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LOWERING SOIL EROSION RISK IN ORGANIC CROPPING SYSTEMS

Final Research Report W2006-09

INTRODUCTION

Soil erosion in agriculture refers to the loss of soil through wind, water and tillage forces. There are a number of negative consequences to soil erosion, but most importantly erosion lowers soil quality, which can reduce the productive ability of a soil (Verity and Anderson 1990). All agricultural practices involve some form of soil disturbance, which may lead to soil erosion. Organic cropping systems preclude the use of herbicides for weed control, usually leading to a higher reliance on tillage for weed control than conventional systems. For this reason, organic cropping systems are often accused of having higher levels of soil erosion than conventional systems.

Despite the poor reputation organic systems have regarding soil erosion risk, there are a number of cropping practices that farmers can adopt to help lower the risk of higher levels of tillage. A study conducted at the University of Manitoba looked at both organic and conventional systems to identify which practices are most effective at lowering soil erosion risk.

A conventional farm (left) and a neighboring organic farm (right). Higher tillage intensities on organic farms may lead to lower soil cover and lower soil organic carbon contents. (A. Nelson)

ORGANIC MANAGEMENT PRACTICES

To study how the management of soil erosion risk may differ in organic systems, it is important to understand how production practices in organic systems differ from conventional. Production practices will affect the soil and its ability to withstand soil erosion. A survey of organic and conventional farmers in Canada in 2003-04 was used to identify how some of the key production practices that affect soil erosion differ.

Tillage Practices: Organic farms tend to use more tillage than conventional farms, as tillage is a major form of weed control on organic farms. Tillage increases soil erosion risk by breaking up soil structure, and reducing the amount of plants and residue covering the soil surface. A much greater proportion of conventional farms have zero tillage and/or direct seeding systems. However, organic farms do use conservation tillage practices, including contour tillage.

Crop Rotation: This production practice is one of the major production differences between organic and conventional systems. Organic cropping systems often design crop rotations that build soil fertility and reduce the risk of weed infestations. Crop rotations in conventional systems are more often designed around the state of the market and crop prices. A majority of the organic farms in Canada have green manures in rotation. Compared to conventional farms, a greater proportion of organic farms have crop rotations that include forages. Both of these crop types lower soil erosion risk. However, more organic farms have summerfallow and row crops in rotation, both of which tend to increase soil erosion risk. Summerfallow is one technique used by organic farmers to help control weeds and sometimes to conserve moisture. However, summerfallow also leaves the soil bare for a growing season, exposing the soil to greater wind and water erosive forces. As well, bare summerfallow in organic systems is often maintained through tillage, lowering soil stability and destroying soil structure.

Other Practices: Some other production practices more common on organic farms than conventional farms (such as compost use, strip cropping and shelterbelts) can lower soil erosion risk. Applying composts can not only add nutrients to the soil, but can also add organic matter, helping to build soil structural stability. Strip cropping (planting strops of different crops in a field), and planting shelterbelts can lower wind speeds across a field, lowering wind erosion risk. However, organic farms have other production practices that can increase soil erosion risk, such as delayed seeding. While delayed seeding allows a farmer to control weeds through tillage before a crop is seeded, it also increases the time in the spring when the soil is not covered by a crop.

Summary: From the survey, it was concluded that organic farms do use soil conservation practices. However, organic farms tend to use more tillage than conventional farms. If the production practices on an average organic farm were taken as a whole, it is unlikely that these are not as powerful as the zero tillage system is at reducing soil erosion.

Table 1: Soil properties measured in study and their meaning for erosion risk

Property	How this relates to erosion risk
Dry aggregate stability	A measure of a soil's resistance to wind erosion. Results for this test are given in Mean Weight Diameter (MWD). Higher MWD values indicate higher resistance to wind erosion.
Wet aggregate stability	A measure of a soil's resistance to water erosion. Results for this test are given in Mean Weight Diameter (MWD). Higher MWD values indicate higher resistance to water erosion.
Organic carbon content	Organic carbon is a measure of organic matter. Organic matter is essential for building soil structure, and will greatly affect a soil's resistance to erosion. Results for this test are given as a percent. Higher percent organic carbon indicates higher resistance to erosion.

