Effects of conservation agricultural practices on soil nitrogen transformations and microbial activity in cotton crops from a long-term experiment in West Tennessee

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BACKGROUND

Nutrient exports from agroecosystems can have severe ecological impacts. Conservation agricultural practices such as reduced tillage and planting winter cover crops can mitigate nitrogen (N) losses and reduce the amount of fertilizer needed while maintaining crop yields.


Hairy Vetch Cover Crop


Winter Wheat Cover Crop

Leguminous cover crops, such as hairy vetch, supplement soil N through biological N_2 fixation, allowing fertilizer N-application rate to be lowered. Non-leguminous cover crops with high C residues, such as winter wheat, usually require additional N to counteract microbial N immobilization. The manipulation of N application rate can directly influence microbial community dynamics and activity which determine rates and pathways for N loss. Consequently, quantifying management-specific influences on microbial activity and N transformation rates is crucial to best management practice decisions.

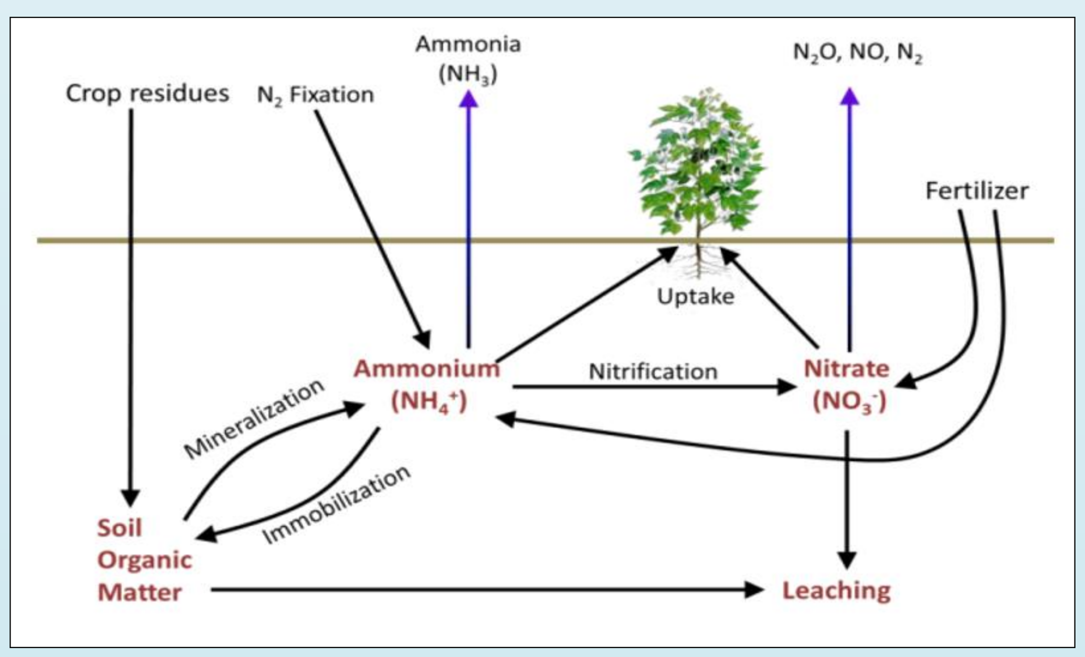


Figure: Simplified view of the nitrogen cycle in agroecosystems.

THE STUDY

This presentation presents preliminary data from an ongoing project assessing the effects of long-term management strategies on microbial activity and N transformation rates in a no-till cotton cropland in west Tennessee. Management treatment strategies include 0-lb and 60-lb nitrogen fertilizer application in combination with no cover, hairy vetch, and winter wheat winter cover crop. We present our first findings for microbial activity rate (determined by incubation respiration rates), N_2O emission rates, and net N mineralization rates.

This study is being conducted at the West Tennessee AgResearch & Education Center University of Tennessee, in Jackson, TN, which provides a cotton cropland with a long-term (>30 years) management application program.

METHODS

- Microbial activity rate was estimated by measuring the rate of soil carbon loss via CO_2 respiration over a seven day period within a closed-chamber incubation lab experiment. (Results in μg-C $g^{-1}_{dry\ soil}$ day^{-1}).
- Weekly to bi-weekly gas collections were measured to determine on site N_2O emissions. Gas samples were analyzed using a gas chromatograph equipped with an electron capture detector at the USDA-ARS laboratory in Lincoln, NE. (Results in μg-N m^{-2} h^{-1})
- Net N mineralization rates are represented as the change in total extractable N (TEN) over a seven day incubation period. . TEN is determined by measuring NO_3^- in extracts oxidized with sodium persulfate which converts all mineral forms of N to NO_3^-. (Results in μg-NO_3 $g^{-1}_{dry\ soil}$ day^{-1})

