Impact of Diverse Crop Rotations and Cover Crops Under Different Tillage Systems on Soil Health in South Dakota, USA

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Introduction

- Crop rotations, cover crops (CC) and reduced tillage systems are among the most promising conservation practices for sustainable productivity of agroecosystems that can also safeguard soil health and biological diversity. [Drury et al., 1999. Agron. J. 91:101-108]
- Inclusion of CC in cropping systems may provide marked advantages relative to no cover crop (NC) in nutrient cycling, enhancing microbial activity and stabilizing enzymatic activity.
- Soil microbial biomass and enzymes respond to soil management changes long before other soil health indicator changes are detectable.

Objective

- To investigate the impact of crop diversification and cover crops under two tillage systems on soil health by biochemical parameters.

Materials and Methods

- Long-term experimental site (>26 years) is located at the Southeast Research Farm of SDSU near Beresford, South Dakota. (*A brief overview and history about treatments is presented in Table 1*)
- Experiment field was established on Egan soil series with slope less than 1%.
- Soil samples were collected from surface depth (0-to-7.5 cm) twice in vegetation season of maize (before planting and after planting in 2017).
- Studied biochemical parameters included soil microbial biomass carbon (MBC) and nitrogen (MBN) and soil enzymatic activities (urease and β-D-glucosidase).
- All analyses were performed on field moist soils.
- The means of each parameter were separated by Latin Square Design (LSD) at P ≤ 0.05 using the GLIMMIX procedure in SAS 9.4 program.

Table. 1. Study site, treatments and experiment design

Design	Split-Split Plot laid within RBCD		
Treatments	Rotation	Tillage	Cover type
	2 - yr; maize - soybean	No - till (NT)	*Cover crop (CC)
	3 - yr; maize - soybean -oat	Conventional till (CT)	No cover crop (NC)
	4 - yr; maize - soybean - oat - winter wheat		
Time frame	1991 to present		2012 to present

**Rye planted after maize harvest and blend of legumes/brassica after small grains harvest in each rotation.*
**CC cultivated in winter where rye killed off by herbicide at flowering stage whereas blend was killed by frost.*

Results

Fig. 1 and 2: Significance of the effects of experimental factors and their interaction on urease activity. P was always < 0.05 (LSD test).

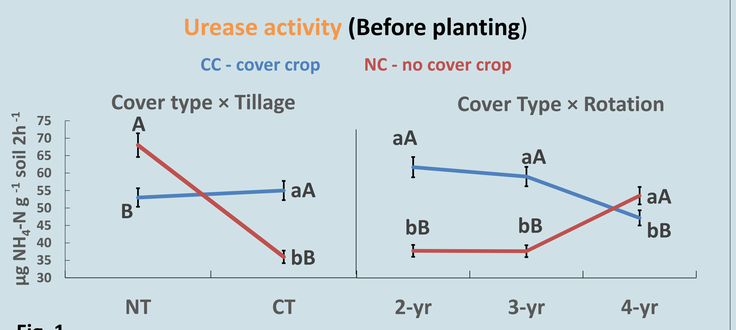

Fig. 1
Means within the same cover type followed by the same uppercase letters are not significantly influenced by tillage and rotation. Within the same tillage and rotation, significant effects are shown by different lowercase letters.

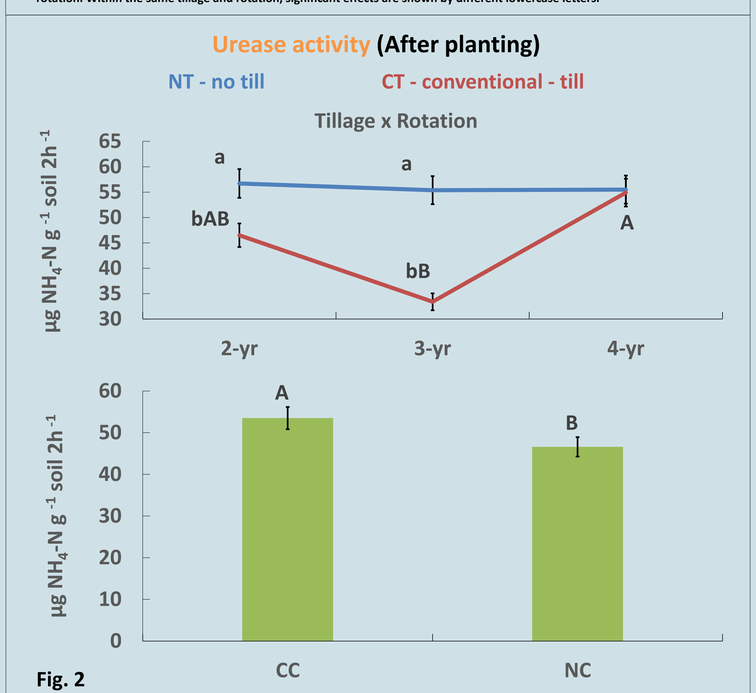

Fig. 2
Means within the same tillage system followed by the same uppercase letters are not significantly influence by rotation. Within the same rotation, significant effects are shown by different lowercase letters.

Fig. 3 and 4: Significance of the effects of experimental factors and their interaction on β-D-glucosidase activity.

