The College of Agricultural, Food and Environmental Sciences

Long Term Effects of Crop Management:
Soil Quality

Results from VICMS study at the Southwest Research and Outreach Center in Lamberton, Minnesota

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The study

The Variable Input Crop Management Systems (VICMS) research plots were established in 1989 in southwestern Minnesota to study the effects of four management systems under 2-year and 4-year crop rotations. This fact sheet summarizes soil quality measurements made in 2000 and 2001 on the VICMS1 plots. The results represent the effects of more than 10 years of crop management systems.

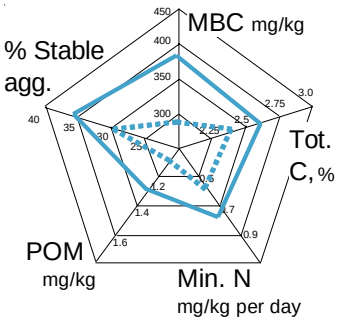
Results

The diagrams below represent the soil quality under each of the four management systems. The spokes of each wheel represent five soil quality indicators. The thick colored lines mark the measured values for each of the indicators. Values toward the outside of the wheel are associated with higher soil quality, so the greater the area outlined by the colored line, the better the overall soil quality for the system examined.

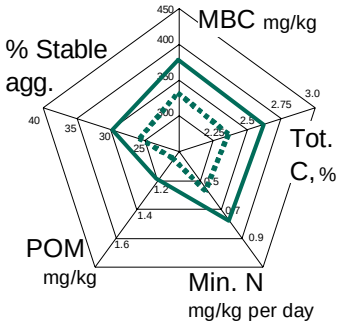
2-yr rotation = corn-soybean

4-yr rotation = corn-soybean-oat/alfalfa-alfalfa

No inputs (NI) = No fertilizers or herbicides. The only inputs are seed and tillage.



High input (HI) = Broadcast fertilizer and herbicides. Moldboard plowed most years.

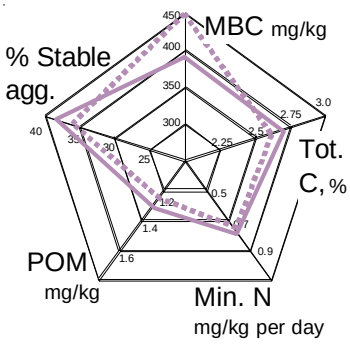


The NI and HI systems have the lowest soil quality, as shown by the smaller area encompassed by the colored lines.The areas encompassed by solid lines (4-yr rotations) are much larger than those of the dashed line (2-yr rotations), showing that the NI and HI systems had greater positive responses to the extended rotations than did the RI and OI systems.

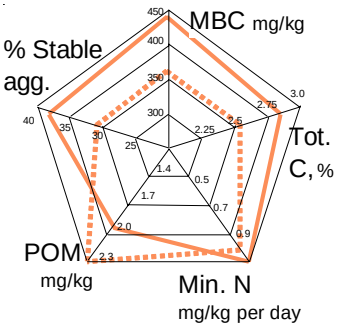
Assessing soil quality

Soil quality is the ability of soil to function to support plant growth and protect water quality, now and into the future. Soil quality is assessed by measuring indicators that change quickly in response to management differences and allow farmers to predict what will happen to their soil health and productivity in the long-term. Useful indicators reflect important soil processes, such as soil structure, nutrient supply, and soil microbial activity. The soil quality indicators reported in this fact sheet are:

- **Total organic carbon (Tot. C)** - an estimate of total soil organic matter. (Organic matter is about half carbon.) Tot.C changes more slowly than the other indicators.
- **Mineralizable nitrogen (Min. N)** - a measure of the amount of plant available N that can be released over time from the soil organic matter.
- **Particulate organic matter (POM)** - an estimate of "active" organic matter. A measure of large organic matter particles >0.053 mm.
- **Large stable aggregates (Stable agg.)** - a measure of how well the soil holds together. Aggregate stability affects workability, root growth, and water infiltration.
- **Microbial biomass carbon (MBC)** - an estimate of the number of microorganisms in the soil.



Reduced input (RI) = Reduced rates of banded fertilizer and herbicides. Reduced tillage, with no-till in most years.



Organic input (OI) = No chemical fertilizers or herbicides. Aged manure is applied. Weeds are controlled through delayed planting and cultivation.

The OI system had the greatest overall soil quality as seen in the greater areas delineated by both the 2- and 4-yr rotation lines. The RI system was comparable to the OI system for aggregation, microbial biomass, and total carbon levels.

