WINTER COVER CROP EFFECTS ON SOIL HEALTH IN SLOPING CROPLAND

Hanna Poffenbarger, Lucas Pecci Canisares, Ole Wendorth, and Montse Salmeron
University of Kentucky, Lexington

OBJECTIVE

Healthy soils are critical for high and stable productivity of wheat and other crops grown in Kentucky. Growing cover crops is one way to improve soil health. However, research findings about cover crop impacts on soil health and sustainability are derived mainly from flat research plots that are not representative of the rolling cropland that is common in Kentucky. These existing datasets may overlook the disproportionate benefits that cover crops can provide on sloping land. The objective of this study is to determine the effects of cereal rye and mixed cereal rye-crimson clover cover crops on soil organic matter and other soil health indicators at three different landscape positions. We expected to find that cover crops would have greater benefits for soil health on sloping land than flat land.

METHODS & MATERIALS

We investigated winter cover crop effects on soil health using an existing field study at University of Kentucky's Spindletop Farm. The study includes two fields that rotate between corn and soybeans. The study was established in the first field 2018 and in the second field in 2019. Each field includes three landscape positions – top of hill (summit), side of hill (backslope), and bottom of hill (toeslope). At each of those positions, three winter cover crop treatments – cereal rye, cereal rye-crimson clover, and winter fallow were established. The project involves routine sampling for soil moisture, soil inorganic nitrogen (N), cover crop biomass and N uptake, corn N uptake, and crop yields. Cover crop biomass and crop yield data from this study are summarized in Table 1. On April 19, 2021 just before cover crop termination, we took soil samples at 0-10 and 10-20 cm (0-4 and 4-8 inches) in the first field. The samples were air-dried, sieved through a 2 mm screen, and analyzed for soil organic carbon (C), potential respiration, potential N mineralization, and wet aggregate stability. Soil organic C was measured using the dry combustion method. Potential respiration was measured using a soil incubation in which 100 g of air-dried soil were brought to 60% water-holding capacity and carbon dioxide concentrations were measured in the incubation jars after 0, 24, 48, and 72 hours of incubation. Potential N mineralization was measured using a soil incubation in which 8 g of air-dried soil were brought to 60% water-holding capacity and inorganic N was measured after 0 and 7 days of incubation. Wet aggregate stability was determined as the portion of 1-2 mm aggregates that remained on a 0.250 mm sieve following three minutes of oscillation in water. We repeated the sampling in spring of 2022 in the second field, but analysis of those samples is still in progress.

