Soil Nitrate, Cropping Systems, and Economics

Can Iowa cropping systems simultaneously protect water quality and be profitable?

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More than 150 community water supplies in Iowa obtain their water from shallow wells located in alluvial aquifers that are highly susceptible to nitrate contamination. These aquifers are typically overlain and/or surrounded by intensive crop production systems dominated by corn and soybean. Fields planted to these annual crops tend to "leak" nitrate even when best management practices are utilized. The city of Sioux Center, located in Northwest Iowa, is impacted by these dynamics. It obtains more than 50% of its drinking water from an alluvial aquifer accessed by 12 wells that are 30 to 45 feet deep. In recent years, several of these wells have produced water with nitrate concentrations greater than 10 parts per million, the maximum contaminant level (MCL) set by the U.S. Environmental Protection Agency. The city responded by blending water from multiple sources to keep the nitrate level in finished water below the MCL. However, for long-term sustainability it wanted to reduce the level of nitrates entering its shallow wells. With the help of the Iowa Department of Natural Resources the city formed a Source Water Protection Planning Team, and began to investigate cropping systems that had the potential to reduce non-point source contamination of the well field.

The central research question was, "Can we identify cropping systems that produce relatively low residual (late fall) soil nitrate levels while generating a reasonable economic return for farmers?" To answer this question five different cropping systems were evaluated in a 40 acre field experiment (with four replications) conducted near the Sioux Center well field from 2009 to 2013. Each year, in November, 18 soil cores (6 feet deep - see photo below) were taken from each plot and divided into 1 foot increments to determine nitrate content throughout the soil profile. The higher the soil nitrate levels, particularly deeper in the soil, the greater the risk of nitrate moving into groundwater. Economic data, including opportunity costs, were recorded for each cropping system.

Cropping Systems Evaluated

1. Continuous Corn* (with a cereal rye cover crop)
2. Perennial Grass
3. Oat (alfalfa under-seeded) – Alfalfa – Corn
4. Oat (with a red clover cover crop)- Corn*
5. Soybean – Winter Wheat – Corn* (with a cereal rye cover crop)

*N fertilizer was side-dressed based on results from the late spring nitrate test.

Residual Soil Nitrate

Data from the soil cores indicated that the perennial grass system resulted in the lowest residual (late fall) soil nitrate content, while continuous corn produced the highest soil nitrate content (Figure 1). The relatively high nitrate levels at the 4, 5, and 6 foot depths following continuous corn, even though nitrogen fertilizer was side-dressed based on soil tests, and a rye cover crop was used, were particularly striking. However, a 3 year oat-alfalfa-corn rotation resulted in nitrate levels below 3 feet that were almost as low as those under perennial grass. A 2 year oat/red clover-corn rotation also resulted in relatively low nitrate levels below the 3 foot depth.

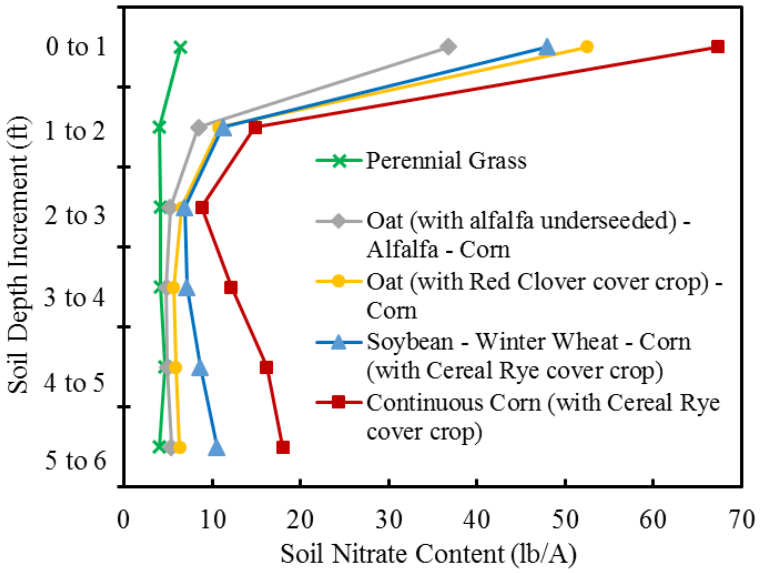

Figure 1. Residual (late fall) Soil Nitrate Content was affected by cropping system. Data points represent means of the 2010 to 2013 cropping years.

