The Role of Reduced Tillage and Organic Agriculture in Soil Nitrous Oxide Emissions

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INTRODUCTION

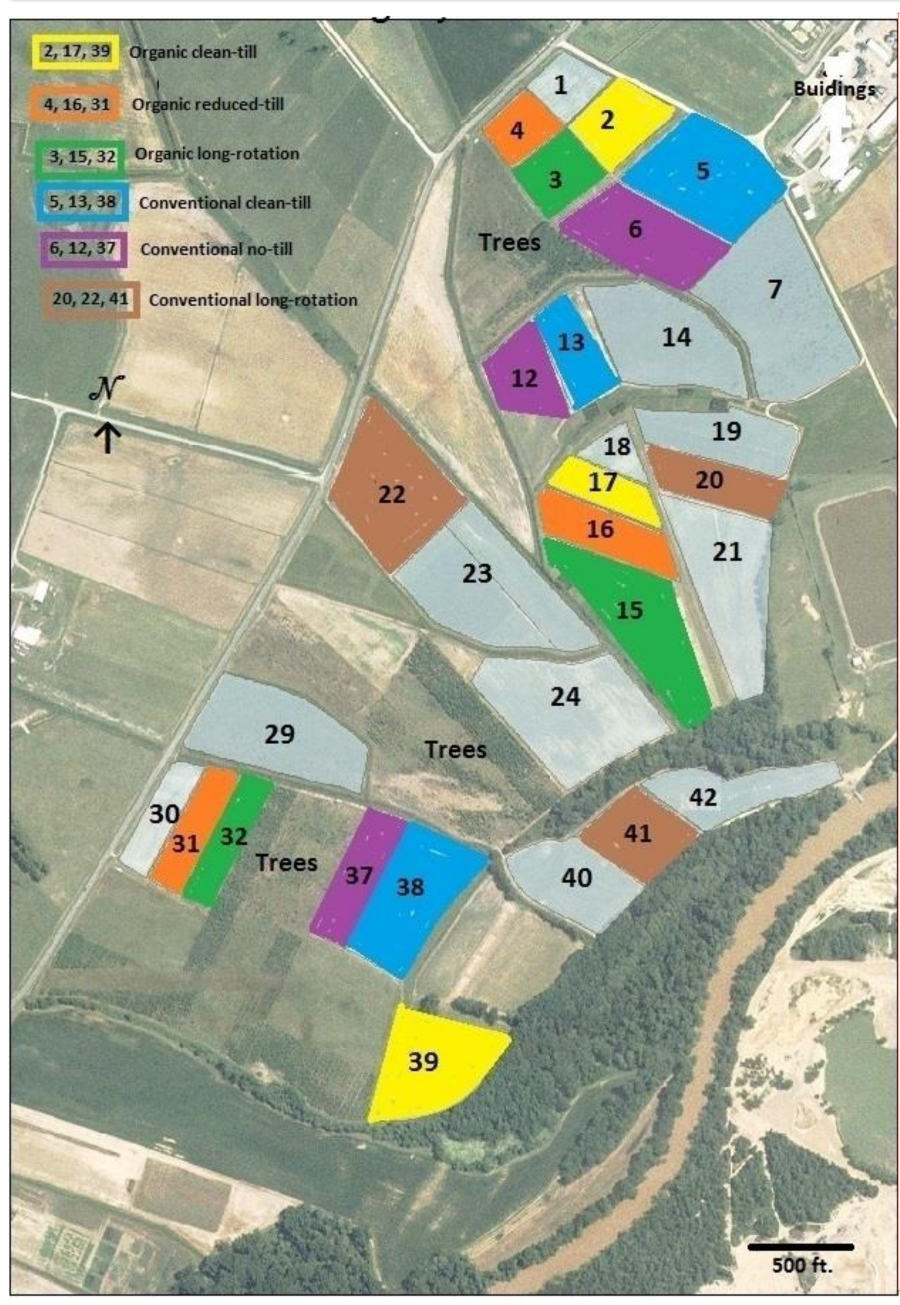
Alternative farming systems such as organic management, conservation tillage, and rotations that include perennials have been shown to enhance ecosystem services. These include enhanced soil carbon (C) sequestration, tightened nitrogen (N) cycling, reduced erosion, and improved surface water quality. However, it is less clear whether such systems also cause the release of more or less nitrous oxide (N2O) than conventionally managed soils. Agricultural soil management is responsible for 75% of US N_2O emissions. With a global warming potential 296 times higher than CO_2, and as an important ozone depleter and loss of soil N, **it is critical that we learn to manage for reduced N_2O emissions**. Furthermore, we must link management systems N_2O emissions to soil C and N cycling dynamics. Although it is accepted that certain properties, such as pH, water filled pore space, and temperature have consistent effects on denitrification, **the relative importance of N availability and different soil organic matter pools are yet unclear**.

