Carbon Dioxide and Nitrous Oxide Emissions from Soils Following Corn Residue Removal for Bioenergy Production

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ABSTRACT. Corn stover has been identified as a potential cellulosic ethanol feedstock prompting assessments of the effects of residue removal on soil processes. The objective of this study was to determine the effect or corn residue removal on carbon dioxide (CO_2) and nitrous oxide (N_2O) fluxes from soil. A replicated field trial of continuous corn (*Zea mays* L.) production was established in 2007 on Endoaquoll and Hapludoll soils near Ames, IA. Treatments included 0, 50, and 100% surface residue removal from corn under chisel plow (CP), no-tillage (NT), and chisel plow with a one-time 18,500 kg ha^{-1} biochar application (Biochar). Soil CO_2 flux was measured using a Li-Cor LI-8100 infrared CO_2 analyzer at one PVC collar (0.031 m^2 area) inserted into the soil at in-row and between-row positions in each plot. Soil N_2O flux was measured by collecting gas samples beneath closed covers on the same collars followed by sample analysis by gas chromatography. Hourly soil water content (θ) and temperature (T) at 5 cm adjacent to each collar were measured with Decagon 5TM or EC-TM sensors and EM50R dataloggers. 100% and 50% residue removal reduced annual soil CO_2 flux by an average of 11% and 2.5% across all years and treatments. Fluxes of N_2O were dominated by high values following a sidedress application of 32% UAN at 180 kg ha^{-1} rate and with Agrotain urease inhibitor. The measured N_2O fluxes in 2011 had an average global warming potential (GWP) equivalent to 15.8% of the CO_2 fluxes, also with lower fluxes with increasing residue removal.

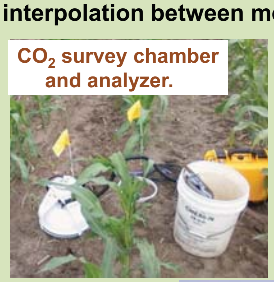
OBJECTIVE

Use static chamber, soil T and θ measurements to estimate the annual soil CO_2 and N_2O fluxes for continuous corn cropping systems under chisel plow (CP), no-tillage (NT), and chisel plow with a single biochar application (Biochar) with removal of No, 50% and 100% of surface residue following grain harvest.

MATERIALS & METHODS

- Study initiated in 2008 at Iowa State University Agronomy/Agricultural and Biosystems Engineering farm located in central Iowa.
- Randomized complete block with 4 replicates of 22 treatments in 12.2 x 91.4 m plots.
- Soils: Webster silty clay loam (fine-loamy, mixed, superactive, mesic Typic Endoaquolls), Clarion loam (fine-loamy, mixed, superactive, mesic Typic Hapludolls), and Canisteo silty clay loam (fine-loamy, mixed, superactive, calcareous, mesic Typic Endoaquolls).
- CO_2 and N_2O fluxes were measured from 2 20 cm-diameter PVC collars (in-row and between-row) in each plot of 9 treatments (CP, NT, and Biochar with No, 50%, and 100% surface residue removal) with a Li-Cor LI-8100 analzyer and 8100-103 survey chamber and constructed static chambers following GRACEnet (http://www.ars.usda.gov/research/programs/programs.htm?np_code=204&docid=17271&page=1) protocols, respectively. Measurement intervals ~biweekly during growing season and ~monthly over winter with strategic N_2O sampling follow N fertilization.
- Soil T and θ measured with Decagon 5TM or EC-TM sensors and EM50R dataloggers at 5 cm depth adjacent to each flux collar.
- Annual flux estimates from interpolation between means of treatment data points.

Decagon logger with buried T and θ sensors.



CO_2 survey chamber and analyzer.

N_2O chambers with survey soil T and θ sensors.

Long-term, continuous CO_2 chamber system added in 2012.

