Nitrous Oxide, Nitric Oxide, and Methane Emissions Under Varying Tillage and Fertilizer Management in the Upper Mid-West

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OBJECTIVES

• Increased soil C resulting from reduced tillage could have the Unintended Consequence of altering denitrification rates and soil nitrous oxide (N_2O) emissions. Tillage practices may also affect the exchange of methane (CH_4) and nitric oxide (NO) between soil and atmosphere.

• Because N_2O and CH_4 have much higher global warming potentials (GWPs) than CO_2 (approximately 300 and 25 times higher, respectively), alterations in their exchange rates have the potential to either offset, or augment, gains in soil C from a greenhouse gas (GHG) perspective. NO emissions can promote tropospheric ozone (O_3) formation. O_3 is also a very potent GHG.

• The objective of this study was to examine how tillage and fertilizer mgmt practices affect the exchange of non-CO_2 GHGs and GHG-precursors (NO) in an upper mid-west corn/soybean system.

METHODS

The experimental plots have been maintained since 1991 under 3 different tillage management practices:

CT = Conventional: Fall moldboard plowing following corn and chisel plowing following soybean with spring pre-plant cultivation for corn and soybeans.

CsT = Conservation: Fall chisel plowing following corn and no tillage following soybean with spring cultivation only for soybeans.

NT = No tillage: No fall tillage or spring pre-plant cultivation.

Plots are 36 rows wide by ~ 200 feet long. Each treatment is applied to 3 corn plots, 3 soybean plots, and 3 continuous corn plots each year. This study was done in the corn following soybean plots during the 2003 and 2004 growing seasons.

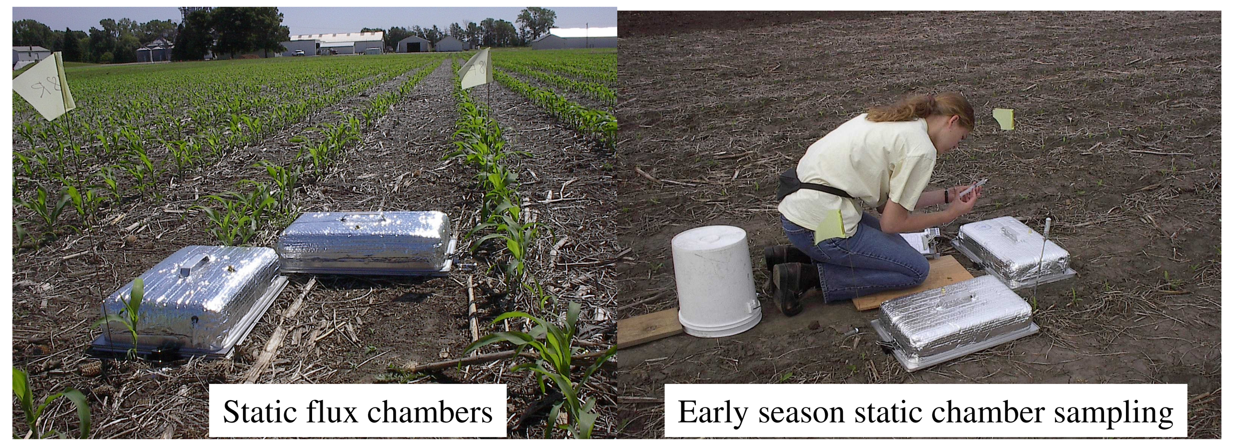
We measured N_2O and CH_4 exchange using vented static chambers twice/wk for most of the study. Samples are collected in glass vials and subsequently analyzed by GC/ECD and GC/FID. In 2004, we also measured NO fluxes using dynamic chambers and a portable chemiluminescent analyzer.

In 2003, all plots received 120 kg N ha^{-1} as broadcast urea (BU) applied 4 wk after planting.