OBJECTIVES

Compare N_2O emissions potential among different farming systems

Link those emissions to soil C and N dynamics as influenced by farm management

EXPERIMENTAL SETUP



Long term research-farm experiment established in 1999 at Center for Environmental Farming Systems, east-central NC:

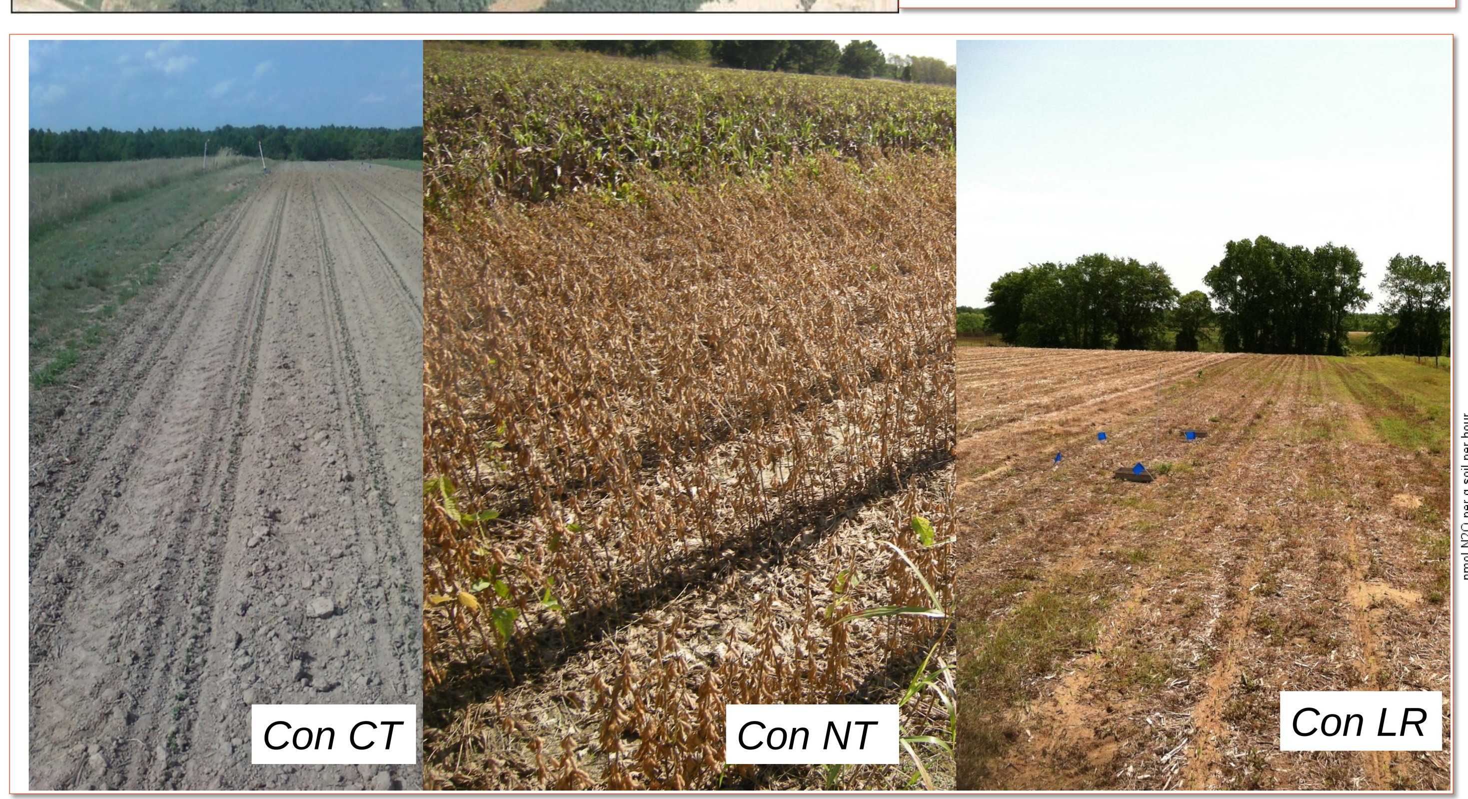
Three Best Management Practices (BMP):

