Cover crop and ridge tillage effect on greenhouse gas emission at diverse agricultural landscapes

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Introduction and Rationale

Most of agricultural practices in conventional cropping systems contribute to emission of greenhouse gases (GHG) such as carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) that causes global warming and climate changes. As a result, introducing cover crops and ridge tillage systems to conventional cropping system are some of the strategies to adapting and mitigating climate changes. Because cover crop enhances soil carbon sequestration, reduce amount of nitrogen fertilizer and herbicide application, prevent soil erosion, conserve soil moisture, and protect water quality. Similarly, ridge tillage is used for early planting in poorly drained soils, reduce erosion when used on contour, and conserve soil moisture. However, the actual economic and environmental benefits of cover crops and ridge tillage system depend on soil type, topographic position, climatic condition and agronomic management. Topographic positions, particularly, can affect most of environmental and economic benefits of cover crop and ridge tillage system. The objectives of this study were to (i) evaluate the performance of rye cover crop at different topographic positions (ii) understand the effects of cover crop and ridge tillage system on CO_2 and N_2O emission.

Experimental Procedure

Study sites

- Kellogg Biological Station (KBS) and
- Mason Research Field of Michigan State University
- The field research was established in 2011.

Treatments

- Two tillage systems (chisel and ridge) as main plots
- Rye cover crop (cover and no cover) as subplots.

The treatments were laid out at three topographic positions (Fig. 1).

Table 1. selected soil properties of the study sites.

KBS	Texture	Buffer pH 1:1	OM, %	CEC, $cmol_c\ kg^{-1}$
Summit	Sandy loam	6.78	1.93	5.83b
Slope	Sandy loam	6.74	1.90	6.82a
Depression	Sandy loam	6.76	2.18	5.87b
Mason				
Summit	Sandy loam	5.59b	1.81b	5.69b
Slope	Sandy loam	6.13a	1.64b	7.33a
Depression	Sandy loam	5.39b	2.24a	6.96a

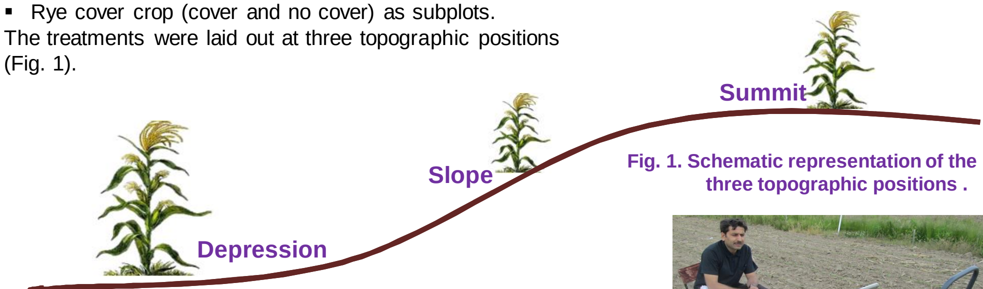

Fig. 1. Schematic representation of the three topographic positions .

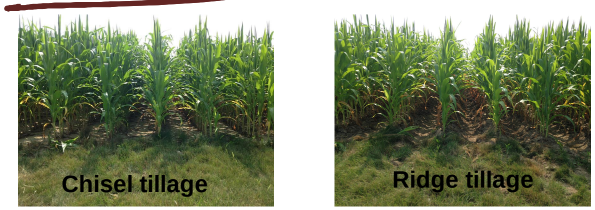

Fig. 2. Corn performance under different tillage systems

Fig. 3. Greenhouse gas sampling procedures.

Results and Discussion

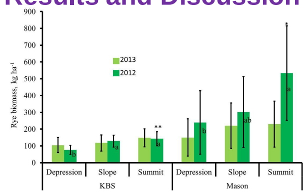

Fig.4. Performance of rye cover crops across locations and growing seasons. Different letters show significant differences among topographic position at 0.05 and 0.1 probability levels for KBS and Mason, respectively.

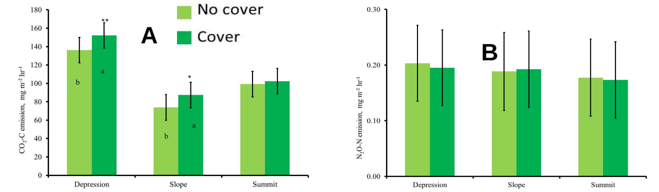

Fig. 5. Rye cover crop effects on CO_2 (A) and N_2O (B) emissions at different topographic positions. Letters show significant difference between cover and no cover at each topographic position at 0.1 and 0.05 probability levels as indicated by *, and **, respectively.

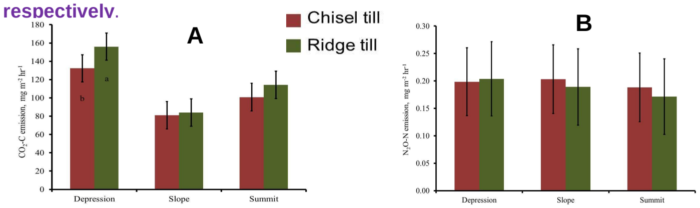

Fig. 6. Effect of different tillage systems on CO_2 (A) and N_2O (B) emissions at different topographic positions. A pair of columns indicated by different letters are significantly different at ($P<0.1$).

- The performance of rye cover crop was inferior at depression to slope and summit positions (Fig. 4) because long term water logging and long winter season in Michigan inhibit the growth of rye cover crop at depression.
- The presence of cover crop significantly increased CO_2 emission at depression and slope positions (Fig. 5A), whereas the overall emission of CO_2 at the depression was the highest because of the highest concentration of soil organic matter at the depression (Table 1).
- Ridge tillage significantly increased CO_2 emission at depression (Fig. 6A) that can be attributed to ridge tillage conserved more soil moisture than other positions, particularly, during dry spell.
- Neither topographic position, cover crop nor tillage systems significantly affected the emission of N_2O emission (Fig. 5B and 6B). This can be explained by sandy loam soils of the study sites did not create favorable conditions for N_2O emission.

Conclusions

- Topographic positions should be considered for growing winter rye cover crop in regions of long winter season.
- The higher emission of CO_2 in cover crop treatment and depression is the reflection of good soil quality as higher soil organic matter and addition of carbon with cover crop improves soils.
- The emission of N_2O may not be important in sandy loam soil rather nitrate leaching should be considered in future research endeavors in such soils.

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