SOIL MANAGEMENT FOR CONTINUOUS CORN

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Introduction

It is estimated that ethanol production will consume about 30% of the US corn crop by 2010. This phenomenon is encouraging favorable grain prices and dramatically increasing corn acreage. Recent USDA data show that corn production rose nearly 20% last year from 78 million acres in 2006 to nearly 94 million acres in 2007. While farmers are expected to plant slightly less corn in 2008, in favor of wheat and soybean, it is anticipated that corn acreage could return to a level above 90 million acres in 2009. A consequence of long-term continuous corn production could be the adoption of more aggressive tillage to manage large amounts of crop residue. This could potentially lead to decreased soil quality and increased soil loss. Research has shown that aggressive tillage systems such as moldboard and chisel plowing reduce aggregate stability. Coupled with the lower surface crop residue resulting from tillage the affected soils are prone to more erosion than no-till or other low disturbance systems. Soil quality degradation and increased soil erosion would be a poor trade-off for fuel independence. Therefore, producers must carefully consider tillage options when growing corn on corn. Additionally nutrient management considerations within a continuous corn production may require some adjustment based upon tillage intensity and the need to incorporate manure or other amendments.

Continuous Corn Production and Soil Quality

There is considerable interest currently regarding the impact of crop production practices on soil quality. Soil quality is a property of a soil that integrates a variety of biological, chemical, and physical properties. Ideally a soil having a "high quality" would be fertile, have good structure, hold adequate plant available water, produce high yields, and be resistant to degradation from compaction and erosion. Qualitative assessment of these factors is sometimes done to make comparison between fields or production systems.

Karlen et al. (1994) evaluated several soil quality parameters in at a research site located at the Lancaster Agricultural Research Station that had been in continuous corn under moldboard, chisel, and no-till management for 12 seasons. Averaged over the 12 years, the grain yields were 140, 139, and 137 bu/acre in the moldboard, chisel, and no-till systems, respectively. They noted that following the 12 years of continuous corn the highest soil quality assessment was found in the no-till system. Kladivko (1994) found that aggregate stability, measured as aggregate mean weight diameter, was greatest in a no-till system under continuous corn when compared to moldboard and chisel.

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Aggregate stability decreased when soybean was introduced into the rotation. Adding corn residue in the fall to a field where soybean was grown did not affect aggregate stability suggesting that factors such at the root contribution from corn were important for aggregate stability.

Continuous corn grown in reduced system can be as profitable as conventional systems. The past several season have contained significant mid-summer drought periods. It is known that reduced tillage systems tend to store more soil moisture because they have more small pores (Datiri and Lowery, 1990). They may also drain well following heavy precipitation events assuming that macro-pore from earthworm activity and root channels are open to the surface. It would be appropriate to recommend that producers consider conservation tillage systems where continuous corn is to be grown to maintain or build soil quality. If managed properly they are economically and environmentally sustainable.

Tillage and Corn Yield

Continuous corn production could be expected to increase crop residue level over time to an elevated level compared to that found in corn following soybean, especially in a reduced tillage system. Because of the extra residue and concerns with plugging within tillage equipment, many producers elect to chop stalks to improve residue flow through the equipment. Decreasing the size of the residue also makes it easier to bury residue by tillage. An evaluation was conducted several years ago at the Arlington Agricultural Research Station where stalks were chopped or not chopped prior to no-till or chisel tillage. Crop residue levels were 98 and 100% in no-till when stalks were chopped or not chopped, respectively. The residue cover following chiseling was reduced to 42 and 56%, for the chopped and not chopped treatments, respectively. These measurements were taken immediately after chopping and tillage, so final residue values for the chisel system would be considerably lower following secondary tillage for seedbed preparation.

Successful conservation tillage systems must overcome soil environment limitations that may be found; such as greater bulk density, and cooler and wetter soil conditions. Certain hybrids have been suggested to perform better in this environment. Kaspar et al. (1987) examined four hybrids in no-till, disk, and moldboard plow systems and found that while there were differences in the vegetative phase of growth grain yield was not affected by tillage. Most modern no-till planters are adapted to planting in high residue conditions. Newer planters are heavy and most employ row clearing coulters. Strip-tillage implements are also being modified to handle more crop residue. Producers should be able to find equipment that can perform well in high residue conditions.