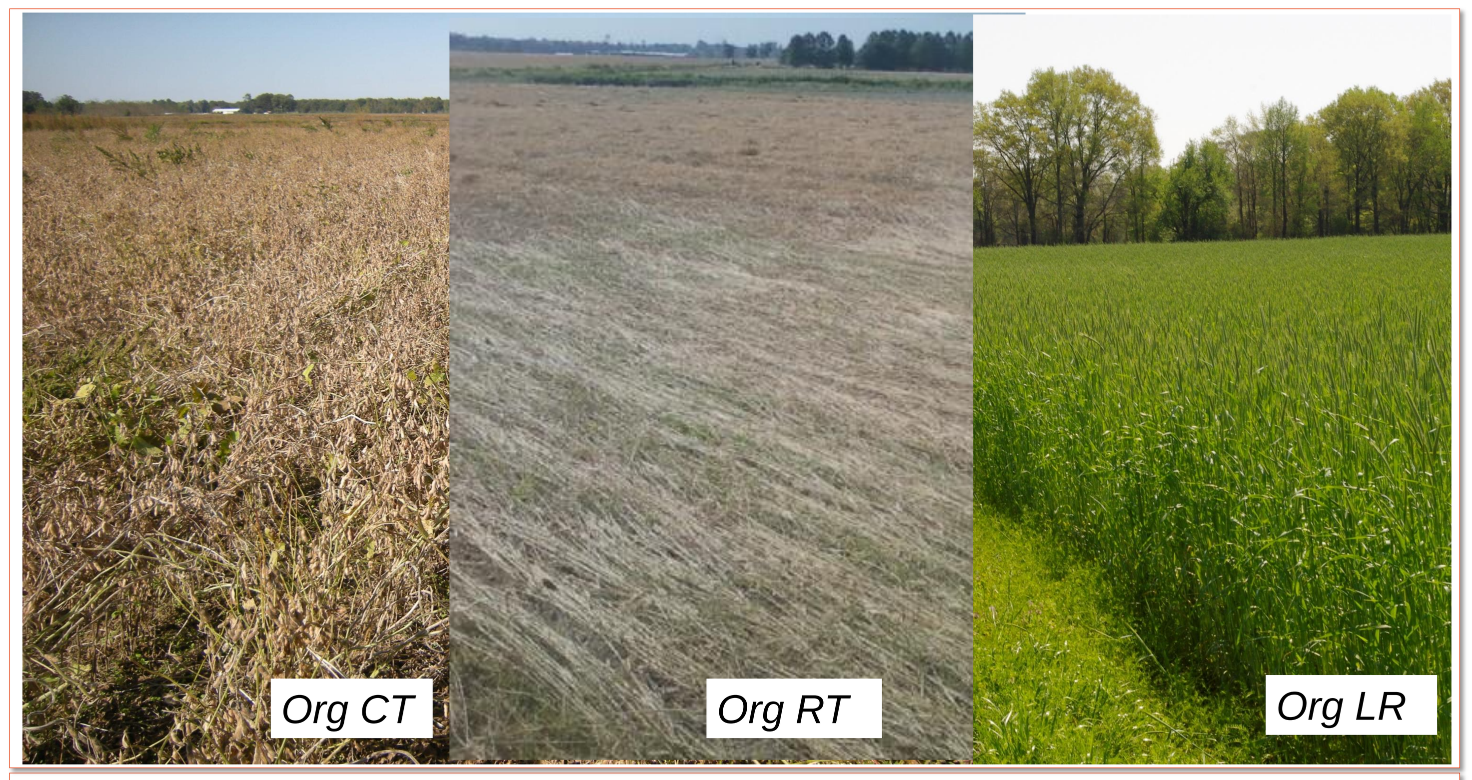
- Conventional, no tillage (Con NT)
- Conventional, with tillage (Con CT)
- Conventional, long rotation including hay, no tillage (Con LR)