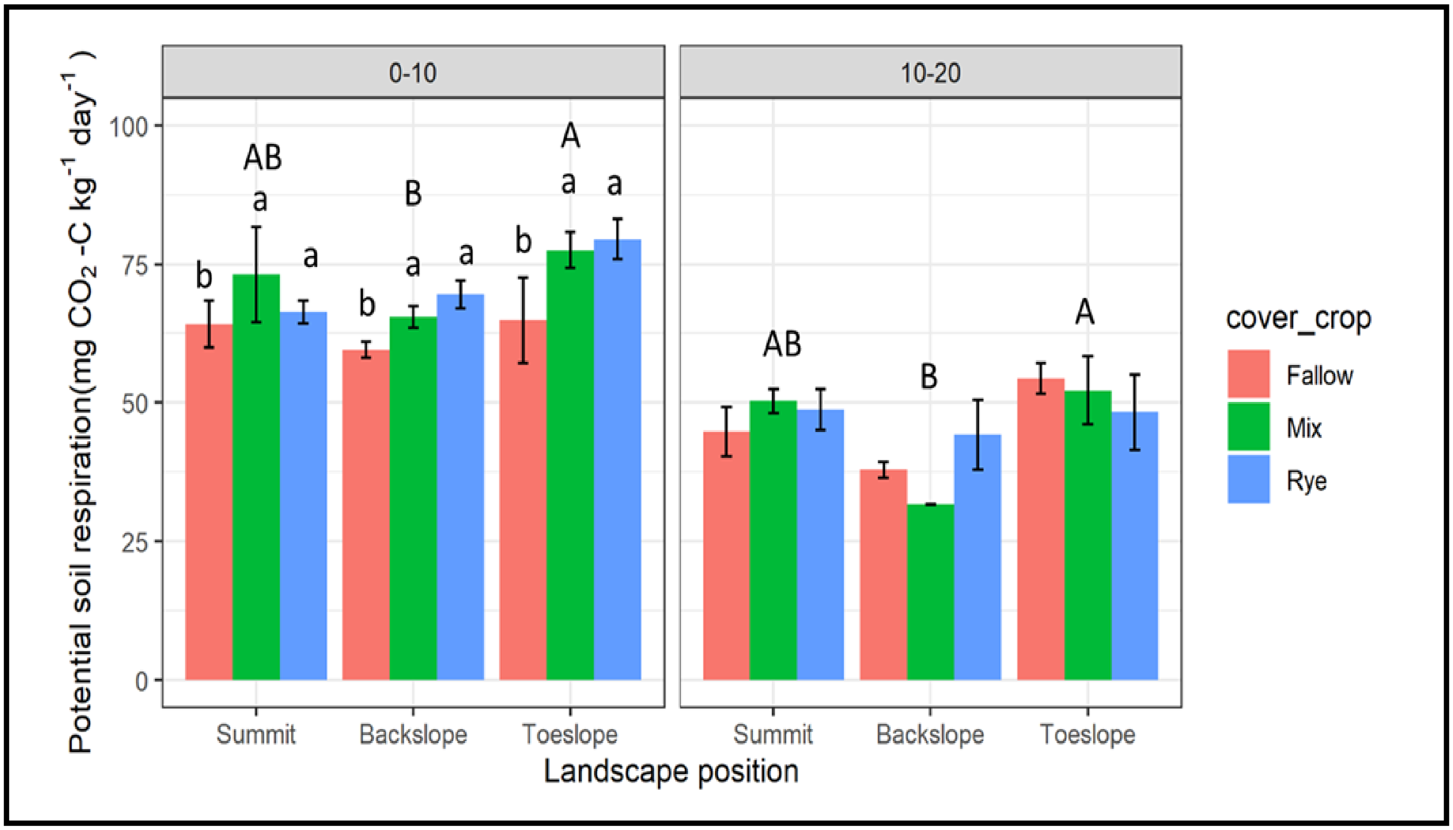

Figure 2. Potential soil respiration for 0-10 cm (left) and 10-20 cm (right) by landscape position measured in spring 2021 following three years of cover crop treatments in a corn-soybean rotation. Different capital letters show differences among landscape positions averaged across cover crop treatments, while different lowercase letters show differences among cover crop treatments within each landscape position. There were no significant effects of cover crop treatment on potential soil respiration at 10-20 cm.

Potential soil respiration is an indicator of microbial activity and fast-turnover soil organic matter. In the surface 0-10 cm, potential soil respiration was 15% greater on the toeslope than the backslope position, while the summit had an intermediate potential respiration rate. In addition, potential soil respiration was 15% greater with a mixture or rye cover crop than winter fallow. The effect of cover crop use was similar across landscape positions. The 10-20 cm had generally lower potential respiration than the 0-10 cm layer. While the toeslope maintained higher soil potential respiration than the backslope at 10-20 cm, there was no cover crop effect at that depth.