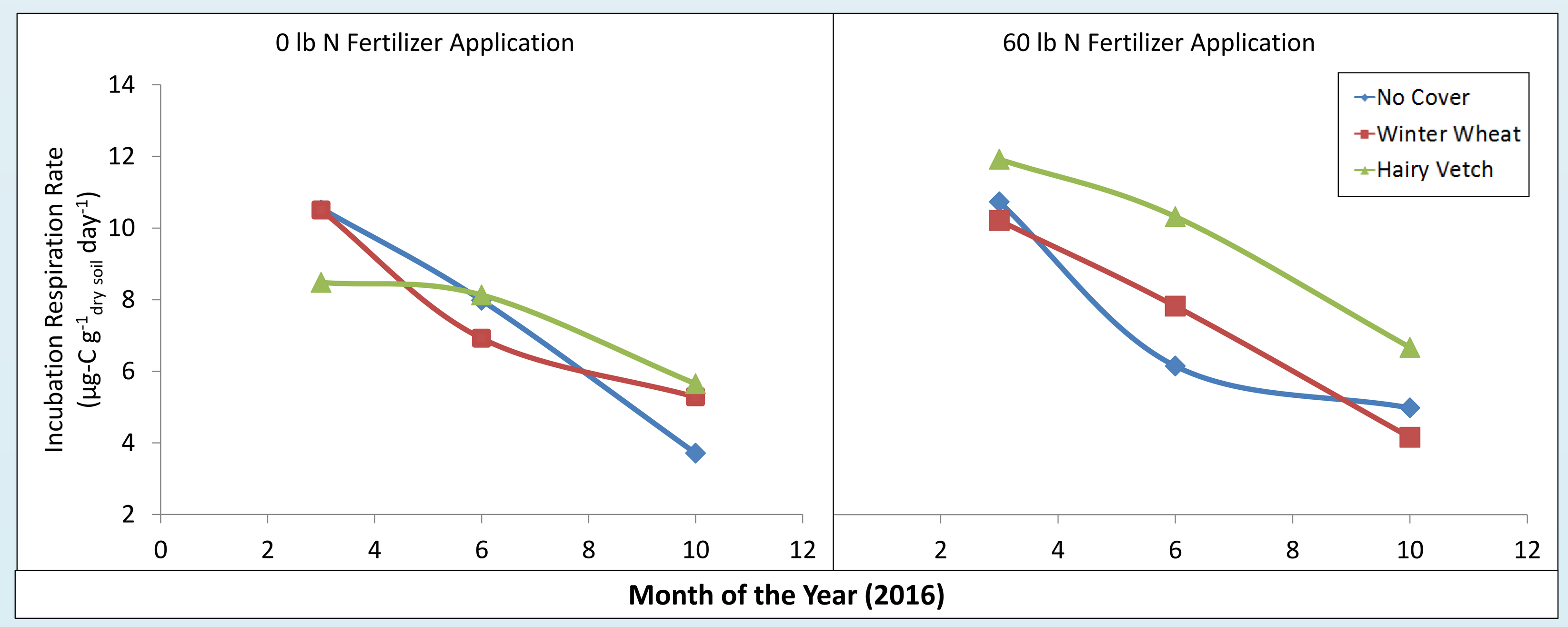
RESULTS

Microbial Activity

Microbial activity is more stable throughout the season under vetch cover crop in the 0 lb-N per acre fertilization treatment.

There is a significant decline in microbial activity throughout the growing season at the no cover and winter wheat cover sites for both the 0 lb-N and 60 lb-N fertilization treatments.

Microbial activity under vetch cover with 60 lb-N is higher in the early season, but decreases more rapidly through the season than in the 0 lb-N treatment.