Three USDA Organic:

- Organic, reduced tillage (Org RT)
- Organic, with tillage (Org CT)
- Organic, long rotation including hay, with tillage (Org LR)

Three replications





Field soil sampling timeline

Measurements of field soil:

- NH_4^+ -- and NO_3^- nitrogen (Mineral N)
- Microbial biomass N (MBN)
- Microbial biomass C (MBC)
- Extractable organic carbon (DOC)

Additional soil was used for 4-week incubations to determine:

- N_2O emissions potential
- Heterotrophic respiration (non-root)
- Mineralizable N

Top: Gas chromatograph
Bottom: 5mL gas sample collection vial (Left) and individual soil sample incubation container with rubber septa (Right)

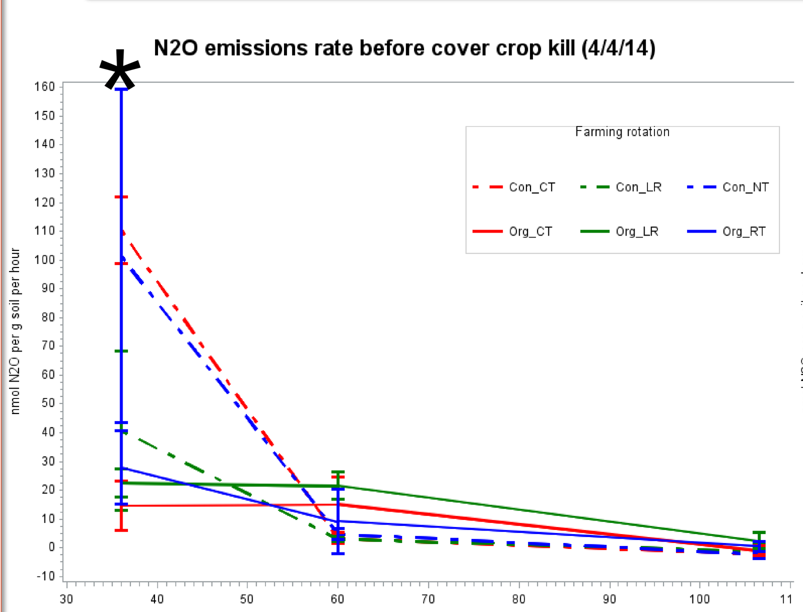
INCUBATIONS ANOVA

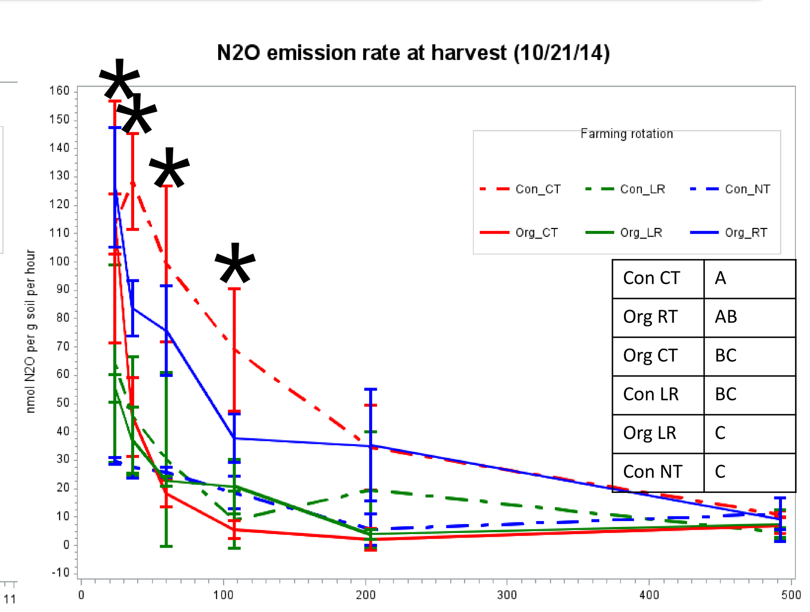
		Measurement	
Sampling time	Factor	CO_2	N_2O
Prekill	Rotation	ND	ND
	Rotation * incubation hour	ND	*
Planting	Rotation	**	ND
	Rotation * incubation hour	*	ND
Midseason	Rotation	*	ND
	Rotation * incubation hour	***	ND
Harvest	Rotation	**	*
	Rotation * incubation hour	**	***