Root Depth and Length of Growing Season

The soybean-winter wheat-corn cropping system resulted in lower residual soil nitrate levels than continuous corn, but nitrate levels below 3 feet were still fairly high (Figure 1). This appears to be due to the absence of a deep-rooted crop with an extended growing season, such as alfalfa or red clover, which can remove nitrate remaining after the corn crop. In this cropping system, soybean (following corn) reduced soil nitrate content in the upper part of the soil profile, but residual soil nitrate content below 4 feet was relatively high (Figure 2).

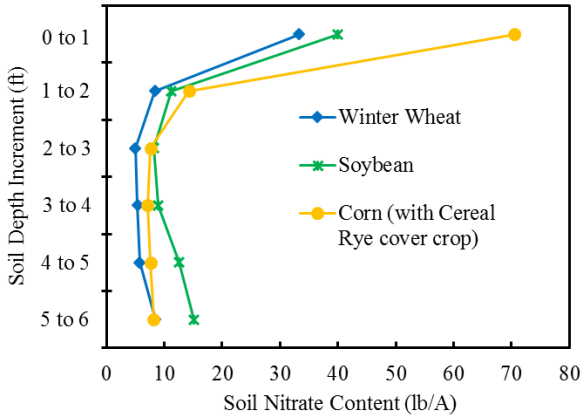

Figure 2. Residual Soil Nitrate was affected by individual crops in the soybean – winter wheat – corn cropping system. Data from 2010 to 2013.

Profitability

Although there were large changes in crop prices and yields during 2010 to 2013, continuous corn was, on average, the most profitable cropping system, followed by soybean-winter wheat- corn, oat-alfalfa-corn, oat/red clover-corn, and finally perennial grass (Table 1). Production expenses were highest for continuous corn, lowest for perennial grass, and intermediate for the other cropping systems. The 'Adjusted Means' and the 'Iowa Averages' methods of calculating net profit resulted in similar outcomes and identical rankings. Looking at individual crops within rotations, corn was the most profitable followed by soybean, alfalfa, winter wheat, and oat.

The Intersection of Residual Soil Nitrate and Profitability

At first glance, low residual soil nitrate content and high profitability don't seem to occur simultaneously. However, there are some promising options. The oat-alfalfa-corn system, for example, resulted in very low soil nitrate levels below the 3 foot depth, and was profitable. Other rotations such as corn-corn-alfalfa-alfalfa or corn-soybean-alfalfa-alfalfa are also promising from both economic and water quality perspectives. However, given the extra management and somewhat lower net profit expected for these cropping systems (compared to continuous corn), consistent implementation in areas affecting community water supplies will likely require new/additional incentives and/or policy changes.

Table 1. Economic Data.

Expenses and profitability for each crop and cropping system during the 2010 to 2013 production years. [a] Losses are shown in parentheses.

Cropping Systems and Crops	Production Expenses ($/A)	Net Profit ($/A) Adjusted Means [b]	Net Profit ($/A) Iowa Averages [c]
1 – Continuous Corn/Cereal Rye	**713**	**215**	**176**
2 – Perennial Grass	**371**	**(155)**	**(78)**
3 – Oat-Alfalfa-Corn	**506**	**107**	**86**
3a – Oat	387	(53)	(94)
3b – Alfalfa	531	116	64
3c – Corn	601	258	287
4 – Oat/Red Clover-Corn	**543**	**57**	**42**
4a – Oat/Red Clover	396	(49)	(115)
4b – Corn	690	162	199
5 – Soybean-Winter Wheat-Corn/Cereal Rye	**526**	**140**	**117**
5a - Soybean	510	174	89
5b – Winter Wheat	362	28	81
5c – Corn/Cereal Rye	706	273	183

[a] Profitability is based on revenue from plot yields at market prices (Iowa State University suggested closing inventory prices for each crop in each year), less actual expenses.
[b] In 2013, Sioux County average yields for corn and soybean were used instead of actual yields. Actual yields were artificially low due to poor soybean stands and other management challenges.
[c] Profitability is based on revenue from average annual yields and market prices from the state of Iowa, less actual expenses.

For More Information contact Dr. Robb De Haan at Robert.dehaan@dordt.edu. For a pdf of this document, and for a detailed research report, see: http://digitalcollections.dordt.edu/faculty_work/524. **Support for this Research** was provided by the Leopold Center for Sustainable Agriculture, the Iowa Department of Natural Resources, the city of Sioux Center, AJS Farms, and Dordt College.