SOIL EROSION RISK

The survey provided valuable information regarding production differences on Canadian organic and conventional farms. However, there is a need to know how these production differences affect actual soil erosion risk. In order to test how production differences affect soil properties, soil samples were taken from long-term organic and conventional crop rotation trials, as well as from working organic and conventional farms across Canada. The risk of soil erosion is partly determined by the soil's ability to resist erosive forces like wind and water. Soil structural stability and organic matter content have a significant effect on a soil's resistance to erosion. Dry aggregate stability, wet aggregate stability and organic matter content were measured on the soil samples. Table 1 summarizes what the soil properties tell us about erosion risk.

LONG-TERM RESEARCH TRIALS

Two long-term rotation trials across the prairies were assessed to determine the effects of management system and crop rotation on soil erosion risk. Soil samples were taken at the Glenlea Long-Term Crop Rotation Study in Manitoba, and the Scott Alternative Cropping Systems Trial in Saskatchewan. Each of the trials has three different crop rotations: an annual rotation, a biennial or diverse rotation and a perennial rotation. At both trials all three of the rotations were grown under organic and conventional management. The purpose of the study was to determine what the effect of different rotations and the different management practices was on the soil properties that affect soil erosion risk.

Dry Aggregate Stability: The soil's resistance to wind erosion was affected by crop rotation. At both the Glenlea and Scott trials, crop rotations that contained only annual crops had significantly lower Mean Weight Diameters (MWD). An annual rotation is not sufficient to protect against wind erosion under both organic and conventional management. Systems management (organic versus conventional) did not affect dry aggregate stability.

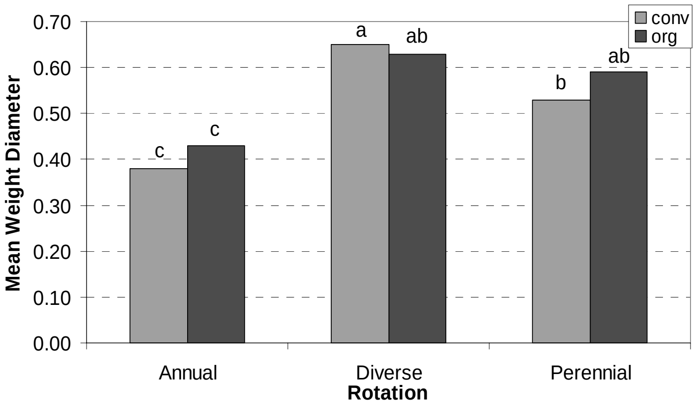

Figure 1: Dry aggregate stability under organic and conventional management for three rotations at Scott (treatments with the same letter are not significantly different, P=0.05)

Wet Aggregate Stability: At Glenlea, the soil's resistance to water erosion was affected by both crop rotation and management system. The biennial/diverse rotation had the highest MWDs (greatest resistance to water erosion). The organically managed plots had higher MWDs than the conventionally managed plots, indicating that organic management lowers the risk of water erosion. Crop rotation and management did not affect wet aggregate stability at Scott.

Organic Carbon Content: At Glenlea, conventional management resulted in higher organic carbon percentages. The organic plots had an average of 4.8% carbon, while the conventional plots had an average of 5.1% carbon. The lower carbon levels in the organic plots are most likely due to the fact that there was more tillage than in the conventional plots.

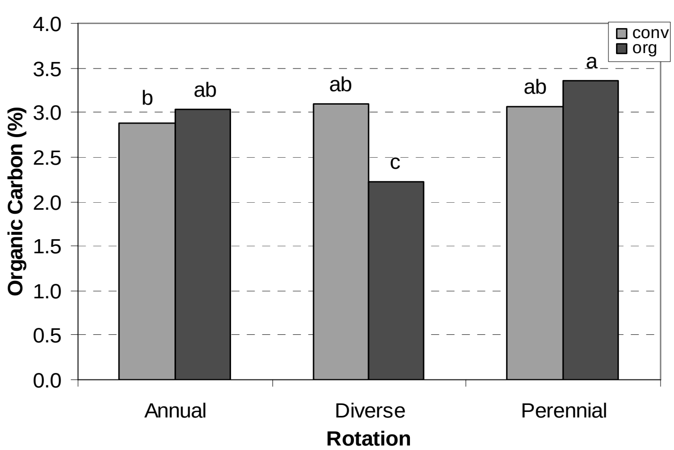

Figure 2: Organic carbon % under organic and conventional management for three rotations at Scott (treatments with the same letter are not significantly different, P=0.05)