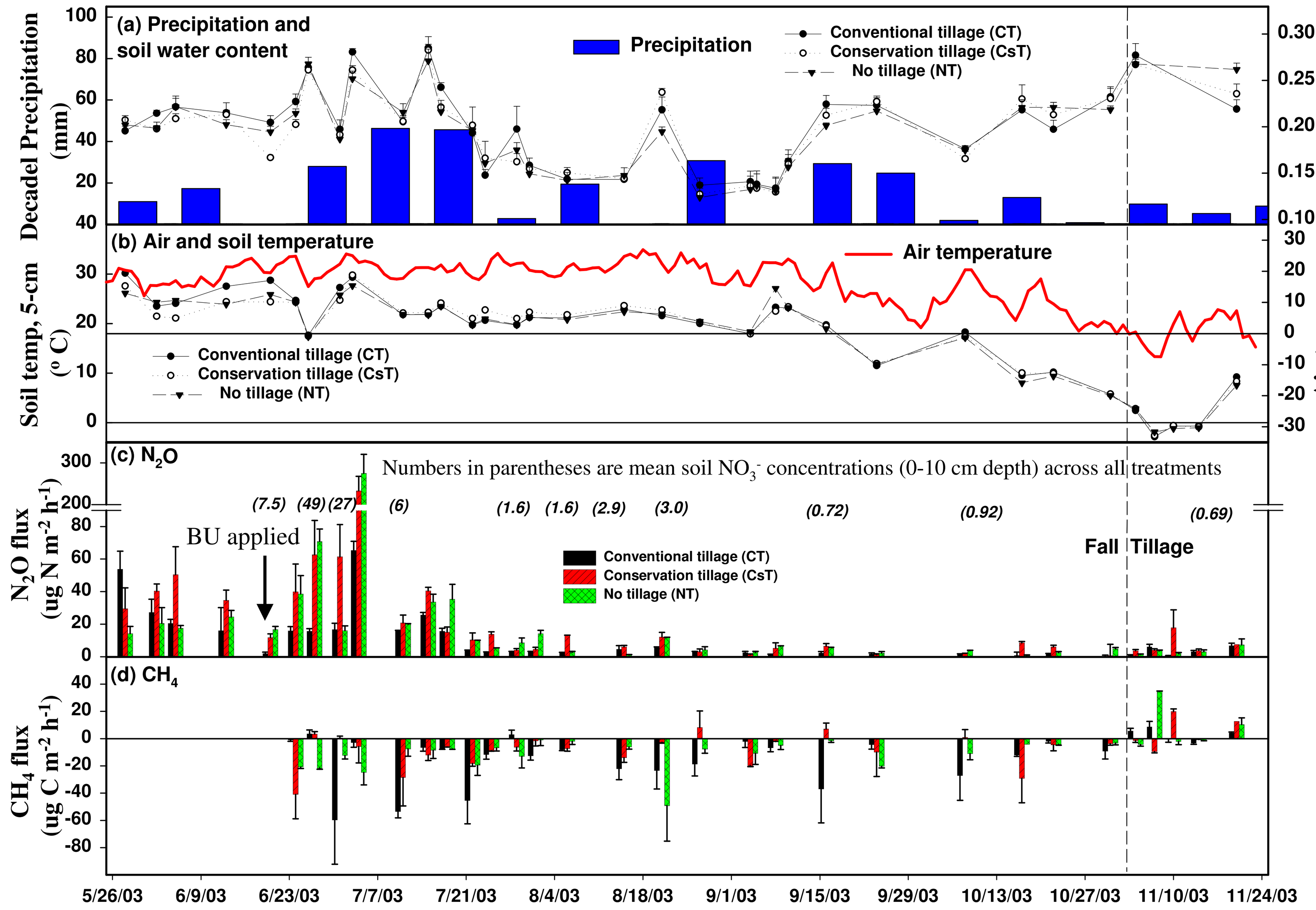
In 2004, we subdivided each tillage plot into 3 subplots. Subplots within each main plot received 120 kg N ha^{-1} as either:

* Injected Anhydrous Ammonia (AA) (applied pre-planting)
* Surface-applied liquid UAN, (applied pre-planting), or
* Surface applied urea (BU) (applied 3 wk after planting).

