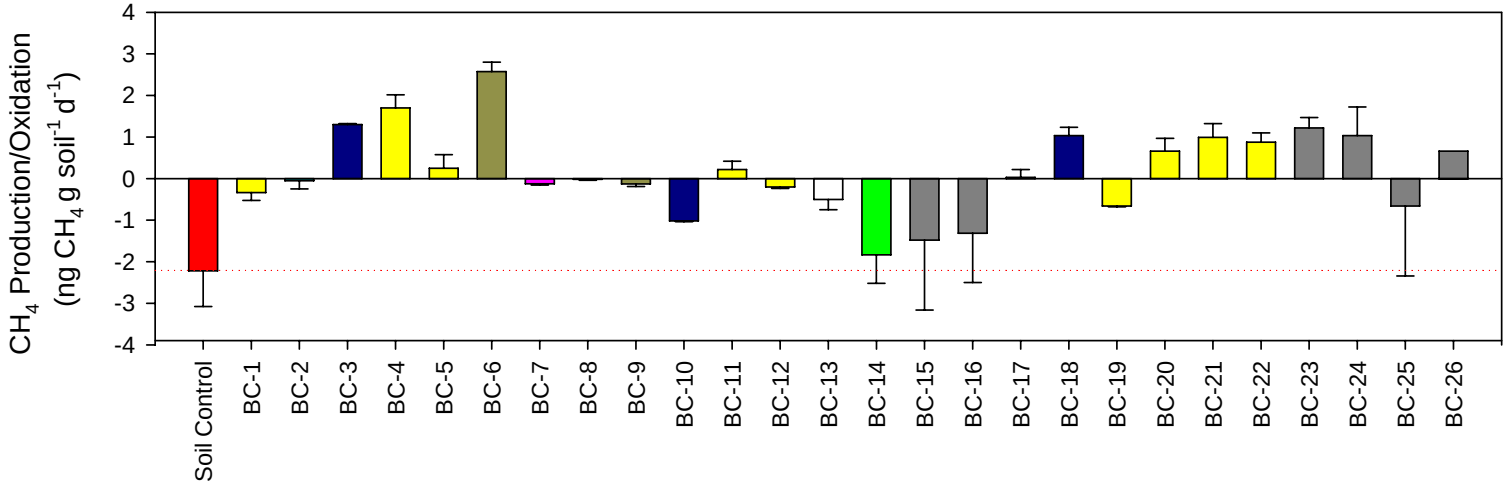
Turkey manure

Wood

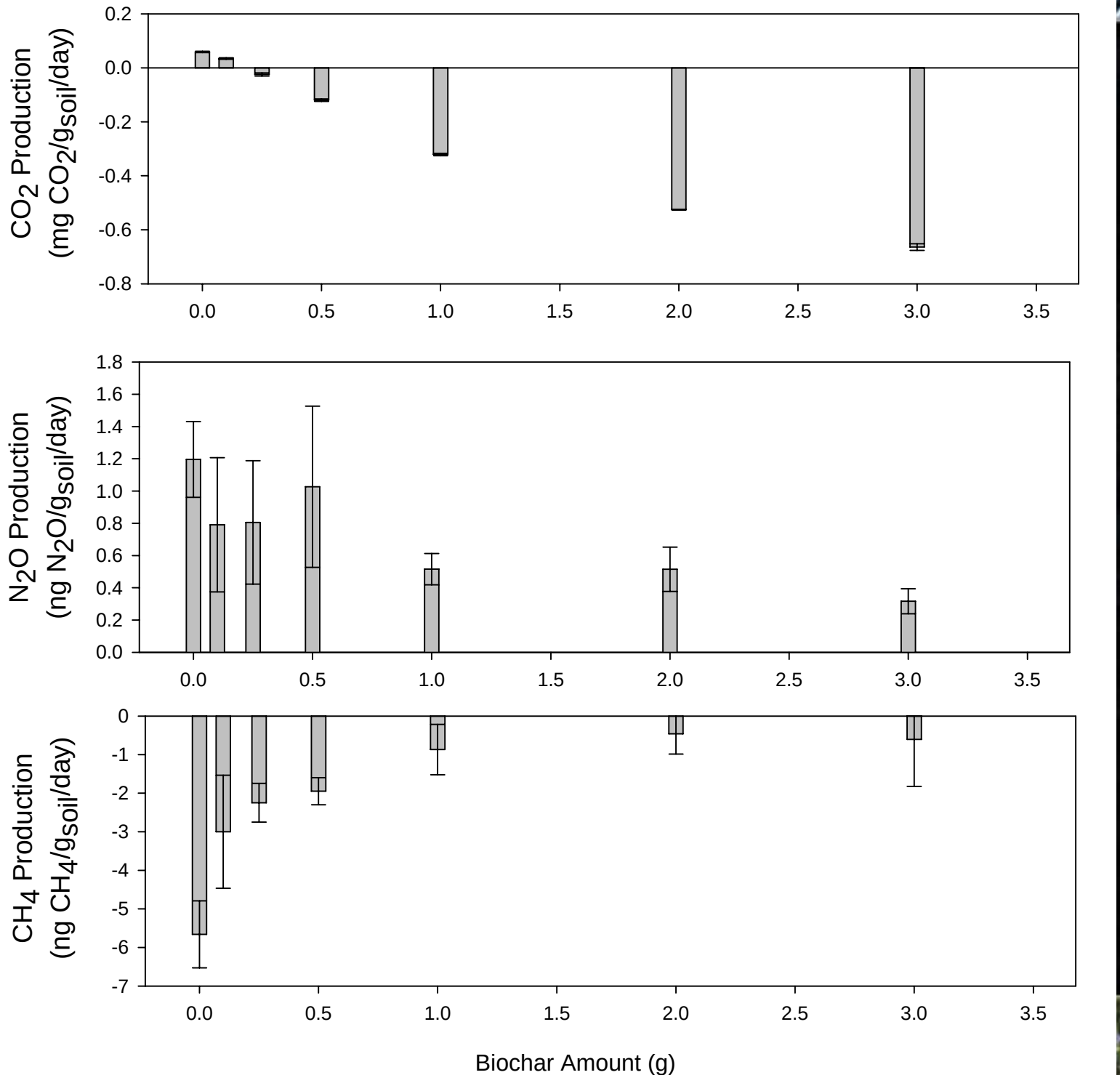