There are few long-term Wisconsin studies that examine tillage management in continuous corn. One example is a study that this author has overseen since 1997 that has included fall chisel, fall strip-till, and no-till in continuous corn and corn/soybean rotations, along with several fertilizer placement treatments. Data for the main effect of tillage in the continuous corn portion are shown in Table 1. The no-till system in this study did not employ any in-row residue management to move residue from the row area. Yield was not measured in 2000. Over the 10 years that these tillage treatments were compared, significant yield differences were observed in only three seasons, each time in favor of the chisel system. The yield in the strip-till system was superior to the no-till system in 2 of the 3 years. Averaged over the 10 years, grain yield was 4 and 8% lower for strip-till and no-till, respectively. A detailed economic analysis is required to determine the overall profitability between tillage systems, however more soil loss could be anticipated for the chisel system, especially if stalks were shredded prior to tillage and an aggressive chisel implement were used.

There are likely soil conditions where no-till will not be the best tillage system choice. West et al. (1996) evaluated continuous corn production in Indiana over a 20-year period on a poorly drained soil and found stand reductions that lead to a consistent yield reduction. This result conflicts with others in that state that showed no-till yield began to increase after 3 years after conversion from conventional tillage.

Table 1. Tillage effect on corn grain yield in continuous corn, Arlington, Wis. 1997 - 2006 (Wolkowski, unpublished data).

	Tillage				
Year	Chisel	Strip-till	No-till	Pr>F	LSD
	------------------------------------ bu/acre------------------------------------				
1997	190	178	176	0.37	--
1998	161	160	164	0.85	--
1999	147	135	147	0.34	--
2001	189	182	151	<0.01	11
2002	181	175	174	0.41	--
2003	161	157	149	0.26	--
2004	187	178	159	<0.01	17
2005	182	187	176	0.19	--
2006	210	181	166	<0.01	15
2007	212	204	205	0.58	--
Average	182	174	167	--	--

Soil Loss in Continuous Corn

Soil loss can be predicted using RUSLE2, the most current erosion prediction model utilized by the USDA-NRCS. Components of this program run within the Snap-Plus nutrient management program and produce an estimated soil loss for a given cropping system based on soil type and slope, rotation, conservation practices, and tillage. A simulation of the soil loss for six common Wisconsin soils was conducted over a 4-year continuous corn rotation for an 8% slope of 150 ft in length. Table 2 shows the soil loss estimates for these six soils. As expected, there was variation in soil loss between soils, but in all cases the moldboard system exceeded allowable soil loss. Using a chisel system substantially reduced soil loss but depending on the soil type the loss was still relatively high. No-till generated very little soil loss, but some producers may not be able to produce sustainable crop yields using strict no-till and will likely opt for some form of tillage, which could include strip-tillage or other methods of in-row residue management.

Table 2. Estimated average soil loss for four years of continuous corn using three tillage systems on six Wisconsin soils.

Soil	State location	Tillage			Allowable soil loss (T)
		Moldboard	Chisel	No-till	
		---------------------------tons/acre/year ------------------------			
Plano	SC	6.3	2.8	0.1	5
Fayette	SW	10.4	4.6	0.2	5
Norden	WC	9.2	4.1	0.2	3
Kewaunee	NE	4.1	1.8	0.1	3
Loyal	NC	5.4	2.4	0.1	5
Hochheim	SE	6.4	2.9	0.1	5

Slope = 8%; slope length = 150 ft.

Producers and their consultants need to balance the aggressiveness of the selected tillage system with its effect on soil quality and soil loss. A return to clean tillage systems will not be sustainable and will likely result in soil loss values exceeding “T”. While the increase crop production for biofuels is offering opportunities to producers care must be taken to avoid “back-sliding” into practices that in the long term will reduce productivity and impact water quality.

