Global Climate Change & Biochar

Impact of Biochar on Soil Greenhouse Gas Emissions

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Importance of Biochar's Effect on Soil GHG Emissions

- According to the IPCC, human activities will need to become net carbon negative by the end of the century
- We know that biochar application adds carbon to the soil, but less is known about its effect on soil greenhouse gas (GHG) emissions
- If biochar were to stimulate soil GHG emissions, carbon sequestration efforts would be reduced or negated

Observed Effects of Biochar

- Decrease Emissions
  - Increase aeration
  - Reduce microbial activity via PAHs
  - Increase humification of residues
  - Strong sorption of DOC
- Increase Emissions
  - Increased soil moisture
  - Increased soil pH
  - Bioavailable C
  - Stimulate microbial activity

The net effect of biochar on soil GHG emissions is highly dependent on biochar and soil properties.

Soil GHG Emissions: Context-Specific Response to Biochar

- Most studies show reductions or no change in N2O and CH4 emissions following amendment with fresh biochar; response of CO2 is more variable.
- Many factors affect response:
  - Biochar properties: High N and P biochars, gasification biochars, and low temperature biochars have been shown to induce increased emissions
  - Soil properties: Response in emissions to biochar amendment has been shown to

Goals

- quantify the impact of biochar properties on GHG emissions from diverse soils
- identify mechanisms by which biochar properties influence GHG emissions from soils

Hypotheses

- Fresh biochar will decrease GHG emissions of soil
- Aged biochar will either decrease or not change GHG emissions of soil
- Aged and fresh biochars will both increase soil moisture
- GHG emission rates will be positively correlated with soil moisture content

General Approach

- Overall study to be conducted in three phases
  1. Biochar characterization
     - Total alkalinity, organic alkalinity, inorganic alkalinity, ash, surface area
  2. Incubations of biochar with soil
     - Three closed incubations (in jars)
     - **One column study (in greenhouse)**
  3. Two field studies
     - **Glacial till-derived Hapludoll**
     - Loess-derived Hapludoll

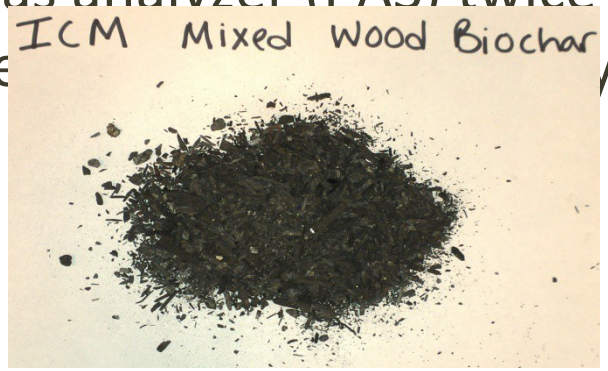
Field Site and Biochar

- Clarion loam soil under no-till continuous corn
- Mixed wood gasification biochar pyrolyzed ~600°C (ICM)
- 0-50 tons/ac of biochar (~50% water) amended in October 2010 and incorporated to ~30 cm
- 10 tons of corn stover applied to surface to prever
- Only 0 analyzed in this s
- Treatments arranged in incomplete Latin square

0	30	20	10	40	50
40	50	30	0	20	10
20	10	40	50	0	30

Field Study Design

- One pan was placed in the interrow of each plot
- Fertilizer (32% UAN) was spoke-applied to the rows on 6/11
- Additional pans placed in the rows following fertilizer application
- N2O and CO2 emissions quantified using a photoacoustic gas analyzer (PAS) twice a week for two weeks following fe y for on