At Scott, there was an interactive effect between crop rotation and management. Fig. 2 shows that the diverse rotation, managed organically, suffers a significant decrease in soil organic carbon content. There were difficulties establishing legume crops in the diverse organic rotation at Scott, possibly explaining why this rotation/management combination did so poorly in terms of organic carbon content.

Summary: From the long term studies it was concluded that aggregate stability was mostly influenced by crop rotation. The biennial rotations had the highest soil structural stability. Organic systems had lower organic carbon levels than conventional systems at Glenlea, but this did not influence aggregate stability. The organic systems are most likely stabilizing aggregates through some mechanism other than total organic carbon levels. Arbuscular mycorrhizal fungi have been found to have higher infection levels in organic systems, and have been shown to stabilize soil structure.

ORGANIC AND CONVENTIONAL FARMS

While research trials are helpful in determining the effect of specific management practices on some factor, they may not reflect actual agricultural systems. To better understand soil erosion risk on working farms, soil was sampled from 50 organic and conventional farms across Canada. These farms were paired to reduce the distance between fields, as well as differences between soil type and crop rotation. Dry and wet aggregate stability and organic carbon content were compared for the organic and conventional farm pairs with the same soil texture, as well as for just the organic vs. conventional farm pairs that had vastly different tillage practices. The measured soil properties were compared for all farms on the basis of crop rotation (rotations including annuals or perennials) rather than management. The results are shown in Table 2.

The farm pairs that had the same soil texture were analyzed for differences in soil properties between organic and conventional farms. Organic farms had lower organic carbon levels than their conventional neighbours; this was the only significant difference in soil properties between management practices.

Table 2. Soil properties from comparisons of organic/conventional farms and annual/perennial rotations (significant differences are highlighted)

		Aggregate Stability		Organic Carbon (%)
		Dry	Wet	
Same Texture	Organic	2.28	1.79	3.7
	Conventional	2.15	1.76	4.3
Different Tillage	Organic (conventional tillage)	2.17	2.36	3.6
	Conventional (zero tillage)	3.72	2.86	3.4
Rotations compared	Annual Rotation	2.04	1.62	3.0
	Perennial Rotation	2.10	2.55	4.4

Tillage Practices: The soil properties on organic and conventional farm pairs that had vastly different tillage practices were compared. In these farm pairs the conventional farms had zero tillage practices while the organic farms had conventional tillage practices. Wind erosion risk (dry aggregate stability) was significantly lower on the conventional, reduced tillage fields as compared to the organic, conventional tillage fields. Organic carbon levels were not significantly different between these farm pairs, indicating that tillage is not the only factor affecting organic carbon levels in organic farms.

Crop Rotation: The management system (organic vs. conventional) was ignored in the final comparison, and farms were compared on the basis of crop rotation. Fields that had only annual crops in rotation were compared to fields that had perennials in rotation. Rotation had a much bigger effect on soil properties than management system on Canadian farms. Fields that had perennials in rotation had significantly higher resistance to water erosion, and significantly higher organic carbon levels. Perennials add more carbon to the soil because they have more biomass in their roots.

Summary: Crop rotation had a much larger effect on soil erosion risk than management system on farms. Crop rotations that included perennials lowered the risk of soil erosion by increasing soil organic carbon content and wet aggregate stability. As was found for the long-term studies, organically managed soils had lower organic carbon levels than conventionally managed soils. However, the lower carbon levels in organic systems did not affect soil aggregate stability, indicating that something other than organic carbon is stabilizing the soil aggregates.

The Bottom Line...

Results from farms and long-term research trials indicate that crop rotation has a greater effect on erosion risk than the choice of organic or conventional management practices. Including perennial forages in a rotation can help reduce erosion risk. Organically managed soils had lower levels of organic carbon but no difference in wet or dry aggregate stability. Other factors may be affecting soil stability in organic systems.

References

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