Algae



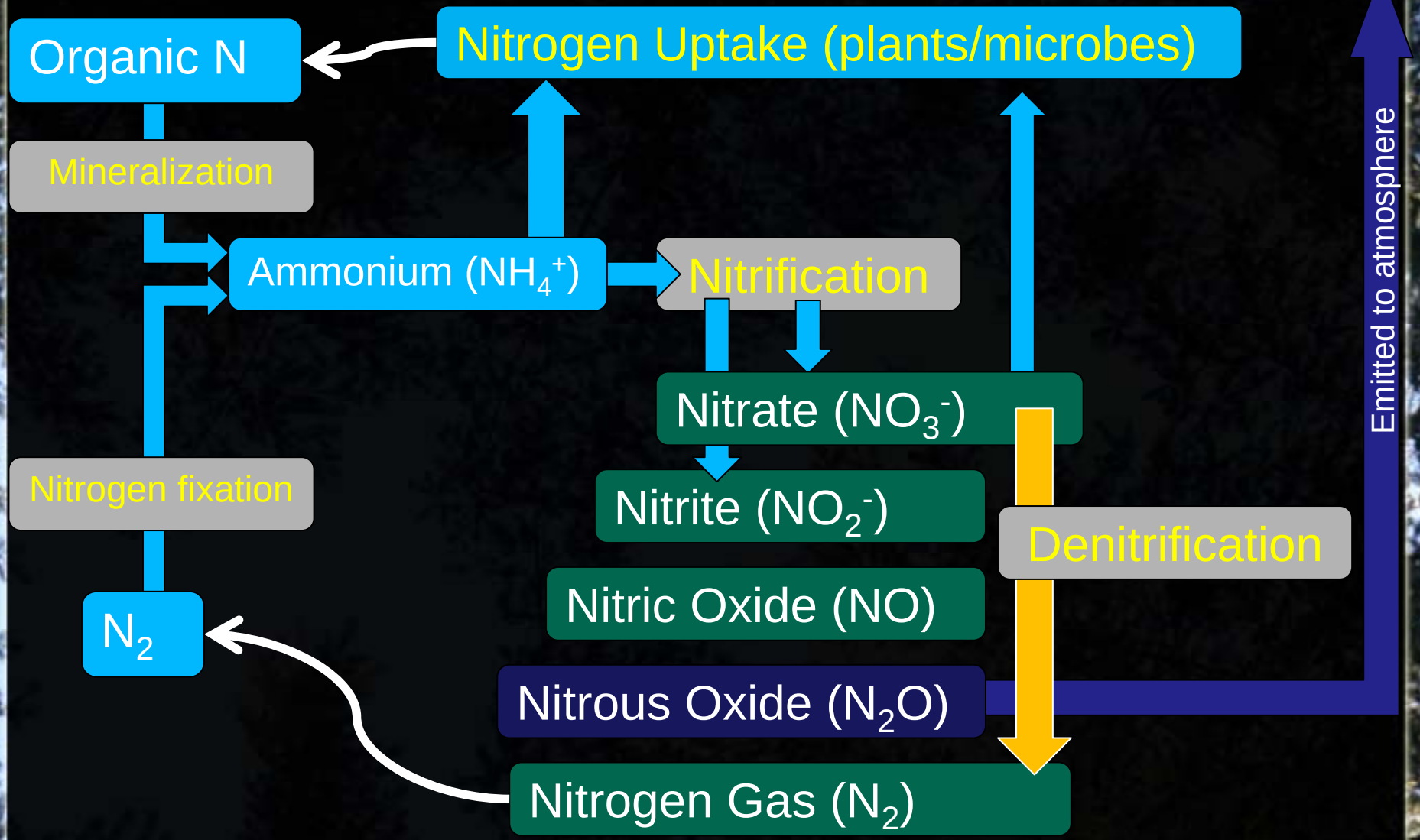