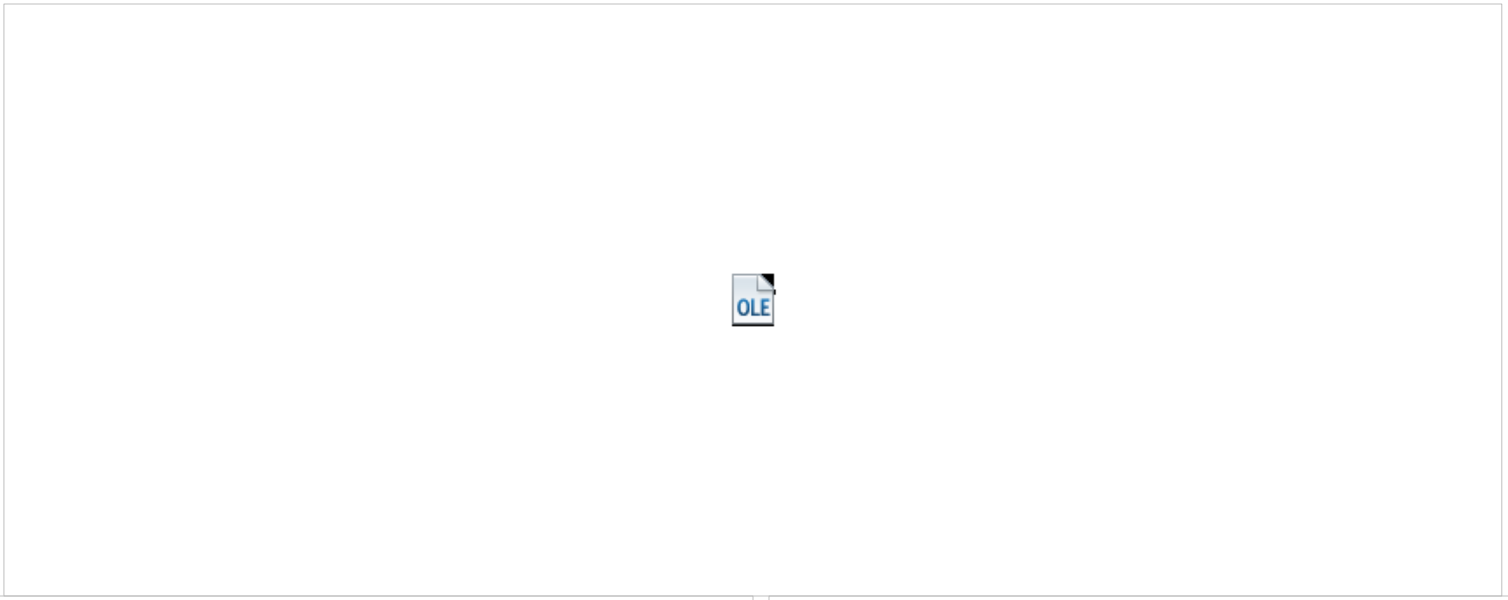


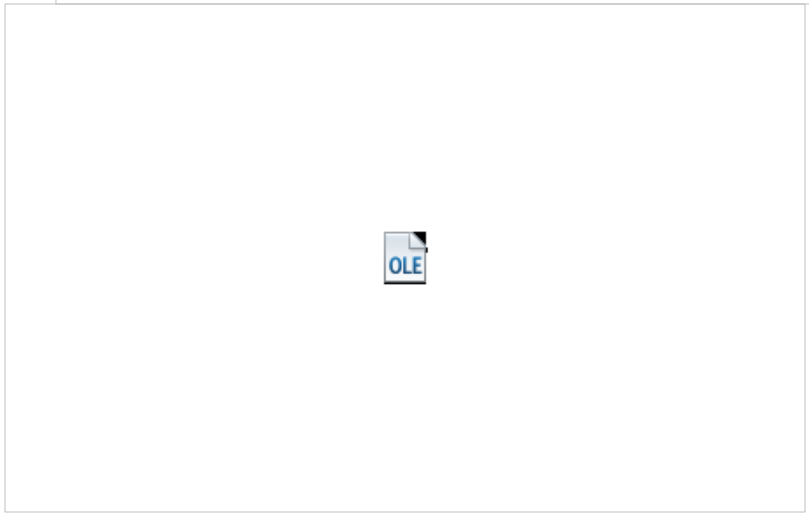
Column Study Design

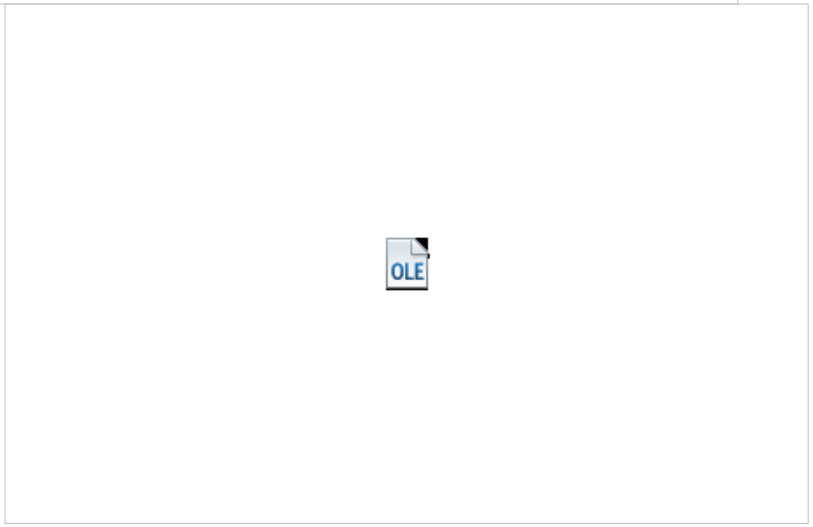
- Fresh char treatment: soil taken from control plot, sieved, and biochar mixed in
- Aged char treatment: soil taken from plots with biochar (aged 2.5 years) and sieved
- Columns packed with ~1kg of soil to bulk density of 1.3 g/cm3.
- Columns leached with 200-250 mL of dilute CaCl2 three times
- Fertilizer added after 37 days of equilibration
  - 90 lb/ac N as NH_4^+ or NO_3^-