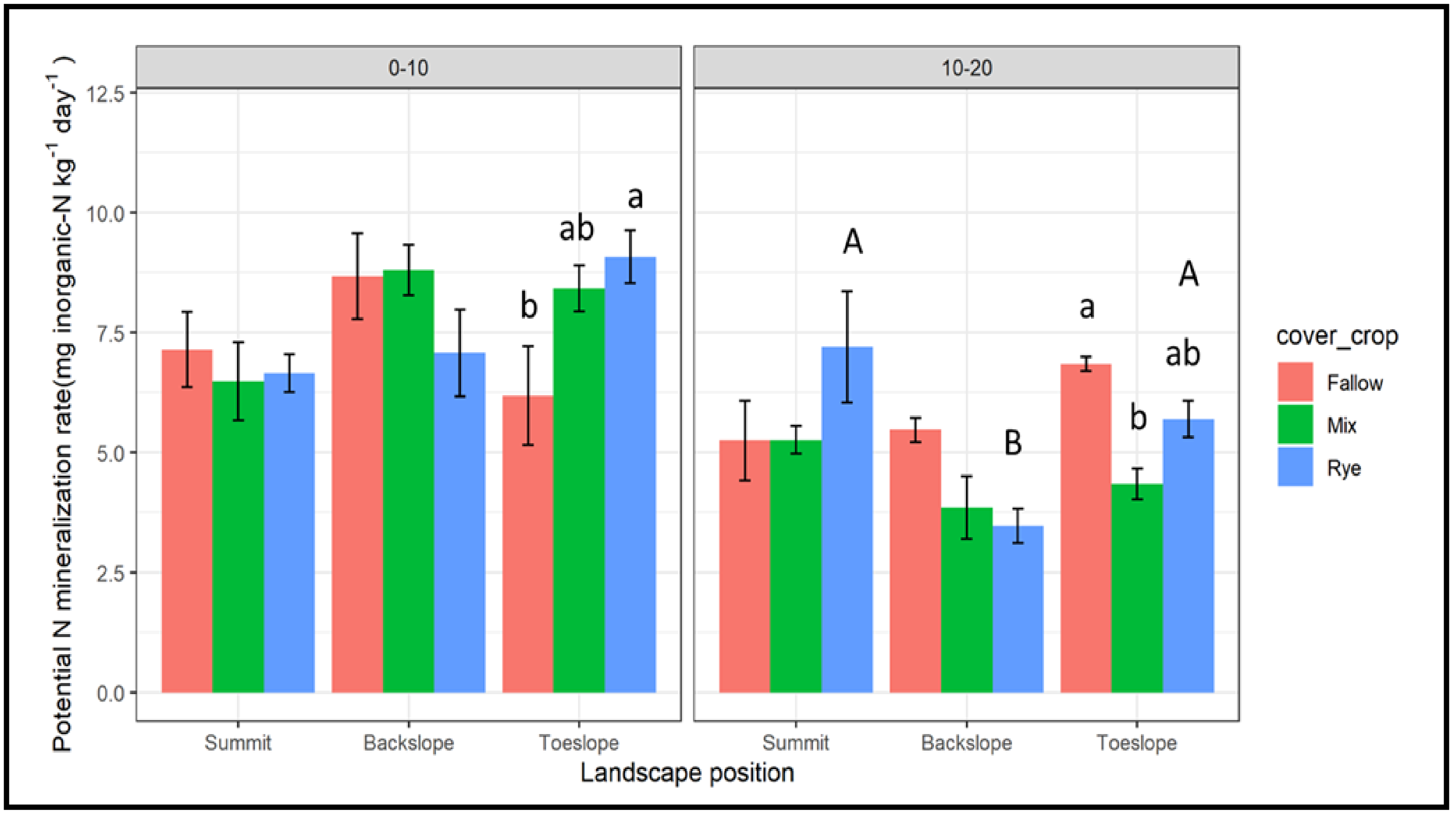

Figure 3. Soil potential N mineralization for 0-10 cm (left) and 10-20 cm (right) by landscape position measured in spring 2021 following three years of cover crop treatments in a corn-soybean rotation. Different capital letters show differences among landscape positions for a particular cover crop treatment while different lowercase letters show differences among cover crop treatments within a particular landscape position. There was no effect of landscape position on potential N mineralization at 0-10 cm and no effect of cover crop treatment on the summit and backslope position at either depth.

Potential N mineralization is an indicator of the soil's ability to supply plant-available N. In the surface 0-10 cm, potential N mineralization was greater with a rye cover crop than winter fallow on the toeslope position. However, the cover crop effect on the toeslope was reversed in the 10-20 cm depth, where the cover crop mixture led to significantly lower potential N mineralization than fallow. The rye cover crop increased variation in potential N mineralization among landscape positions at 10-20 cm, with significantly greater N mineralization on the summit and toeslope than on the backslope in the rye cover crop treatment.