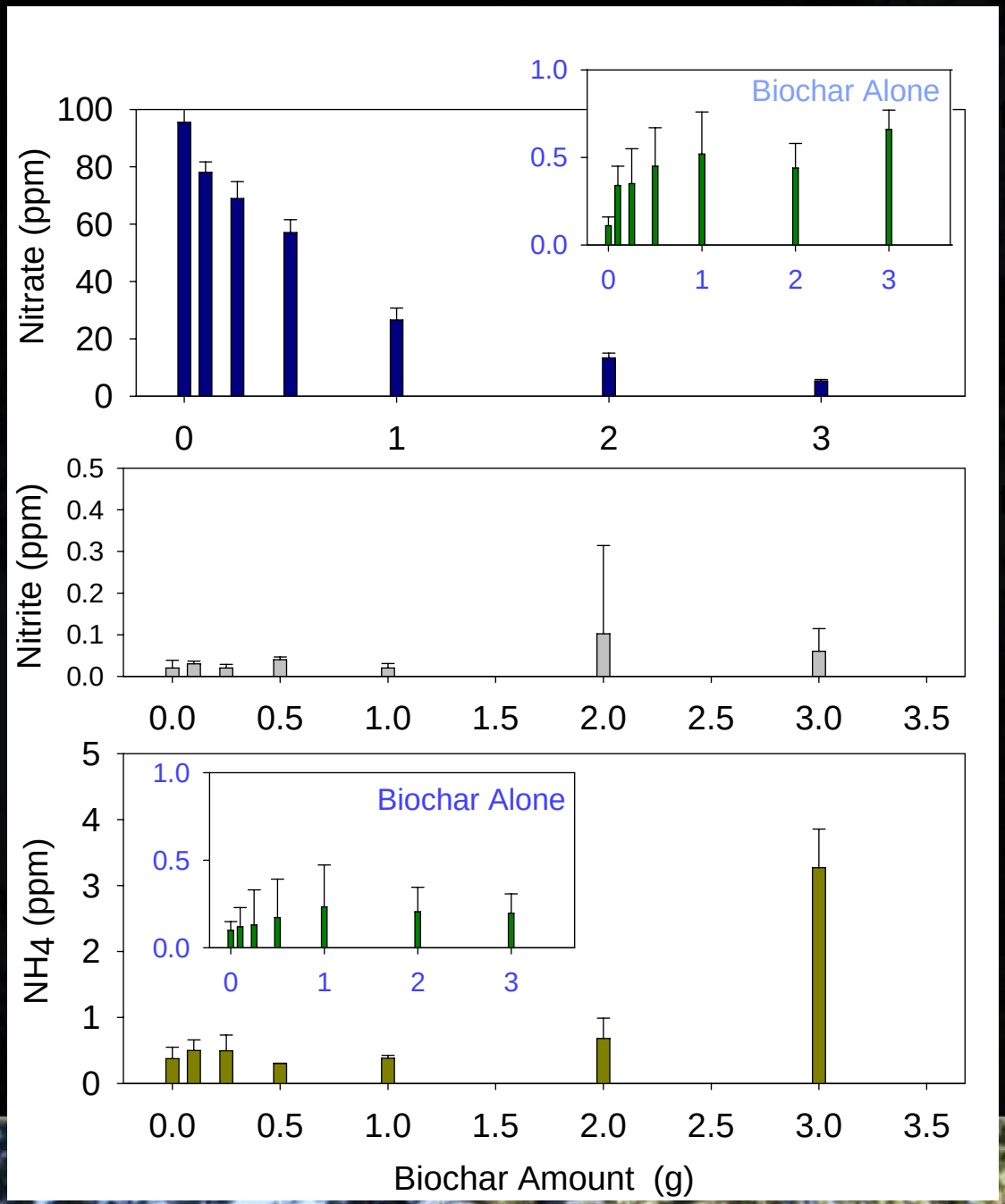
Influence of biochar additions on GHG Production