Pre-plant cultivation, spring 2003

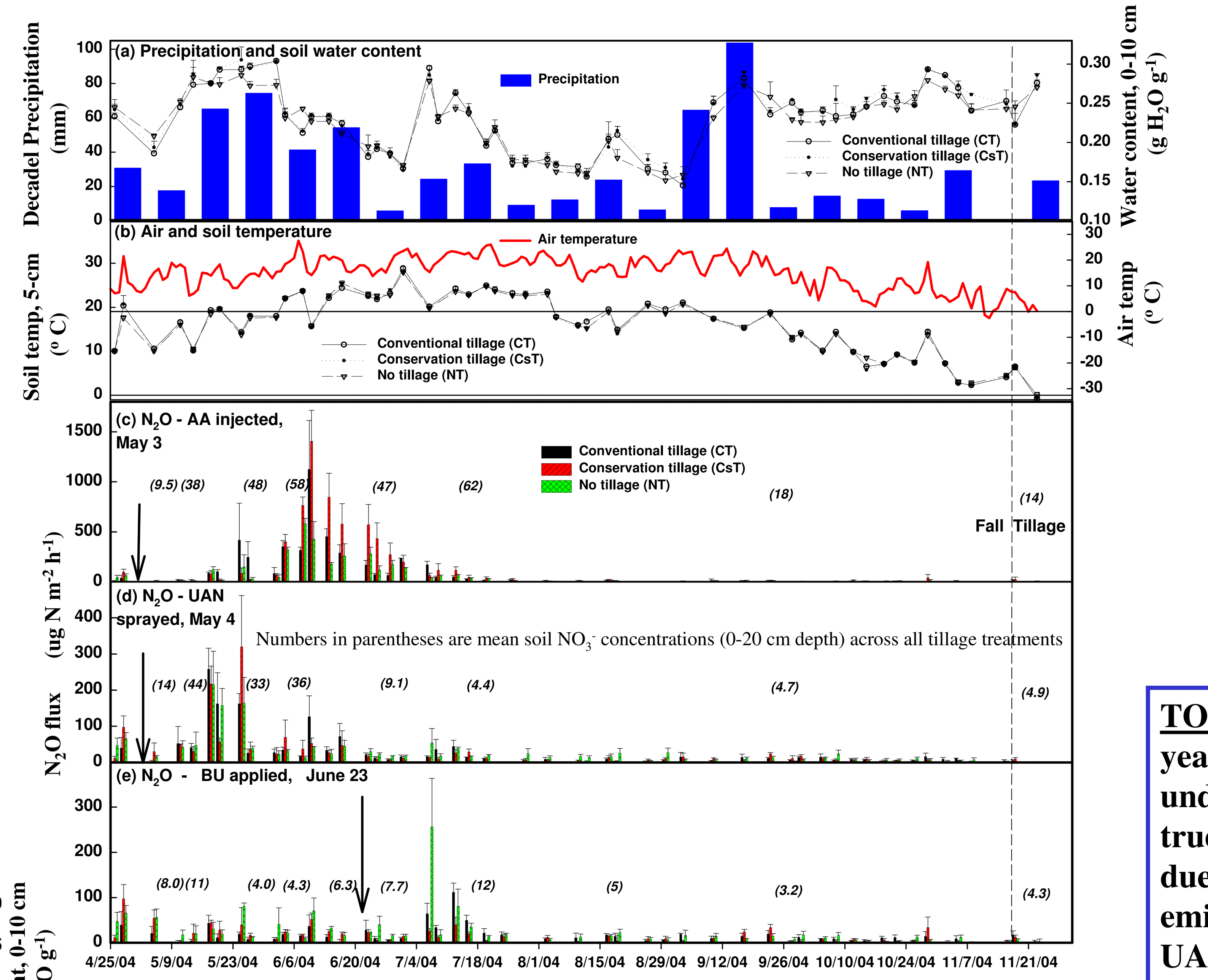


2003 data: Temporal dynamics of N_2O and CH_4 exchange rates under three tillage practices with a single N fertilizer treatment (broadcast urea)



SUMMARY OF 2003 RESULTS (above): N_2O fluxes on most dates were lower under CT than CsT or NT. Soils were a sink for CH_4 except on a few dates, with no apparent differences due to tillage treatment. Growing season precipitation was 40 % of normal. No differences in soil water content (0-10 cm) due to tillage treatment were observed.

