Sustaining Soil Organic Matter in No-tillage Corn Production

W. W. Frye and R. L. Blevins[1]

INTRODUCTION

Soil organic matter imparts many beneficial qualities to soils. These include higher cation exchange capacity; enhanced labile soil fertility, especially N and S; greater buffering capacity; improved structure and with it higher infiltration rate, lower runoff and erosion, and higher water supplying capacity.

One of the most important relationships is between soil organic matter and soil erosion. Soil organic matter decreases soil erosion and soil erosion decreases soil organic matter content (5). This relationship has important implications in the effects of tillage on soil organic matter. Controlling soil erosion with conservation tillage not only conserves soil organic matter but further decreases soil erosion. Conversely, when tillage accelerates soil erosion it accelerates both the loss of soil organic matter and the erosion process.

Tillage systems affect soil organic matter in another way also. Soil disturbance and manipulation and mixing of plant residues into the soil by plow tillage and the secondary tillage normally associated with it increase the rate of decomposition of soil organic matter. In no-tillage, on the other hand, little soil is moved or mixed. Plant residues and soil amendments are applied to the soil surface and are not mechanically mixed into the soil. Plant roots tend to concentrate near the soil surface. The surface few centimeters of soil usually are cooler, wetter, less oxidative, and more acid than in conventional tillage soil (3). These conditions in no-tillage tend to cause the soil organic matter content to increase near the surface and to decompose at a slower rate relative to conventional tillage.

[1]Dept. of Agronomy, University of Kentucky, Lexington, KY 40546-0091.

Finally, crop yields are not only affected by soil organic matter content, but in turn, affect it. The improved soil conditions and increased plant nutrients from soil organic matter usually increase crop yield, as does increased nitrogen fertilizer. As crop yields increase, more residue is returned to the soil, increasing soil organic matter content (5). To a point, there is a self-perpetuating relationship between soil organic matter and soil productivity.

Our objective was to determine the effects of tillage, N rate, and time on the soil organic matter content under continuous corn starting with an old (50 to 60 years) bluegrass sod.

EXPERIMENTAL PROCEDURES

This paper reports data from a tillage field experiment at Lexington, KY. The soil was a Maury silt loam. The experiment was established in 1970 and has been in continuous no-tillage (NT) and conventional tillage (CT) corn production since then. Soil samples reported on here were taken after corn harvest in the fall of 1989, and the results are compared to results from similar samples taken before tillage in the spring of 1975 (2).

The CT plots were plowed to 8 to 9 inches depth in late April to early May each year. Corn was planted about May 10 to 15 each year with a no-tillage planter. The seeding rate was aimed at obtaining a final stand of about 20,000 plants/acre. All plots were sprayed at planting with recommended rates of a mixture of herbicides (2) for burndown of the rye cover crop and for seasonal weed control. Muriate of potash (KCl, 60% K_2O was applied broadcast at the rate of 100 lb K/acre. No P was applied because the soil is naturally high in phosphate. Corn was harvested from the two center rows of each plot. Soil samples were collected from 0-

to 2-, 2- to 6- and 6- to 12-inch depth increments and analyzed for organic carbon using a wet digestion procedure in 1975 and a dry combustion procedure in 1989. The organic carbon values were multiplied by 1.72 to convert to soil organic matter values. Bulk density was determined by the method of Radcliffe (unpublished M.S. thesis, Univ. of Kentucky). Soil organic matter was calculated to a depth of 12 inches for each treatment.

RESULTS AND DISCUSSION

Soil organic matter in 1989, after 20 years of continuous corn, was greater in NT than CT soil (Table 1). This was consistent with previous observations on these plots (2) and consistent with the results obtained by other researchers at different locations (1, 4, 6, 8). The effect, however, was greatest at 0 to 2 inches and was limited to the 0 to 6-inch depth. Below 6 inches (6 to 12), soil organic matter was greater in CT than NT. Several factors may contribute to this phenomenon. Plant residues accumulate at the soil surface in NT and are not mechanically mixed throughout the plow layer as they are in the case of CT. When mixed into the soil, the residues are in a more favorable environment for decomposition and humification than when left on the soil surface. Moreover, soil disturbance associated with tillage generally increases the rate of organic matter decomposition and carbon mineralization by increasing aeration and exposing heretofore protected soil organic matter (3, 7).