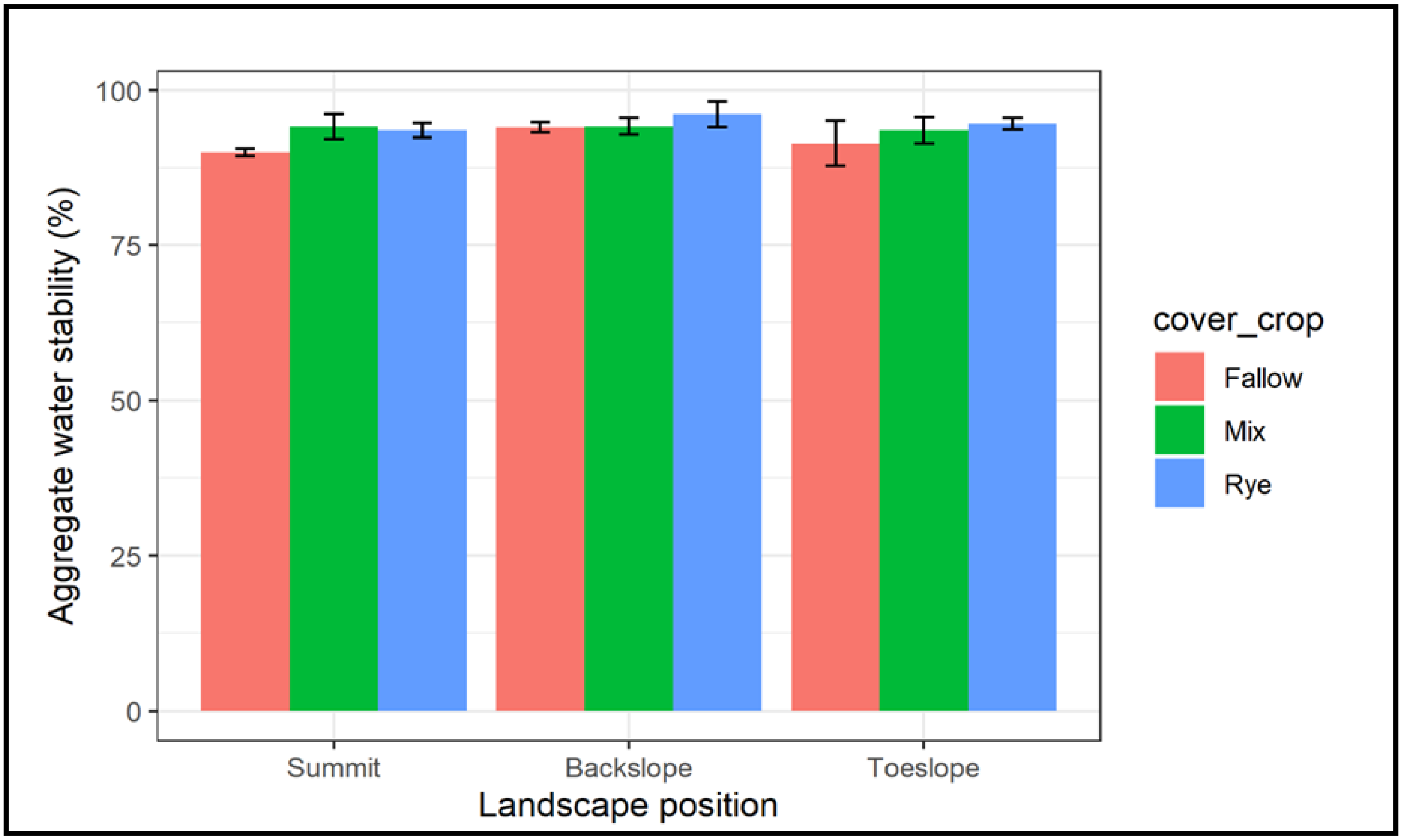

Figure 4. Percentage water-stable aggregates for 0-10 cm by landscape position measured in spring 2021 following three years of cover crop treatments in a corn-soybean rotation. There were no significant effects of landscape position or cover crop treatment on percentage water-stable aggregates.

Soil aggregate stability is an indicator of soil structure and tilth. We found all three landscape positions had very high percentages of water-stable aggregates, and the cover crop treatments tended to increase the aggregate stability, though the effect was not statistically significant. We are still in the process of measuring aggregate stability for the 10 -20 cm depth.