ND: P > 0.05; * = P <0.05, ** = P < 0.01, *** = P <0.001

N_2O: Differences between individual treatments early and late in the season

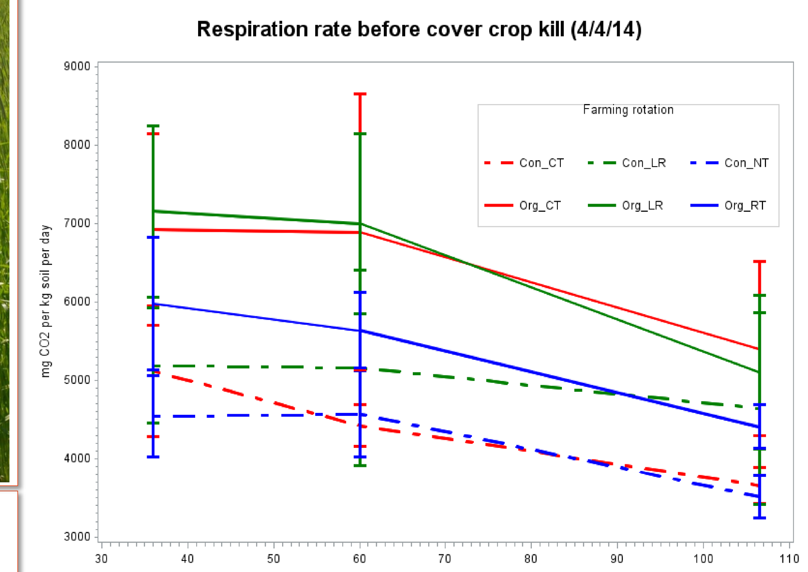
- CCT and CNT have higher N_2O in April
- CCT has highest N_2O among treatments in October
- CNT one of the lowest treatments in October