Nutrient Management Considerations

The major nutrient management concerns that relate to continuous corn production arguably revolve around N management and the need for starter fertilizer. Professor Larry Bundy’s research program examined several soil fertility issues in continuous corn production systems in his 25 year career at the University of Wisconsin. One of his early studies (Bundy et al., 1992) examined N source, placement, and timing at sites near Janesville and Oshkosh in continuous corn using several different tillage systems. This work confirmed the observation that a higher N rate is required for continuous no-till corn, compared to plowed. The lower availability of N is likely a combination of increased denitrification and immobilization of N in no-till. The recent adoption of the MRTN approach for corn N recommendations suggest that producers use the high end of the range for a given nitrogen:corn price ratio. Dr. Bundy also developed the preplant and pre-sidedress nitrate tests that are well suited to determining the in-season availability of N in continuous corn and refining the N application rate.

Another question that producers often ask relates to the need for supplemental N to encourage stalk decomposition that they perceive to be a hindrance in continuous corn production. Dr. Bundy and his research associate Todd Andraski conducted a 3-year study where they evaluated the use of a modest application of N fertilizer to crop residue in the fall (Bundy and Andraski, 2002 unpublished research report). The study showed that fall N applications designed to promote residue decomposition were not warranted and did not enhance residue decomposition and N mineralization, increase spring surface soil temperature, or increase yield.

The final components of Dr. Bundy's research that relates to continuous corn production are the factors that contribute to the use of row-placed starter fertilizer. Many producers are moving away from the use of starter fertilizer because of the cost the attachments add to the planter, the practicality of mounting starter attachments on modern corn planters, and the time required to tend and fill fertilizer boxes or tanks during planting. He conducted an on-farm assessment of the use of starter fertilizer at 100 sites over a 3-year period. The greatest potential for an economic response was found where the sum of the planting date (days from 1 January) and the RM of the hybrid exceeded 235 (Bundy and Andraski, 1999). Their study also found a greater potential for response when the soil test K was below 140 ppm. The response to row-placed fertilizer has generally been greater in conservation tillage systems having minimal soil disturbance.

A final issue related to nutrient management would affect the tillage choice in continuous corn is for situations where manure is applied. Manure would be expected to increase surface residue and inhibit soil drying, such that aggressive tillage may be considered to minimize these effects. A study conducted by the author in 2002 and 2003 examined this issue and a summary of the yield response is shown in Table 3. These data show considerable variation by site, which was due to soil conditions, manure consistency, year, and spreading characteristics. While aggressive tillage tended to produce the highest yields, it is likely that conservation tillage systems such as moderate chiseling or strip-till may be the better economical and environmental choice.

Table 3. Main effects of straw-bedded manure and tillage on the corn grain yield at four study locations in Wisconsin, 2002 – 2003 (NS = not significant).

	Arlington		Lancaster		Marshfield		Spooner	
Treatment	2002	2003	2002	2003	2002	2003	2002	2003
	---------- bu/acre ----------							
Manure (t/a)								
0	147	157	224	125	181	97	167	180
15	175	174	232	138	172	113	173	194
30	182	178	236	145	146	104	178	185
LSD $_{(0.05)}$	25	16	7	NS	19	15	NS	NS
Tillage								
No-till	164	161	234	143	156	96	126	172
Strip-till	166	168	229	143	172	108	173	190
Disk	162	169	236	137	153	100	179	191
Chisel	170	172	229	135	165	110	189	195
Moldboard	178	178	225	122	183	109	198	183
LSD $_{(0.05)}$	11	8	NS	12	14	NS	25	NS
Pr>F								
Manure	0.03	0.03	0.03	0.21	0.01	0.01	0.36	0.40
Tillage	0.04	<0.01	0.11	<0.01	<0.01	0.20	<0.01	0.22
M*T	0.99	0.23	0.17	0.03	0.47	0.11	0.91	0.60

Summary

Currently the high demand for corn grain for ethanol production is encouraging the production of more continuous corn in Wisconsin, at the expense of soybean, processing vegetable crops, and small grains. Continuous corn presents a challenge relative to tillage such that concerned producers may be more likely to use aggressive tillage systems to manage residue and incorporate amendments. Such practices could increase soil loss on sloping soils and considering current fuel prices add substantially to production costs. Producers should be encouraged to adopt conservation tillage management systems that will lessen the risk of soil loss and improve soil quality. More detailed attention to nutrient management will also be required.

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