DISCUSSION

The mixture and rye cover crops increased potential respiration in the top 10 cm across all landscape positions relative to the winter fallow treatment (Figure 2), suggesting that both cover crop treatments were effective in enhancing the fast-turnover, easily decomposable soil organic matter that is responsible for feeding the soil microbial community. The greater potential mineralization of the mixture and rye cover crop treatments may be an early indication of soil organic C buildup. Indeed, the soil organic C concentrations showed a similar trend in response to cover crop treatment as the potential respiration (Figure 1), though the effects were not statistically significant for soil organic C. Soil organic C often takes five years or more to show statistically significant changes, while potential respiration can change more quickly because it represents a fast-turnover fraction of soil organic matter. We observed that the backslope position had the lowest potential respiration despite having the highest soil organic C concentration (Figure 1). This demonstrates that the potential respiration reflects only the easily decomposable forms of organic matter, such as cash crop and cover crop residues. The backslope position is the least productive position in terms of crop yield and thus has the lowest crop residues and lowest potential respiration despite its high soil organic C concentration (Table 1). On the other hand, the toeslope is the highest yielding position and thus has the most crop residue inputs and potential respiration.

The easily decomposable organic matter is thought to contribute to nutrient release. However, the effect of cover crops on potential N mineralization was less consistent than their effect on potential respiration. The rye cover crop increased potential N mineralization in the top 10 cm on the toeslope, but the mixture cover crop decreased potential N mineralization in the 10-20 cm layer on the toeslope. In this study, the C:N ratio of aboveground cover crop biomass ranges from 25 to 35, meaning that the residues contain about as much N as the microbes need to decompose the residue. With a moderate C:N ratio, the cover crop residues are not expected to release N quickly. Since we sampled immediately after cover crop termination, it is possible that the cover crop residue had not decomposed enough to cause significant N mineralization. The C:N ratio of cover crop roots ranges from 35 to 60, and it is possible that the high abundance of roots at 10-20 cm depth led to N immobilization on the toeslope position with the cover crop mixture.

The easily decomposable organic matter is also thought to promote aggregate stabilization. However, we did not find that the cover crop treatments increased aggregate stability. The aggregate stability was quite high even in the no cover crop treatment, which suggests that the soils have favorable structure with minimal opportunity for improvement in this property.

CONCLUSION

Our research suggests that cereal rye and cereal rye-crimson clover mixtures were equally effective in increasing soil potential respiration across landscape positions. The increased soil potential respiration is an early indication that the cover crops are contributing to buildup of soil organic C. We noted that potential respiration increased with crop yield among the landscape positions, suggesting that both cover crops and productive cash crops are beneficial for soil health. The cover crops had inconsistent effects on potential N mineralization and negligible effects on soil aggregate stability.

ACKNOWLEDGEMENTS

We would like to thank the Kentucky Small Grain Growers' Association for their funding support of this project. Funding for the field study was also provided by United States Department of Agriculture National Institute of Food and Agriculture Grant Number 2020-67013-30860. We thank Kristine Gauthier for her help performing the soil health measurements and Laura Harris and Gene Hahn for their help with implementing the field study.

Table 1. Average winter biomass production, corn yield, and soybean yield for field #1 of the landscape position project averaged across years. Corn received 240 lb N/acre. Winter biomass production for the fallow treatment was derived from winter weeds. Standard errors are shown in parentheses.

Cover crop	Summit	Backslope	Toeslope
Winter biomass, lb/acre (2019-2021)			
Fallow	211 (63)	440 (114)	203 (156)
Mix	4000 (544)	3450 (353)	3460 (750)
Rye	3690 (349)	3110 (266)	3040 (377)
Corn yield, bu/acre (2019, 2021)			
Fallow	211 (22)	152 (19)	239 (19)
Mix	220 (25)	136 (25)	237 (16)
Rye	201 (23)	131 (19)	212 (20)
Soybean yield, bu/acre (2020)			
Fallow	54.8 (0.57)	39.0 (2.28)	61.1 (2.07)
Mix	54.5 (1.02)	38.1 (1.55)	61.7 (0.57)
Rye	52.2 (3.19)	39.8 (1.22)	59.1 (1.04)