The effect of N fertilizer rate on soil organic matter was apparent in both tillage treatments (Table 1). There are two possible reasons for higher soil organic matter with higher N rates. First, higher N rates produce greater biomass, adding more plant residue to the soil. A possible second reason is the retarding effects of soil acidity on the rate of organic matter decomposition. During the earlier stages of our experiment, the soil pH decreased to nearly 4.0 on the unlimed, high N plots (2). Soil organic matter tended to be higher in plots with lower soil pH values (2); however, whether or not the relationship was causal is unclear.

Soil organic matter declined sharply from 1970 to 1975 but increased substantially in the 15 years from 1975 to 1989 with both CT and NT (Tables 1 and 2). The soil organic matter content under bluegrass sod appeared to increase slightly during that time, from 40.2 to 43.5 tons/acre in the 0 to 12-inch depth. The 38%

Table 1. Soil organic matter after 20 years (1970-1989) of no-tillage and conventional tillage corn.

	Soil organic matter to 12 inches		
N rate	Conv. tillage	No-tillage	Bluegrass sod
lb acre^{-1}	ton/acre[1]		
0	37.6	42.6	43.5
75	43.3	44.9	
150	43.4	45.2	
300	47.2	51.1	
Average	42.9	46.0	

[1] Average of four replications and sum of three depths (0-2, 2-6, 6-12 inches).

Table 2. Soil organic matter to 12 inches after 5 years (1970-1975) of no-tillage and conventional tillage corn. From Blevins et al. (2).

	Soil organic matter to 12 inches		
N rate	Conv. tillage	No-tillage	Bluegrass sod
lb acre^{-1}	ton/acre[1]		
0	28.0	33.0	40.2
75	30.6	34.9	
150	32.0	35.1	
300	33.4	40.6	
Average	31.0	35.9	

[1] Average of four replications and sum of three depths (0-2, 2-6, 6-12 inches).

average increase with CT and the 28% increase with NT were probably a result of a gradual rebuilding of soil organic matter following the rapid decline that was observed in both tillage systems after the first 5 years of the experiment (Table 2). By 1989, all plots except CT without N fertilizer had returned to the original level (or higher) of soil organic matter. At the 300 lb N/acre rate, soil organic matter appears to have exceeded that of the bluegrass sod. All corn residue and a rye cover crop were added to the organic matter pool each year during the 20-year study period, which, along with N fertilizer, is probably responsible for most of the increases observed in soil organic matter.

SUMMARY

When an old bluegrass sod was converted to corn production, the organic matter content decreased rapidly during the first 5 years with both CT and NT, however, more so with CT than NT. Soil organic matter increased substantially for all treatments between the 5th and 20th years of the study, with all but one treatment (CT, no N) returning to near or above the original level of the bluegrass sod.

Clearly, row cropping decreases soil organic matter content, if initially high, especially with CT. However, if initially low or depleted to a relatively low level, soil organic matter can be increased through nitrogen fertilizer, crop residue, and cover crop management. The increase is greater and probably faster with NT than CT.

LITERATURE CITED

1. Baeumer, **K.,** and W.A.P. Bakermans. **1973.** Zero tillage. Adv. Agron. 25:77-123.

2. **Blevins, R. L., G.W. Thomas, and P.L.** Cornelius. 1977. Influence of no-tillage and nitrogen fertilization on certain soil properties after five years of continuous corn. Agron. **J.** 69:383-386.

3. Doran, J.W. 1980. Soil microbial and biochemical changes associated with reduced tillage. Soil Sci. Soc. Am. J. 44:765-771.

4. Elliott, **L.F., R.I.** Papendick, and **D.F.** Bezdicek. 1987. Cropping practices using legumes with conservation tillage and soil benefits. p. **81-89.** In J.F. Power (ed.) The role of legumes in conservation tillage system. Soil Conserv. Soc. Am., Ankeny, IA.

5. **Frye, W.W., O.L. Bennett, and G.J.** Buntley. 1985. Restoration of crop production on eroded or degraded soils. p. 335-356. In R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. ASA, CSSA, and SSSA, Madison, WI.

6. Giddens, **J. 1957.** Rate of loss of carbon from Georgia soils. Soil Sci. Soc. Am. Proc. 21:513-517.

7. Rice, C.W., **M.S.** Smith, and **R.L.** Blevins. 1986. Soil nitrogen availability after long-term continuous no-tillage and conventional tillage corn production. Soil Sci. Soc. Am. J. 50:1206-1210.

8. Utomo, **M.,** W.W. **Frye,** and **R.L.** Blevins. 1990. Sustaining soil nitrogen for corn using hairy vetch cover crop. Agron. J. 82:979-983.