The bottom line

The results of this study suggest that

- reduced tillage can improve soil structure and microbial activity within the 2-yr rotation.
- extended rotations including small grains and perennial legumes improve soil quality.
- soil quality is enhanced by organic systems that use manure inputs and diverse crop rotations, as long as nutrient balances are maintained.

The graphs on this page take a closer look at these results.

Tillage damages soil structure

- For the 2-yr rotation, soil structure was significantly better in the RI (least tillage) system. For the 4-yr rotation, soil structure was significantly worse in the HI system compared to the other three systems (figure 1).
- Minimizing soil disturbance by reducing tillage maintains good soil structure, resulting in less compaction and greater water holding capacity and infiltration.
- Reducing tillage also increased the amount of microbial biomass and activity (not shown).

Longer rotations improve soil structure

- More large aggregates were found following oats and alfalfa than following corn and soybeans (figure 2).
- All the systems had better soil aggregation in the 4-yr rotation compared to their 2-yr counterparts (figure 1), in part because of reduced soil disturbance.
- The abundant shoot and root residues of oats and alfalfa also helped ameliorate some of the negative effects of tillage. Other small grains or perennial legumes could have similar effects on soil quality.
- High residue crops like alfalfa and corn build organic matter in the soil, increasing aggregate stability. Low residue crops, like soybeans, are detrimental to aggregate stability.
- Beneficial effects of oats and alfalfa in the 4-yr rotation are apparent in the diagrams on the preceding page.
- The importance of the longer rotation in organic systems is illustrated by the increase in aggregation in the 4-yr OI system compared to its 2-yr counterpart (figure 1).

Manure improves soil quality

- Organic matter additions can improve aggregation, microbial biomass, and other soil quality attributes. The greater amount of POM (active organic matter) in the OI system is attributed to manure additions (figure 3).
- Although organic matter additions can benefit soil quality, manure applied to meet all the crop nitrogen needs can result in excessive accumulation of phosphorus. Other sources of nitrogen are needed. Alternative sources of nitrogen include nitrogen-fixing legumes in rotation as cover crops or cash crops.

For additional information about the VICMS study contact Deborah Allan at the University of Minnesota 612-625-3158, dallan@umn.edu.

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Fig. 1. Soil structure in different management systems

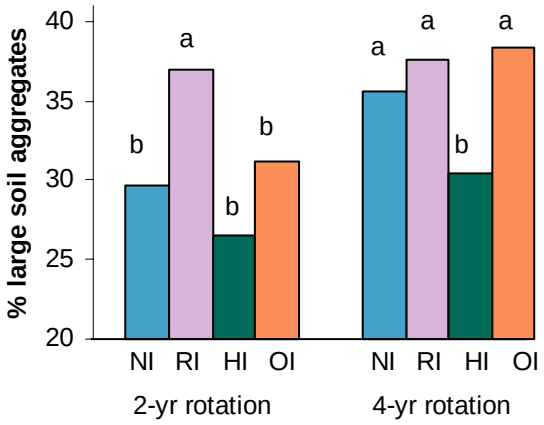


Fig. 2. Soil structure after different crops

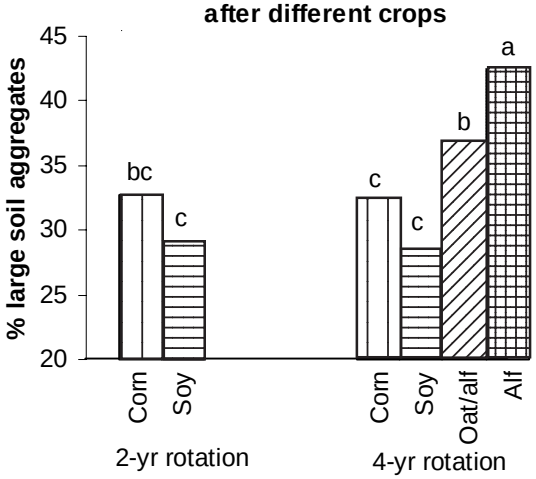
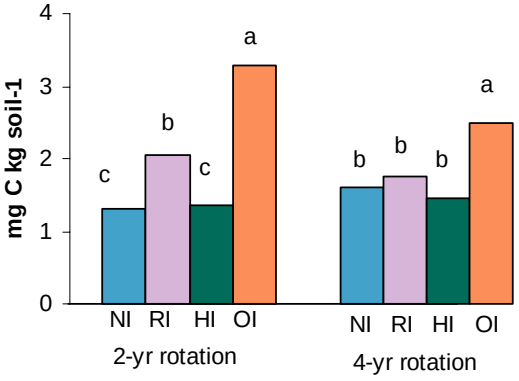


Fig. 3. Particulate Organic Matter Carbon



Identical letters above bars in a graph indicate that the values are not statistically different.