- Results: Field Study

Precipitation and Moisture







Cumulative N2O Emissions in Field

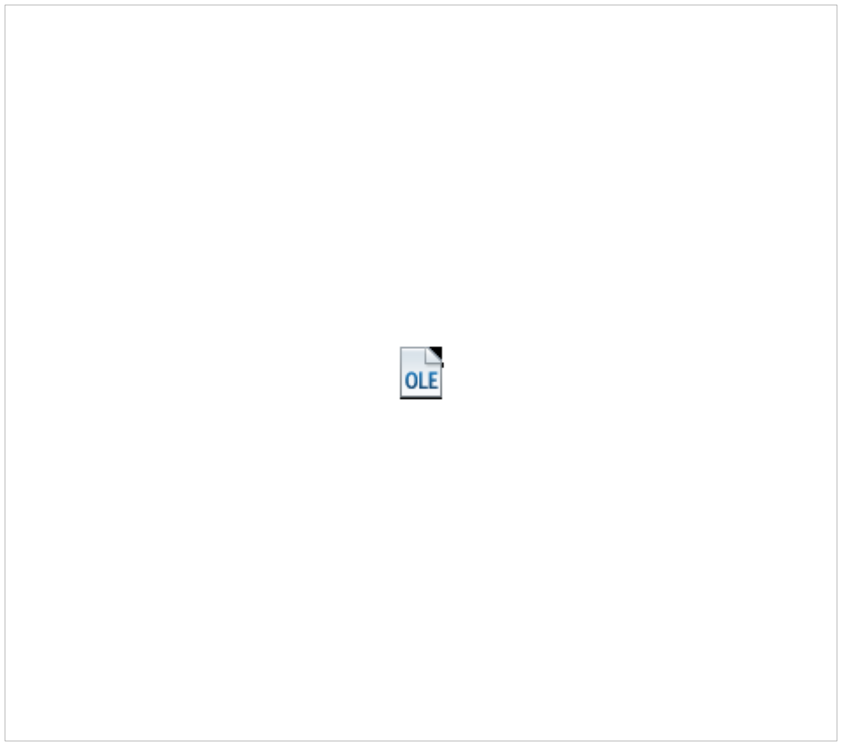
Cumulative CO2 Emissions in Field

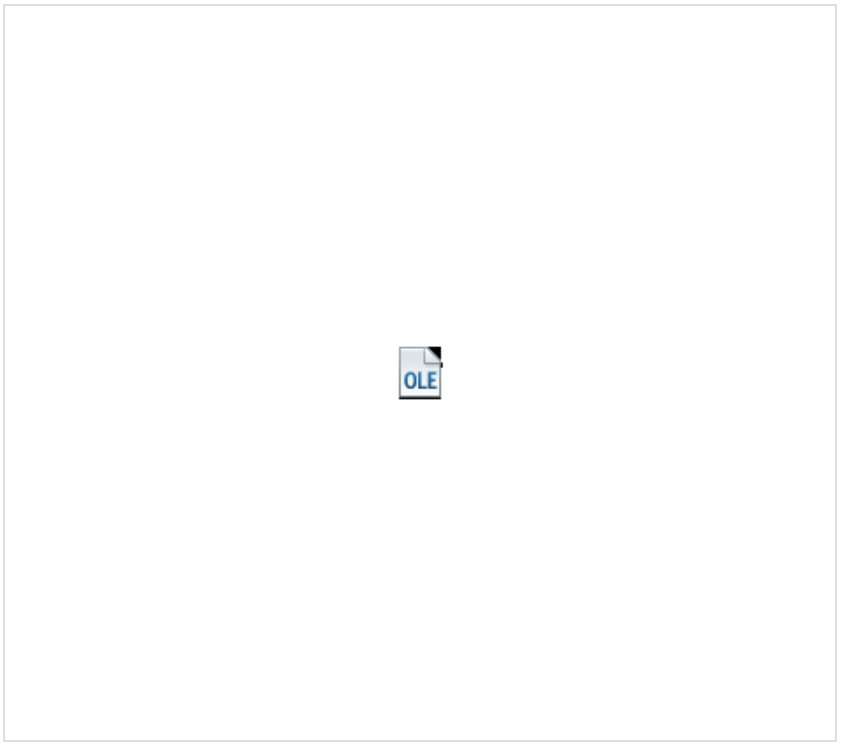
Influence of Soil Moisture on N2O Emissions

Total N2O Emissions in Greenhouse

- Aged biochar increased emissions, especially from columns fertilized with NO3-
- Emissions from NH4+-fertilized columns higher than NO3--fertilized columns

Total CO2 Emissions in Greenhouse





Summary of Field Study Results

- Soil moisture was correlated with N2O emissions
- Biochar amendments significantly increased soil moisture
- Biochar did not significantly increase N2O or CO2 emissions, despite biochar's effect on moisture

Summary of Column Study Results

- Fresh biochar did not affect N2O emissions
- Aged biochar increased N2O emissions only when amended at specific rates
- Neither biochar affected CO2 emissions
- Biochar did not appear to affect soil moisture (study still in progress)

Discussion

- Increased moisture may be a mechanism by which biochar could increase N2O emissions, but this effect may be negligible
- Other properties of biochar may cancel out effect of moisture on N2O emissions
- Biochar may have increased N2O emissions from columns by retaining N in the soil following leaching events
- Field-aging of biochar may negate initial reduction in GHG emissions, or cause an

Conclusions

- Biochar, soil and climate all influence GHG emissions from biochar-amended soils
- Here we observed increased N2O emissions from heavily leached, free-draining soil following application of aged biochar, and no significant change following application of fresh biochar
- The aging of biochar is an important process that influences its properties and interactions with the soil

Next Steps

- Complete characterization of biochar
- Continue monitoring N leached from columns
- Conduct closed-system incubations with two soils and several biochars
- Quantify GHG emissions at other field site (loess-derived soil)

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Questions?