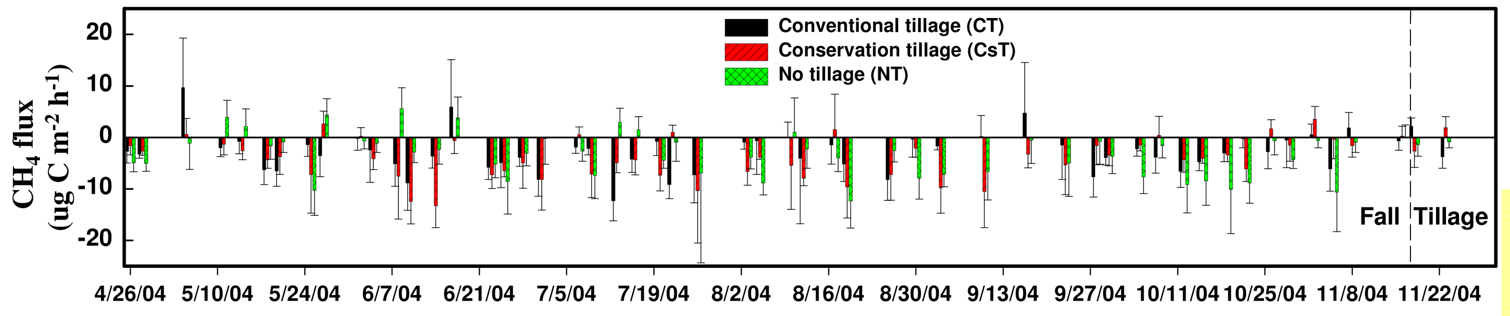
2004 data: Temporal dynamics of N_2O emissions under three tillage practices with three N fertilizer treatments (Anhydrous ammonia, UAN, and Broadcast Urea)



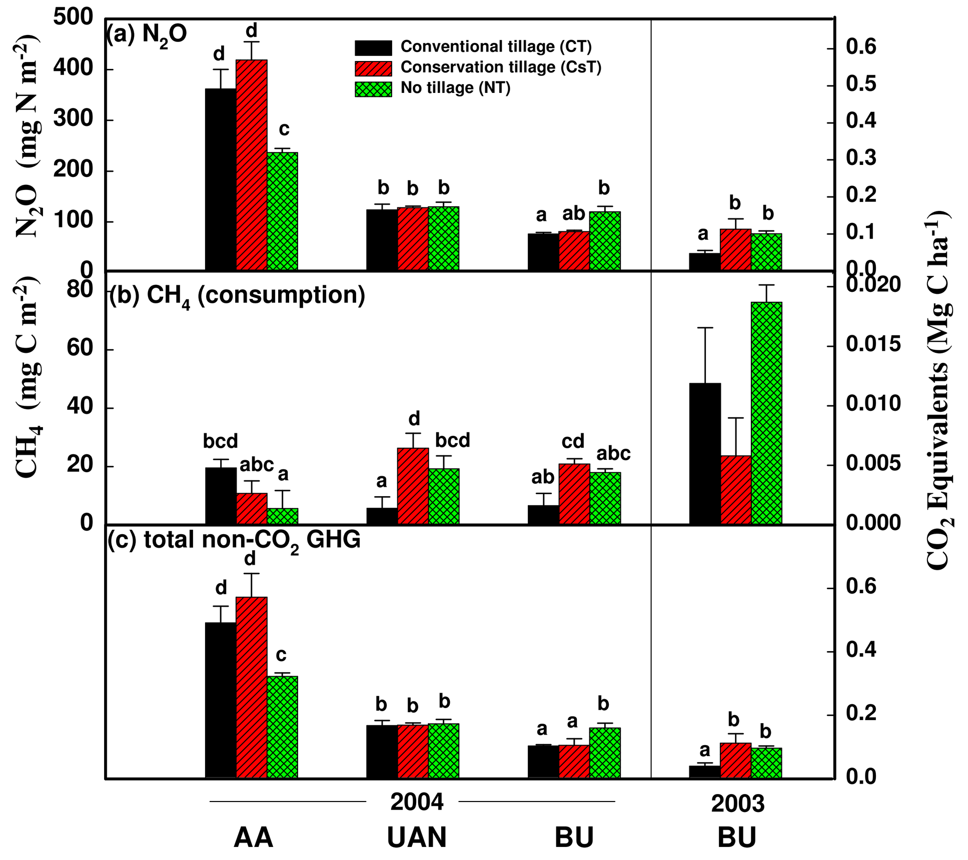
SUMMARY OF 2004 RESULTS: Tillage effects on N_2O flux (above) varied depending on fertilizer treatment. In the AA treatment, N_2O fluxes from NT were lower than CT or CsT. In contrast, in the BU treatment N_2O fluxes from NT were higher than CT, and no tillage effects were observed with UAN. In all fertilizer treatments, temporal dynamics of N_2O fluxes appeared to be driven primarily by timing of fertilizer application. Soil water content tended to be highest under CsT, while Water-Filled Pore Space was highest under NT.

