Twelve years of field research at the NCLE Long Term Field Laboratory yielding a wealth of manure management information

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The NCLE (National Centre for Livestock and the Environment) Long Term Field Laboratory was established in 2007 to initially answer 'what happens to nitrogen availability and soil phosphorus levels over time when manure is applied either annually, at rates to meet crop N requirements, or intermittently, at rates to match crop P removal for several years?'.

After eight years, a couple more questions were asked, including 'what is the capacity of the soil to continue to provide nitrogen if manure applications stop?', and 'how does suspending manure application impact drawdown of soil test phosphorus levels?'

Site experimental design: The 17 hectare (43 acre) field laboratory consists of a total of 96 20m x 20m (66ft x 66ft) plots under either an annual cropping system or a perennial forage-based cropping system. Each plot received either annual or intermittent applications of liquid pig, solid pig and solid dairy manures from the University of Manitoba's Glenlea Research Station's swine and dairy production facilities, as well as synthetic fertilizer and control (no fertilizer) treatments for comparisons. In 2015, select plots were split to accommodate additional fertility treatments, resulting in an increase to 144 plots. The site is located at the University of Manitoba's Glenlea Research Station, 18 km south of Winnipeg.

What have we learned?

This long term field study is generating new agronomic and environmental sustainability information pertaining to manure management. The following are key findings to date for the annual crop rotation receiving yearly additions of manure or fertilizer for 8 of 10 years. Project leads for this phase of the research were Don Flaten, soil fertility professor (Don.Flaten@umanitoba.ca) and Trevor Fraser, soil science technician.

<u>Nitrogen (N) fertility</u>

- Liquid pig manure was an excellent source of readily available N for crop growth, generating yields similar to those of plots receiving synthetic fertilizer. Over the entire study, crop yields for plots with a history of solid pig, solid dairy and liquid pig manure were respectively 45%, 74% and 105% of the yield increase under continuous synthetic fertilizer. Yields with yearly applications of solid pig and dairy manure were considerably lower, mainly because Manitoba's traditional formula for calculating manure application rates greatly overestimated the amount of N available in the year of application for these solid manures.

- The 8-year history of annual manure additions created a soil N reserve to provide mineralizable N for future crops. As a result, yields from the solid manure treatments gradually improved over the 10-year period, becoming similar to yields under continuous synthetic fertilizer in the final 2 years, after annual additions of manure ceased.
- Fall residual soil nitrate N periodically increased during the 10-year study for both manure and synthetic fertilizer treatments, although these levels remained well below Manitoba's regulatory threshold. However, levels might have increased if the mineralization of organic N was not accounted for when determining the rates of fertilizer and manure N application for the subsequent crop. Therefore, annual soil testing for fall residual nitrate-N continues to be recommended for these situations in Manitoba, to minimize the risk of leaching of nitrate N to groundwater and gaseous loss of N to the atmosphere, as well as the cost of excess application of N fertilizer.
- Although gaseous losses of N as ammonia or the greenhouse gas nitrous oxide were not measured as part of these phases of the study, greenhouse gas measurements under select treatments began in 2017 as part of a new study now underway at this site

<u>Phosphorus (P) fertility</u>

- Annually applying manure at rates to meet crop N requirements resulted in a rate of P application that was much greater than P removal by the crops, increasing soil test P levels (STP, measured as Olsen P) over time. However, the extent of build-up in a given year greatly depended on the type of manure that was applied (e.g., annual applications of solid pig manure resulted in higher levels of STP than for liquid pig manure or solid dairy manure), as well as on growing conditions, manure N availability and soil moisture … which affected crop growth and associated P uptake, plus the rate at which the manure P was stabilized in the soil.
- Excess STP poses an increased risk for runoff loss to surface waters, which may contribute to algae growth in water bodies. During the first 8 years of the study, annual applications of manure at N-based rates led to build-up of STP that exceeded Manitoba's first and even second P regulatory thresholds at times.
- Following cessation of annual manure additions, STP decreased faster for sites with higher STP (i.e. solid pig and dairy manures) than for sites with lower STP at the start of the ninth year. However, these decreases were larger than would be expected with crop removal, indicating that the available P is likely being stabilized into less available, more stable forms of soil P.
- Nitrogen fertilization did not accelerate the drawdown of STP in plots where manure application ceased after 8 years, because crop yields and P removal in these plots were maintained by the supply of N from historical manure applications.

Getting the information out

Lessons in learnings and knowledge transfer at the NCLE Field Laboratory take many shapes, depending on the audience. Numerous field days, workshops, clinics and tours over the years have attracted producers, agronomists, regulatory and extension specialists, university students and professors, and special interest groups. These sessions cover the latest understandings of manure management practices for optimal crop productivity and minimal environmental risk and are often paired with sessions on other production and sustainability-related topics.

Reaching city and rural students: We have also developed specialized educational programming for high school students to broaden their understanding of the role of livestock as nutrient recyclers in producing food that is both economically and environmentally sustainable. Students get their hands dirty as they learn to think more holistically about our shared food system. We explore how manure management practices developed through science-based research are providing both solutions to environmental challenges as well as environmental benefits in the context of our shared food system, making the connection that protecting our resources is a shared responsibility.

At the end of their ½ day program their learning is put to the test to identify manure and land management practices we can use to improve nutrient recycling, soil health, productivity and overall sustainability of farming systems.

Research continues to break new ground

Now in its 12th year, the focus continues to be around the capacity of the manured soil to continue to release plant-available nitrogen, phosphorus and other essential nutrients and how this affects crop yield. Additionally, we are measuring nitrous oxide emissions from select treatments to gain a better understanding of the role of soil nitrogen transformations in generating this potent greenhouse gas. Project lead for this phase of the long term research is Mario Tenuta, soil ecology professor (Mario.Tenuta@umanitoba.ca). It is only because of this history of combined investment of research expertise, funding, and most importantly time at this long term site that we are able to answer these questions and to continue to ask new questions.

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