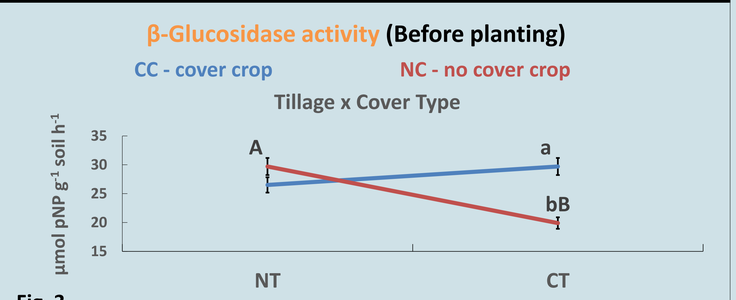

Fig. 3
Means within the same cover type followed by the same uppercase letters are not significantly influenced by tillage. Within tillage, significant effects are shown by different lowercase letters.

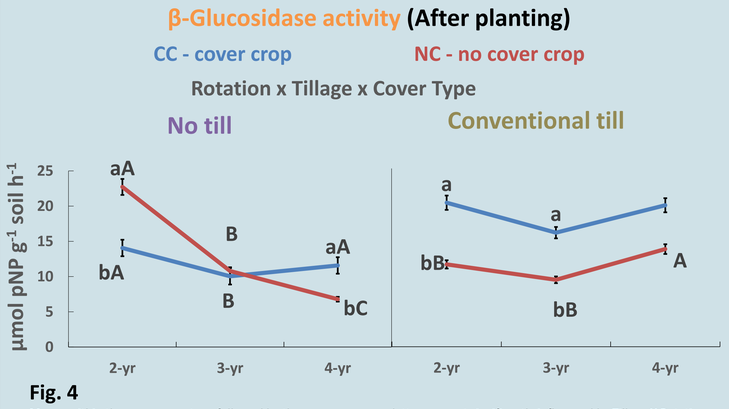

Fig. 4
Means within the same cover type followed by the same uppercase letters are not significantly influenced by Tillage X Rotation. Within Rotation x tillage, significant effects are shown by different lowercase letters.

Fig. 5: Mean effects of experimental factors on Microbial Biomass Carbon (MBC) and Nitrogen (MBN).

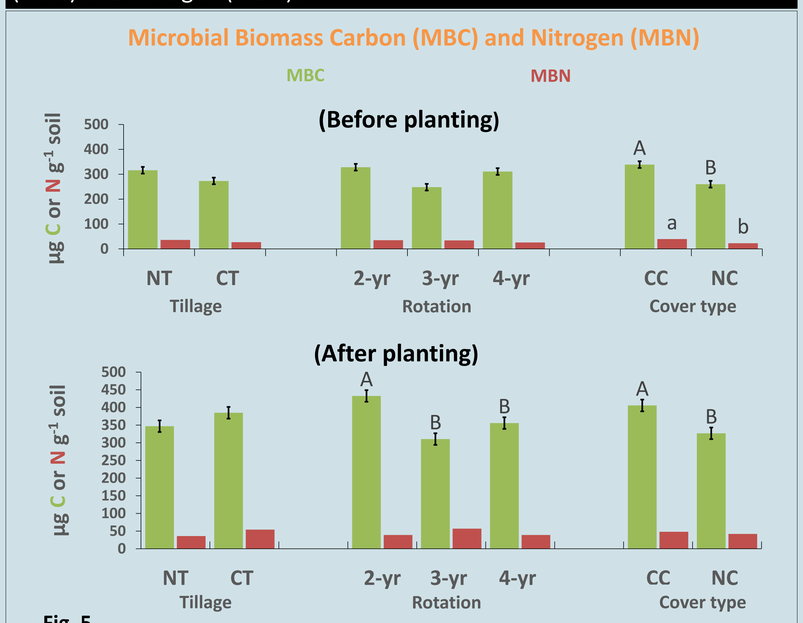

Fig. 5
Within the same factor for MBC and MBN, significant effects are shown by different upper case and lower case letters respectively.

Discussion

- Significant interactions among treatments were observed in enzyme activities' indicator of change in soil health due to rotation, cover type and tillage.
- 'Tillage × Cover type' interaction became evident in both enzyme activities. Ploughing can increase the decomposition rate of plant residues provided by CC on its incorporation into soil. Hence, CC effect was more pronounced with CT system (Fig. 1 and 3).
- On an average, enzyme activities were significantly increased due to CC and NT system because of the additional carbon and nitrogen input and stability of enzymes in soil matrix (Fig. 1 and 2).
- Among rotations, 2-yr with CC and NT had shown significant improvement in enzyme activities (Fig. 1 and Fig. 4). Maize and rye repeated more in the 2-yr rotation cycle which result into substantially higher biomass inputs as compared with oats, wheat and blend of CC to support microbial biomass (Fig. 5).
- MBC and MBN increased in CC as compared with NC, reflecting their potential to increase soil biological activity (Fig. 5).

Conclusion

- Soil biochemical properties were improved by adopting cover crop in rotations.
- To maintain soil biological activity similar to no-till, conventional-till requires inclusion of cover crops.
- Maize-soybean rotation is more effective when managed with cover crops and no-tillage system.