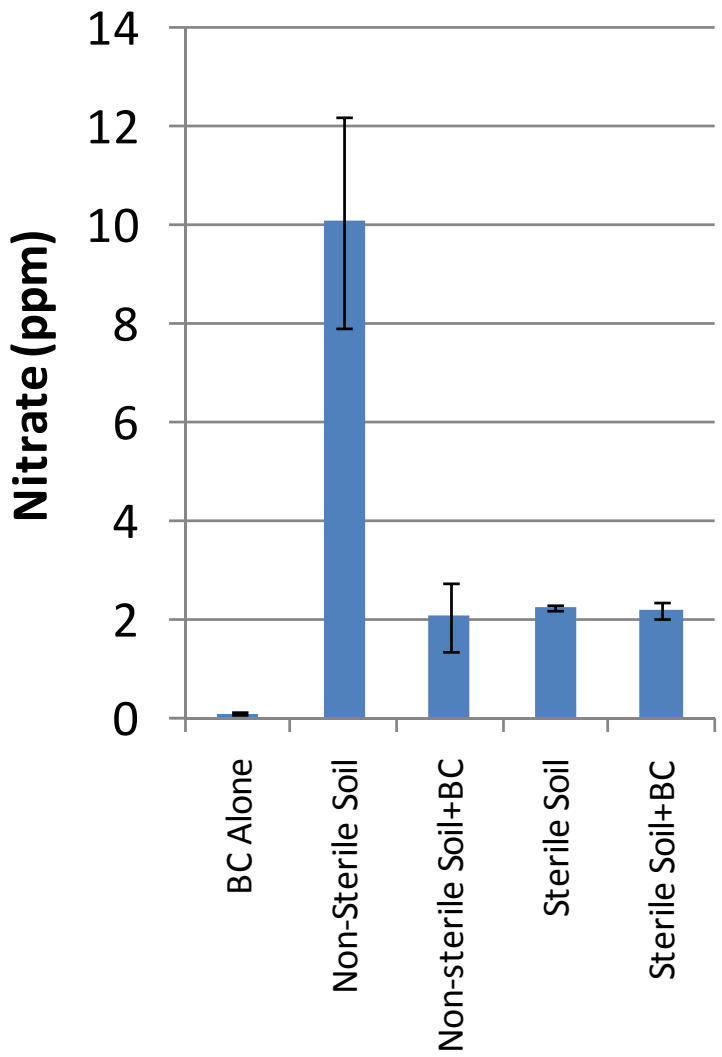
Brief Overview of N-cycle



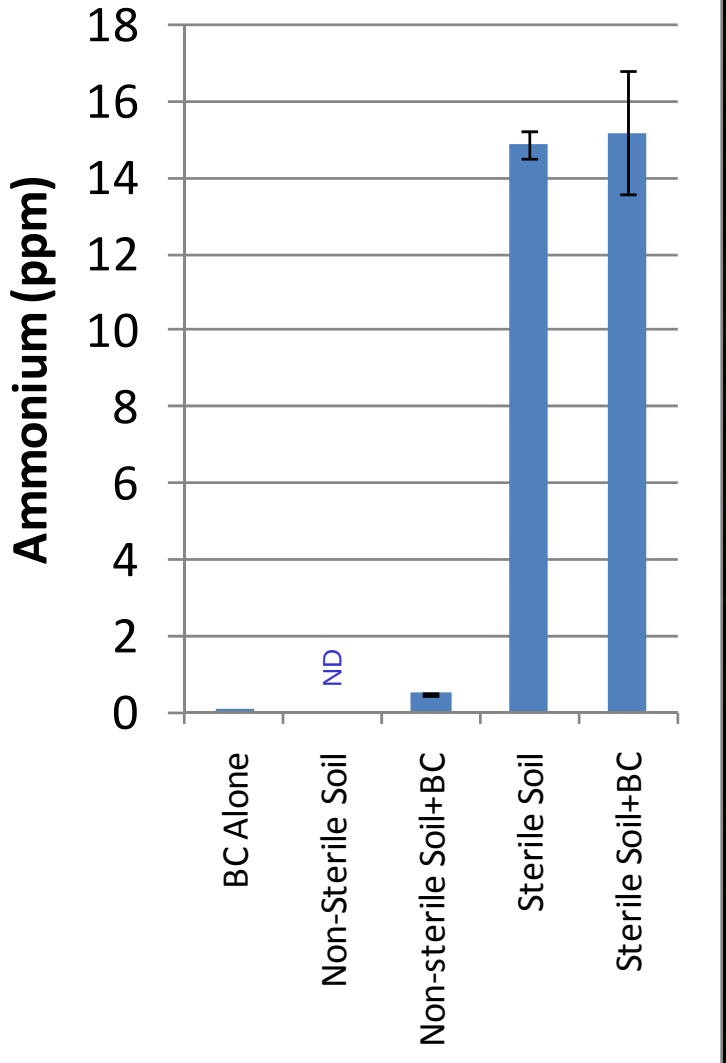
Closer Look at N-cycling



N-cycling: Sterilized soil + biochar

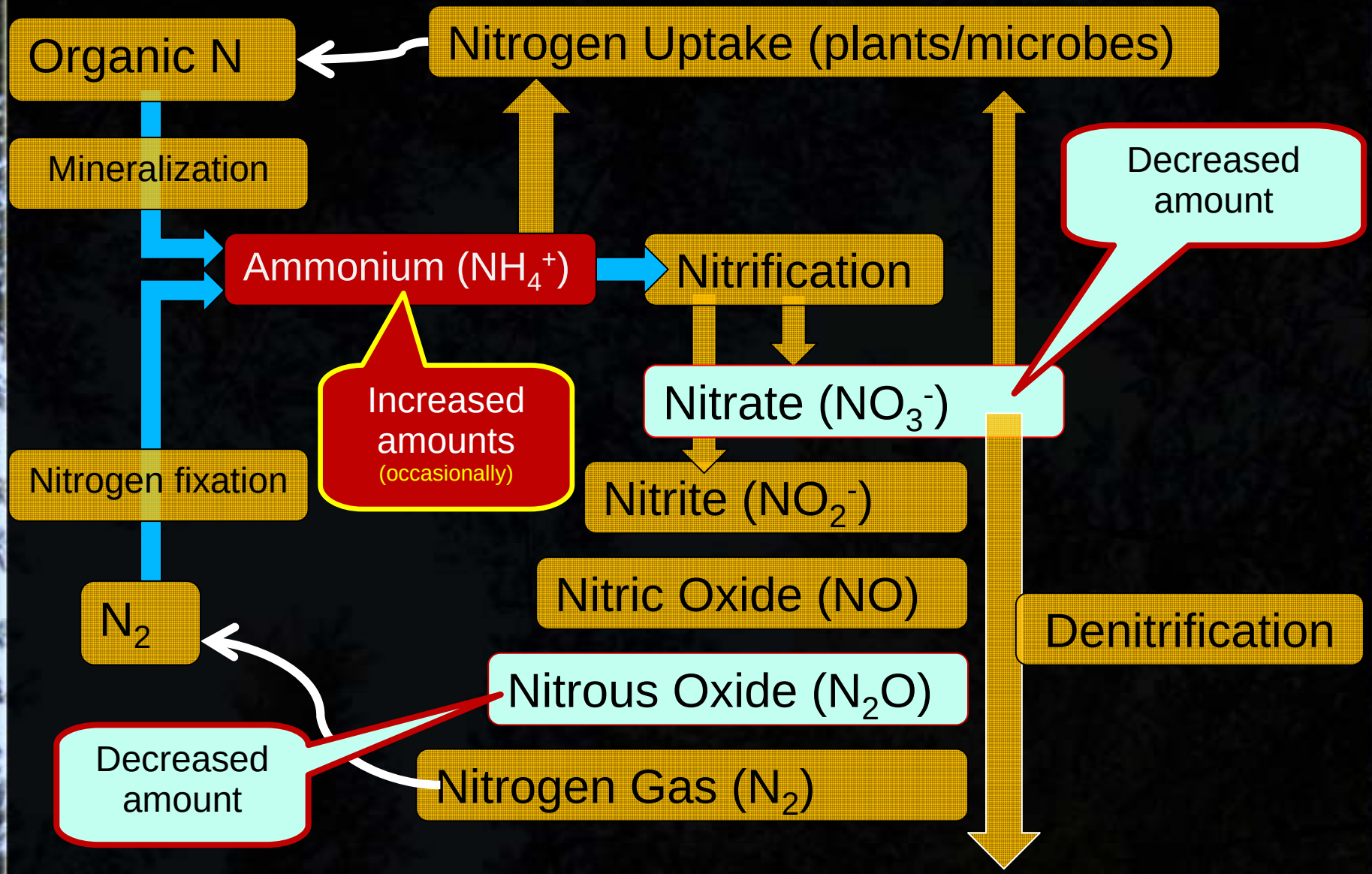


Pine (softwood) char (550 °C)
Slow pyrolysis



Pine (softwood) char (550 °C)
Slow pyrolysis

Putting the pieces together: Not quite a full picture yet



Conclusions

- Positive effect observed so far in laboratory
  - Reduction in N_2O production potential
- Appears to be a consequence of biochar impacting the nitrification process
  - Accumulation of NH^+_4 and decreased NO^-_3
  - Inhibiting nitrification and denitrification ?
- No absolute “biochar” trends
  However, a majority of biochars