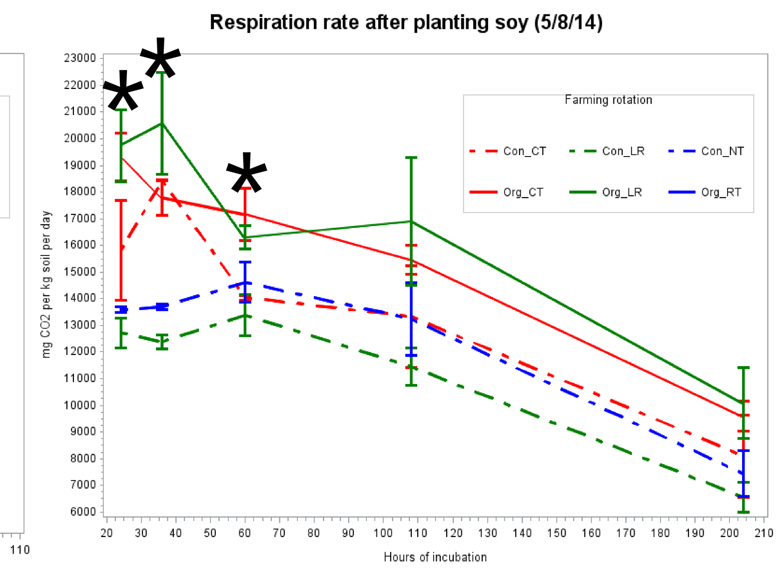


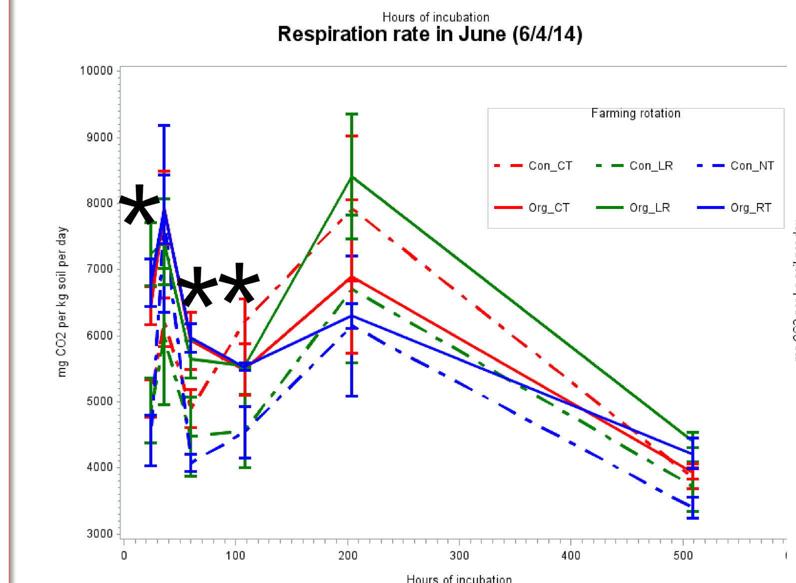


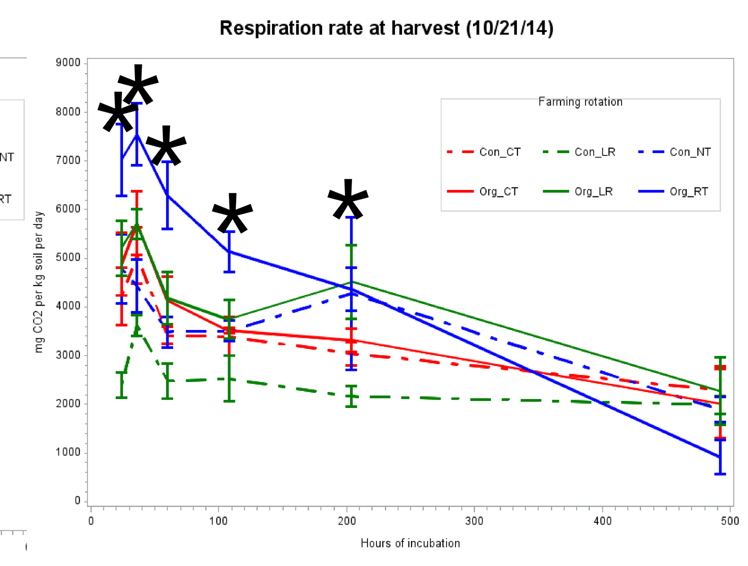
CO_2: Consistent differences between treatments as well as between organic and conventional

- Organic (in particular Org LR) higher respiration
- Con CT high N_2O but low respiration at harvest





