Continuous Grain Corn Production–Menace or Benefit?

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Quebec research shows that high yields of continuous corn benefit soil quality. High corn yields primarily increased soil organic carbon levels. Results support earlier research findings.

CORN provides tremendous dry matter yields, rich sources of energy, protein, and minerals. Yet corn has been singled out as a soil-degrading crop that can cause environmental damage through loss of soil organic matter, resulting in increased soil erosion and reduced soil quality. Is there a possible way that corn could be managed to provide those immense benefits without excessive soil damage?

The benefits and risks with corn production can be phenomenal. It is estimated that each North American consumes about 3.5 lb (1.6 kg) of corn per day, directly, and in meat, dairy products, sweeteners, starch, and in miscellaneous uses such as packaging and plastic. Any idea of removing corn from our food system would be unreasonable.

Corn and Soil Organic Matter

Corn has been implicated in soil degradation in many studies. Continuous corn has been shown to decrease soil organic matter, or more specifically, soil carbon (C) and nitrogen (N). Soil organic matter is intimately associated with organic C and N. Often, the various forms are considered interchangeable. In this study, we used organic C and N as indicators of organic matter, without referring to the many complex forms found in the soil.

Soil organic C and organic N are dynamic materials. The amount of soil organic matter is a balance between the rates of addition of C and N in plant residue and rates of decomposition of organic materials. The effect, then, of a cropping system on soil organic matter is a balance between residues returned to the soil and microbial decomposition. This balance was dramatically shown by Larsen and coworkers where residue additions above 2.7 tons per acre (6 tonnes per hectare) resulted in net increases in soil organic C. Returning less than that amount of residue resulted in soil organic matter losses. Those results emphasize that higher corn yields may hold the potential for increased soil organic matter.

Higher Yield Effects Studied

Is it possible under today's higher yields and better management to think of corn as a potential soil improver? If corn yields are high enough, soil organic matter should increase.

This idea was tested using a long-term corn management experiment on the Macdonald Campus of McGill University near Montreal. The experiment, which began in 1984, involved the use of two fertilizer rates (normal and high), two population densities (normal and high), rainfed and irrigated systems, and two hybrids. The purpose was to determine the interaction among these inputs on soil organic matter levels. Populations were 26,000 and 36,000 plants per acre (65,000 and 90,000 plants per hectare). Fertilizer rates were 150-90-150 and 360-270-360 lb N, P_2O_5,

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and K_2O/A (170-100-170 and 400-300-400 kg/ha). Fertilization practices included preplant N, phosphorus (P), and potassium (K), starter N and P, and side-dressed N at the high N rates. For 5 years, liquid cattle manure was applied to supply 1.8 tons/A (4,000 kg/ha) of dry matter and 62 lb N/A (70 kg N/ha). Irrigation water was supplied the first 3 years using a drip system. Two hybrids were included for comparative purposes. If one of the cultivars yielded significantly lower it was dropped and replaced the next year.

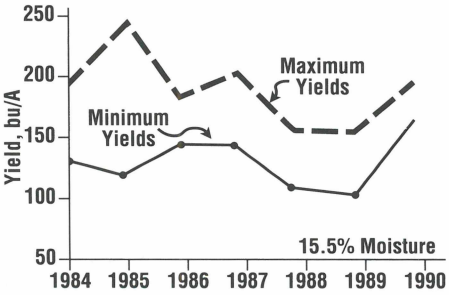

Figure 1. Corn yields over the life of the study.

Results

Hybrid and population density effects on yield and dry matter return to the soil were small, and there was no influence of these factors on soil organic matter. Irrigation increased corn yields two years out of three but there were no effects of irrigation on soil organic matter. For those reasons, only the fertilizer effects on soil organic matter will be discussed.

Maximum grain yields varied from 150 bu/A (9.4 tonnes/ha) to 242 bu/A (15.2 tonnes/ha); depending on the year (**Figure 1**). Low yields varied from 97 bu/A (6.1 tonnes/ha) to 169 bu/A (10.6 tonnes/ha). Stover inputs over the same period calculated in tons of carbon per acre varied from 1.25 to 2.10 tons/A (2.8 to 4.7 tonnes/ha), depending on the year and fertilizer rate (**Table 1**). Carbon from the added manure amounted to approximately 0.7 tons/A (1.6 tonnes/ha) per year.