  - Reduced soil CO_2 respiration or no significant increase
  - Reduced CH_4 oxidation activity
  - Reduced N_2O production activity
  - Reduced NO_3 availability

Acknowledgements

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Fast pyrloysis char (CQuest™) through non-funded CRADA agreement

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Slow pyrolysis char through a non-funded CRADA agreement

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Biochar Brokers

Chip Energy

USDA-ARS Biochar and Pyrolysis Initiative

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Martin duSaire, Tia Phan, Lindsey Watson, and Lianne Endo

Rosemount, MN Biochar Field Trials

- Small scale triplicate plots (16’ x 16’)
  - >Largely due to the limited availability of biochar.

(Application rate : 20,000 lbs/acre)

- Fast pyrolysis biochar (sawdust, CQuest™ Dynamotive[1])
  - With and without manure addition (5,000 lb/acre)
- Slow pyrolysis biochar (woodchip, Best Energies[1])
- Slow pyrolysis biochar (macadamia nut, Biochar Brokers[1])
- Slow pyrolysis updraft gasifier (wood pellets, Chip Energy[1]) [Fall 2009]

- Larger strip plots (16’ x 93’)
  - Hardwood charcoal (ground lump charcoal, Kingsford[1])
  - Slow pyrolysis biochar (macadamia nut, Biochar Brokers[1])
    - 3 rates: 5,000, 10,000 and 20,000 lb/acre

1-Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.