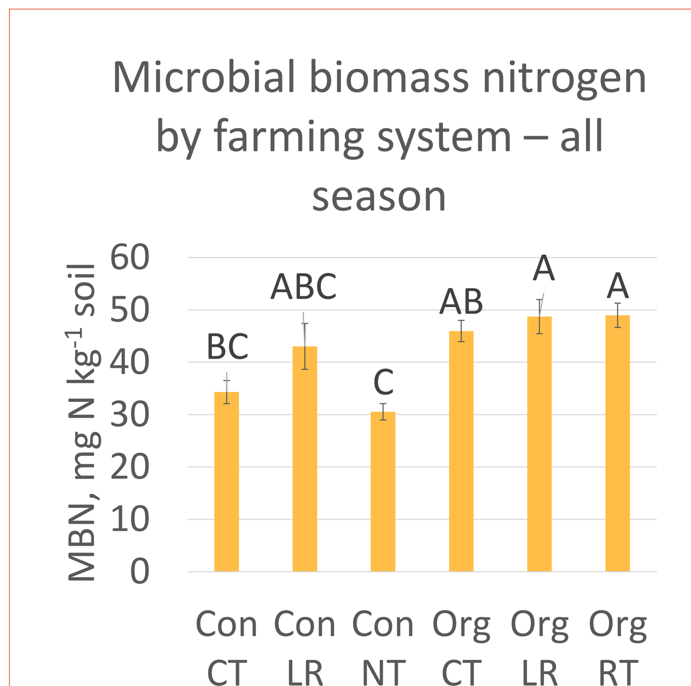


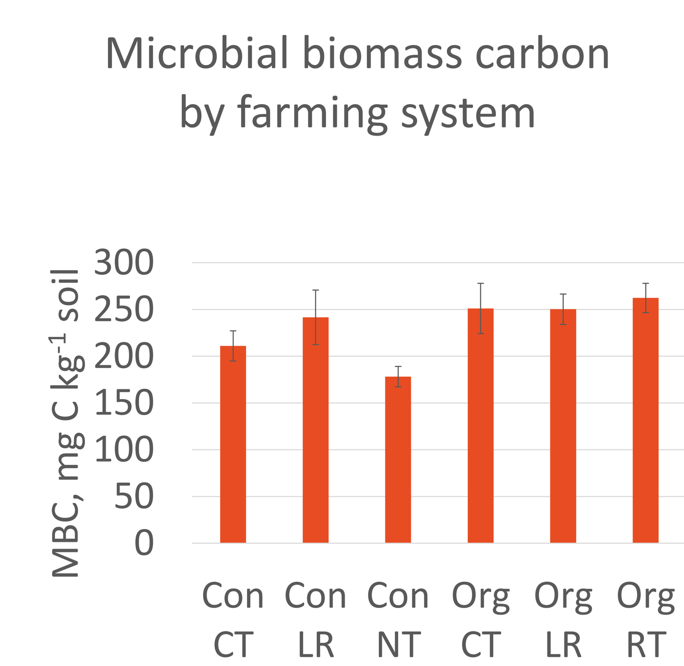


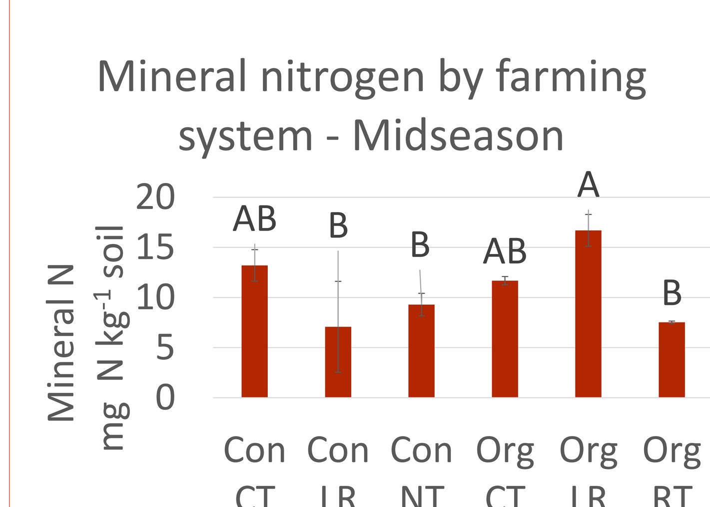
FIELD SOIL ANOVA

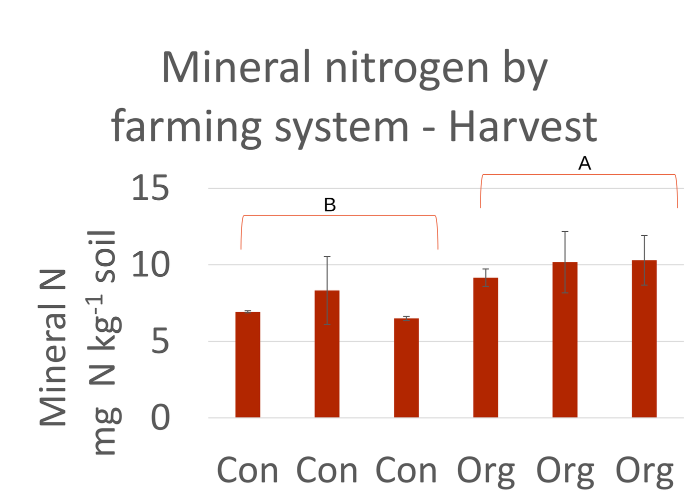
	Measurement			
Factor	$NH_4^+ + NO_3^-$ N	DOC	MBC	MBN
Rotation	ND	ND	ND	*
Date	***	ND	**	***
Date*rotation	**	ND	ND	***

ND: P > 0.05; * = P <0.05, ** = P < 0.01, *** = P <0.001









SUMMARY

- Some indication there is more of a flush in N_2O from Con CT soil in incubations
- Higher microbial activity early and late in the season
- Possible connection between MBC growth and lower N_2O

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