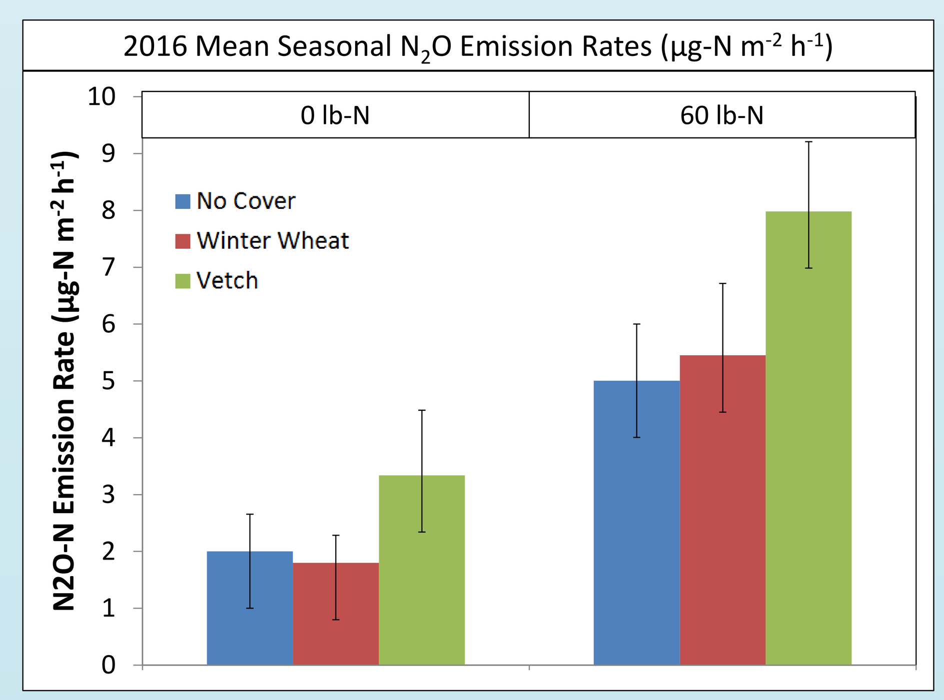
N_2O-Nitrogen Emissions

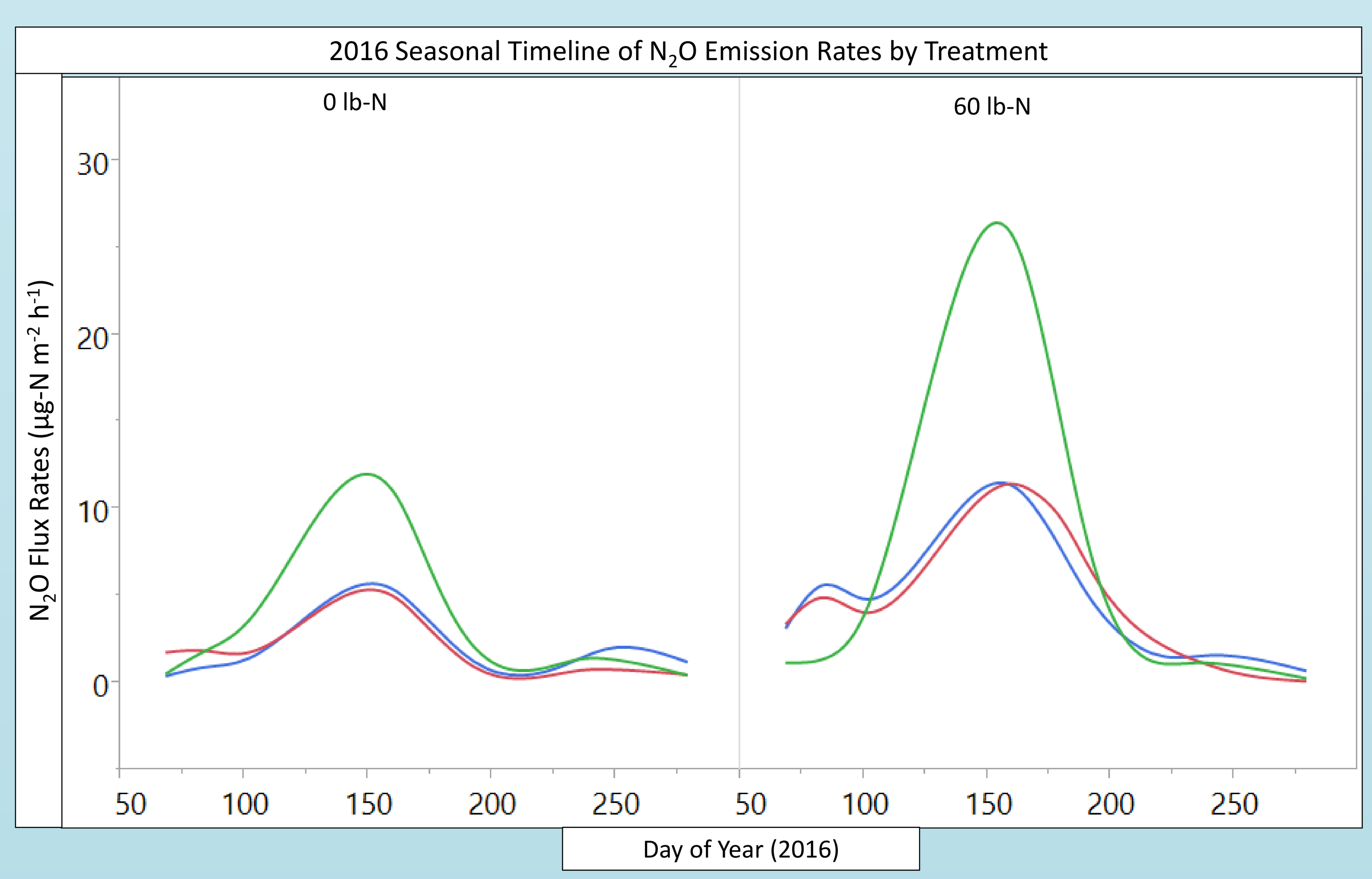
Seasonal mean N_2O-N emission rates are greater with 60 lb N application.