CH_4 uptake (below) was about 50 % lower compared to 2003, due to normal rainfall and wetter soil in 2004. Tillage effects on CH_4 uptake also varied with tillage (see bar graph above right).

2004 data: Temporal dynamics of CH_4 uptake under three tillage practices averaged across all three N fertilizer treatments



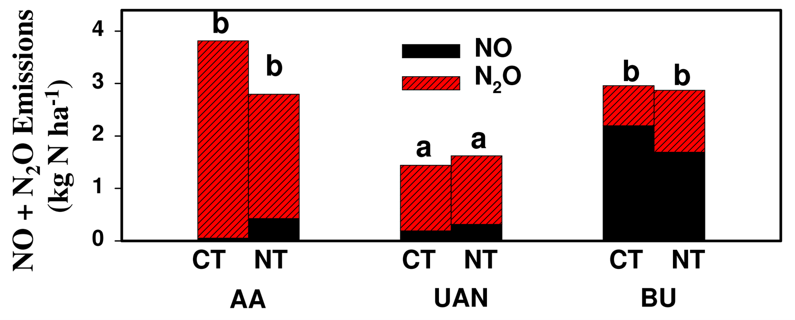
Total Integrated N_2O Emissions and CH_4 Uptake Expressed as CO_2 Equivalents



TOTAL N_2O AND CH_4 EMISSIONS (above): In both years with surface urea application (BU), N_2O emissions under NT were higher than CT, while the reverse was true with subsurface AA injection. The largest effect was due to fertilizer type, with 2- 4 times greater N_2O emissions under AA than BU or UAN. Under BU and UAN, CH_4 uptake increased with reduced tillage (in 2004), while under AA the reverse was true.

Total NO and Total NO + N_2O EMISSIONS (below): NO emissions with BU application were greater than AA or UAN. Total NO + N_2O emissions under UAN were ~ 50 % less than AA or BU. There were no tillage effects on total NO + N_2O emissions. (NO fluxes from CsT plots were not measured).

Nitric Oxide (NO) and Total NO + N_2O Emissions



CONCLUSIONS

1. Tillage-fertilizer interactions were important for N_2O and CH_4.
2. Shifting away from AA equated to C gains of 0.15 – 0.20 Mg C ha^{-1} y^{-1} under NT.
3. Increased N_2O under NT (with BU) equated to C losses of 0.05 Mg C ha^{-1} y^{-1}.

Reference: Venterea, R.T., M. Burger, and K.A. Spokas. 2005. Nitrogen oxide and methane emissions under varying tillage and fertilizer management. *J. Environ. Qual.* (In Press).