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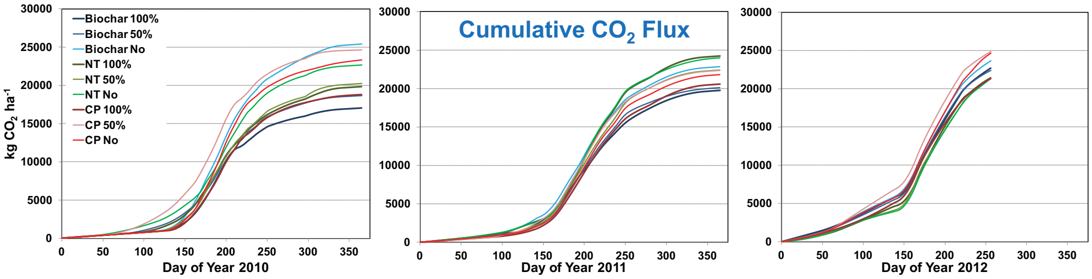
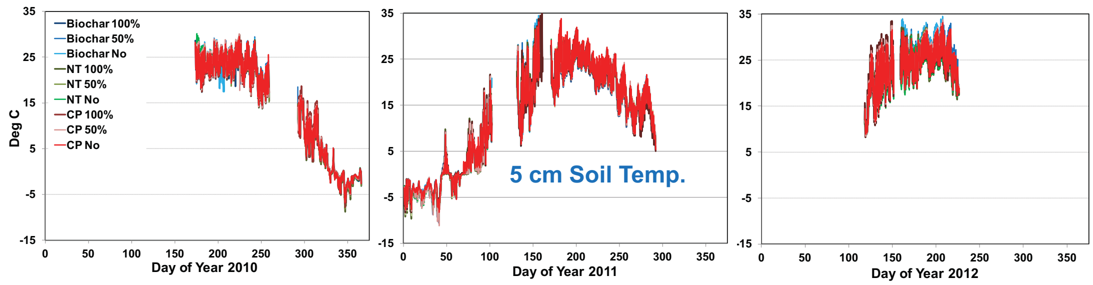
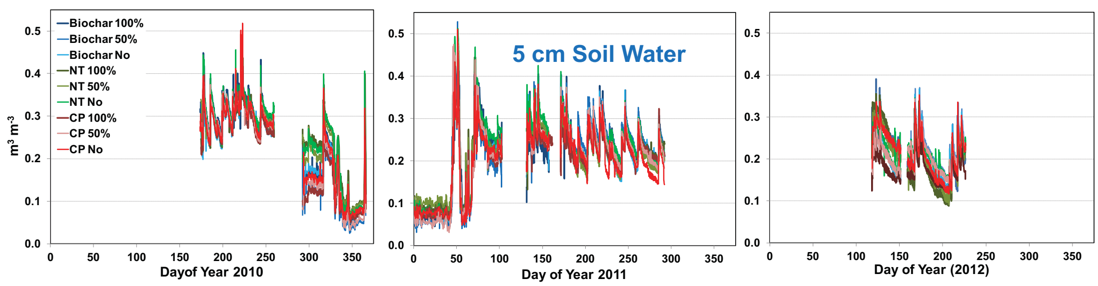
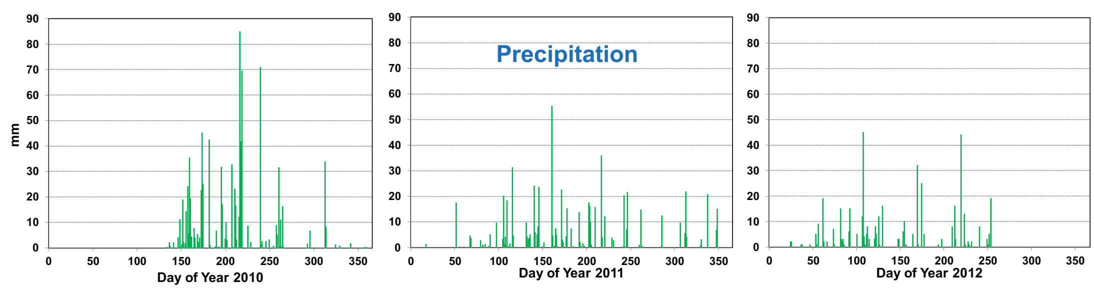
RESULTS

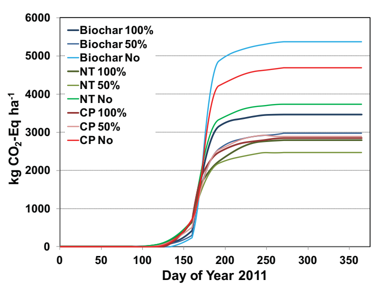




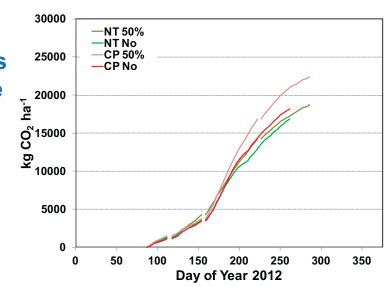




2011 Cumulative N_2O Flux



2012 Continuous Cumulative CO_2 Flux



CONCLUSIONS

- 100% and 50% surface corn residue removal reduced annual soil CO_2 flux by an average of 11% and 2.5%, respectively, across all years and treatments.
- 2011 N_2O flux had on average 15.8% of the GWP as CO_2 (CO_2-Eq range 11.0 to 23.5%). 100% and 50% residue removal reduced N_2O fluxes by 33% and 39%, respectively.
- Compared with CP, Biochar and NT treatments had comparable CO_2 fluxes for No and 100% residue removal but 14.7% and 10.4% reductions with 50% removal. (Note that no CO_2 flux measurements are made during tillage operations.)
- Continuous 2012 CO_2 flux measurements were within 9% of estimates from survey data.
- Residue removal rates did not have significant effects on 5 cm soil T and θ.

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