For seasonal mean N_2O-N emission rates within the 0 lb N sites:
- No significant difference among cover crop treatments
- However, emission rates with vetch winter cover are notably greater.

Seasonal mean N_2O-N emission rates within 60 lb N sites are greater under vetch winter cover sites.

N_2O-N emission rates appear to fluctuate with seasonal climate changes.





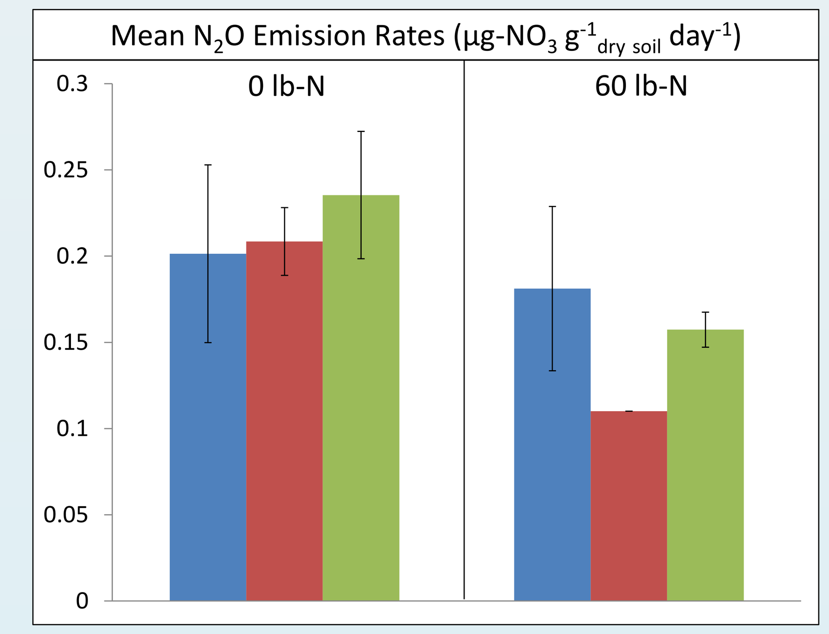
RESULTS

Net N Mineralization

Rates at no cover sites did not vary between 0 lb and 60 lb N treatments.

Within 60 lb N sites, N mineralization was significantly lower in wheat sites.

Rates for wheat and vetch cover were lower at 60 lb N than at 0 lb N sites.



NOTE: Net N mineralization data presented here are only representative of early season conditions. These data are preliminary and do not yet reflect seasonal variation or means.

DISCUSSION

The difference in microbial activity rates between the vetch and other cover treatments suggests that the microbial community responds to two forms of N addition.
- N-fixation by vetch supplies organic N compared to inorganic fertilizer N.
- Organic N at vetch sites appears to better sustain microbial activity throughout the season.
- The pulse of inorganic fertilizer N is more quickly depleted, resulting in a more rapid decline in microbial activity through the season.

Vetch may contribute to 'banking' soil N between seasons, alleviating possible late-season N limitations. However, higher microbial activity corresponds to greater N_2O emissions under vetch sites which may have significant implications for greenhouse gas emissions.

Net N mineralization results are restricted to the analysis of early season samples. Consequently, these data most represent inter-seasonal effects of management treatments. Significantly lower N mineralization in the wheat with 60 lb N application treatment is likely due to high carbon residues from the non-leguminous wheat cover, which can require additional N input to counteract immobilization.

CONCLUSIONS & FUTURE WORK

Our results suggest that hairy vetch as a winter cover crop can 'bank' soil N between growing seasons. Organic N sources from the leguminous cover crop appear to better sustain microbial activity throughout the growing season. These results may have implications for microbial community resiliency to environmental perturbations, such as climate change. Future work will explore this hypothesis with controlled manipulation experiments.

These preliminary data suggest that both the amount and type of N play an important role in soil nitrogen transformations. Organic N deposited by vetch can decrease fertilizer N requirements and sustain soil biological activity. However, increased N_2O emissions may be problematic. Monitoring of these emissions will continue for at least another two years and a nitrogen budget will be developed to better assess N loss tradeoffs among the various treatments.

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