Soil Quality Change during Transition to Organic Grain Production

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Biologically-active soil organic matter is the major nutrient reserve in organic production systems, where soil fertility and plant nutrition are mediated by cycling of C and nutrients through biological pools. Our objective was to quantify changes in soil quality during and after transition to organic grain production. The experiment was initiated in 1998. Rotation treatments included: conventional corn-soybean, organic corn-soybean-oat/alfalfa, and organic corn-soybean-oat/alfalfa-alfalfa. Surface soil samples (0-15 cm) were collected after harvest 1998 through 2004. In this report, we will discuss results from 1 year, 4 years, and 7 years post transition. We quantified soil organic C (SOC) and total N (TN), microbial biomass C (MBC), particulate organic matter C (POMC), potentially mineralizable N (PMINN), stable macroaggregates, NO_3-N, Bray P, EC, pH, and bulk density.

After 7 years of organic management, SOC and TN were significantly greater in the organic systems than in the conventional system. This difference was evident in the 3-year and the 4-year organic rotation in the fall of 2001, when both systems showed similar patterns of increased SOC. MBC and POMC were greater in the organic systems at 1 year after transition and the differences persisted through 2004, when MBC and POMC in the organic rotations were significantly greater than the conventional rotation. Unlike POM C, the response of MBC was only evident in the 4-year rotation. The response of PMINN to the change in management occurred less rapidly than MBC and POM C. PMINN was different for both organic rotations at the end of 2001, and this difference persisted through fall of 2004, when PMIN N was significantly greater in the organic systems than the conventional system. Differences in the macroaggregate structure were evident among the cropping systems early in the experiment. At the end of 2004, the organic systems had significantly more stable macroaggregates than the conventional system. Soil from the 4-year organic rotation had consistently more stable macroaggregates than the 3-year organic rotation, which emphasizes the importance of forage legumes for enhancement and maintenance of soil structural stability

Soil pH was significantly lower in the conventional system (6.43) than the organic systems (6.61) at the end of 2004, reflecting the continued application of chemical fertilizer N. Soil electrical conductivity (EC) was not different between organic (242 μS cm^{-1}) and conventional (242 μS cm^{-1}) management, suggesting that animal manure compost application was not increasing soil salinity.

Bray P was higher in the organic soils after one growing season, and remained higher through the end of 2004, when Bray P was significantly greater in the organic systems than the conventional system. The difference was much more pronounced in the 3-year rotation, presumably because animal manure compost is applied more frequently than in the 4-year rotation.

Amounts of residual soil NO_3-N were consistently higher in the conventional system throughout the experiment, starting at the end of the first growing season. In the fall of 2004, NO_3-N was significantly greater in conventionally managed surface soil than in soil that was managed organically. An additional year of alfalfa in the 4-year organic rotation did not result in significant differences in NO_3-N compared with the 3-year organic rotation.

The ratio of NO_3-N to PMINN is an indicator of the soil's potential to leach N through the soil profile and into shallow (tile drainage water) and deeper groundwater. Larger ratio values indicate a greater potential for environmental contamination. The ratio was smaller in both the 3-year and 4-year organic rotations starting early in the transition period (fall 1998). At the end of 2004, the conventional system ratio was significantly larger than the organic systems ratio, indicating a lower potential for N leaching loss in the organic system. The ratio also offers additional insight into differences in N partitioning into labile organic and inorganic N forms within organic and conventionally managed soils.

This study evaluates changes in soil quality for 7 years after transition from conventionally managed corn and soybeans to organically managed corn-based rotations containing small grains and forage legumes amended with composted swine manure. The results show that transitioning to organic management practices will increase SOC and TN, increase biologically-active organic matter pools, increase stable macroaggregate structure, increase soil pH, and decrease the potential for N leaching loss while maintaining or enhancing crop yield.

Table1. Soil Quality Parameters Neely-Kinyon LTARS to a depth of 15 cm†

	1998	2001	2004		1998	2001	2004
<u>Organic</u>				<u>Conventional</u>			
SOC	43.0	46.6	44.6a‡	SOC	41.3	45.1	42.7b
POM C	7.15	8.88	7.53a	POM C	6.22	7.86	6.71b
MBC	140††	765	709a	MBC	100††	669	664b
PMIN N	78	90	81a	PMIN N	77	82	72b
Macro %	26.3	26.8	24.3a	Macro %	25.5	24.7	22.9b
NO_3-N	12.43	11.07	11.32	NO3-N	17.93	15.13	14.32
Ratio	0.18	0.15	0.17b	Ratio	0.24	0.21	0.23a
Bray P	47	52	51a	Bray P	35	34	31b

† Units: SOC and POMC Mg ha^{-1}; MBC, PMIN N, NO_3-N kg ha^{-1}; Macro % of soil mass; Bray P μg g^{-1}

‡ Values within row followed by same letter not significantly different at $p < 0.05$ (LSD)

†† MBC quantified to a depth of 7.5 cm