Organic Carbon

Soil organic carbon levels (**Table 1**) were influenced by fertilizer rates and by time. Over the 6 years of production, the high rate of fertilizer increased the carbon return over the normal rate of fertilization by about 0.9 tons/A (2 tonnes/ha). The net result was that soil organic C increased from 18 tons/A (40.7 tonnes/ha) in 1984, to 19.4 tons/A (43.4 tonnes/ha) in 1987, to 21.4 tons/A (48.0 tonnes/ha) in 1990. During the same period, corn stover supplied 9 to 9.9 tons/A (20.3 to 22.2 tonnes/ha) of organic C, depending on fertilizer rate. Liquid manure provided 4.3 tons/A (9.6 tonnes/ha). The efficiency of conversion of organic C residue and manure C into soil organic C was about 23 percent.

Organic Nitrogen

Changes in average soil organic N contents during the experiment were not significant, but organic N was influenced by

Table 1. Carbon additions from corn stover and manure–1985 to 1989.

	Added in Stover		Added	Soil
	Low fertilizer rate	High fertilizer rate	in Manure	Organic Matter
Year	Tons C/A	Tons C/A	Tons C/A	Tons C/A
1984	1.56	1.56	0.71	18.16
1985	1.92	2.10	0.71	
1986	1.61	1.70	0.71	
1987	1.43	1.52	0.76	19.38
1988	1.25	1.43	0.71	
1989	1.29	1.61	0.67	
1990				21.43
Additions	9.06	9.91	4.27	
Increase				3.26

Table 2. Effects of N from stover and manure on soil organic N levels.

	Nitrogen added in stover		Nitrogen added in manure all plots	Soil organic nitrogen	
	Low fertilizer rate	High fertilizer rate		Low fertilizer rate	High fertilizer rate
Year	lb/A	lb/A	lb/A	lb/A	lb/A
1984	67	77	62	4,211	4,211
1985	55	76	62		
1986	71	81	62		
1987	54	64	66	3,638	3,877
1988	55	70	62		
1989	53	70	59		
1990				3,757	3,972
Additions	355	438	375		
Soil increase due to increased fertilizer rates					215

fertilizer rates after 3 and 6 years of production (**Table 2**). During the 6 years of the project, soil organic N in the high fertilizer treatment area gradually increased compared to the lower rate. Over the life of the study, N returned in the stover was 438 lb/A (490 kg/ha) for the high fertilizer rate vs. 355 lb/A (398 kg/ha) for the lower rate.

The high fertilizer rate resulted in about 214 lb/A (240 kg/ha) more soil organic N than the lower rate. The increase in soil organic N was greater than the differences in stover N between low and high fertilizer rates, suggesting some possible stimulation in organic N retention by the high fertilizer rate. Increases in organic N with increases in fertilizer rate were not large, but were important on a long term basis.

There is some question as to the quality of the organic matter that results from the corn production. Generally, C/N ratios increased over the 6-year period (8.6 to 11.1), but values were still within an acceptable range (**Table 3**). This increase does indicate that added soil organic matter was somewhat less humified than the original organic matter.

Summary

The results of this 6-year study indicate that residue returns from continuous corn production exceeded C decomposition in these soils, and that fertilizer rates can affect organic C and organic N levels in the soil. High levels of corn production can result in increased soil organic matter and improved soil quality.

Is corn a soil building crop? Certainly, but it requires optimum management and good returns of C and N to the soil. This can best be managed through a program that maximizes corn yields and nutrient returns to the soil. ■

Table 3. Changes in soil organic matter, organic N and C/N ratio after 3 and 6 years of production.

	Organic C		Organic N		C/N ratio	
			Fertilization Rate			
Year	Low	High	Low	High	Low	High
			% in soil			
1984	1.52		0.176		8.6	
1987	1.62		0.152	0.162	9.4	10.0
1990	1.74	1.83	0.157	0.166	11.1	11.0