Internship Report for Sept. 2011 – March 2012

Greenhouse gas emissions from a novel technology for efficient use of manure nutrients (Field 0818)

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Purpose:

To measure greenhouse gas emissions of nitrous oxide from manure and fertilizer applications that has been applied with a more efficient technology.

Background:

The research team in Agassiz at the Agriculture and Agri-Food Canada Research Station, determined that nutrients applied to a single point or field will affect and become a part of the cycle in that field. Nutrients applied to fields enter the whole system through losses and removals in the air, water, and city consumption, which spiral throughout farm and larger ecosystems. Due to this interaction, the attempt to make meaningful gains in the nutrient budget of a regional nutrient sink cannot be solved by simply looking at the field management. The scales in nutrient cycling studies consist of regional scale (optimizing agricultural and urban zones) > whole farm scale (optimizing feed inputs on dairy farms) > field scale (optimizing dairy waste inputs) > soil scale (optimizing inputs in real time), where regional is the largest and soil is the smallest. At each level, leading edge ideas are explored and the integrated regional optimization is in itself a novel approach to tackling the challenge of regional nutrient loads. The Lower Fraser Valley (LFV) is an excellent case study because of its clear geographic and political delineation and high densities of people (2.5 million) and animals; the results from this case study will be relevant to other agro-urban regions. This report pertains to the field scale where nutrient inputs are optimized in dairy waste.

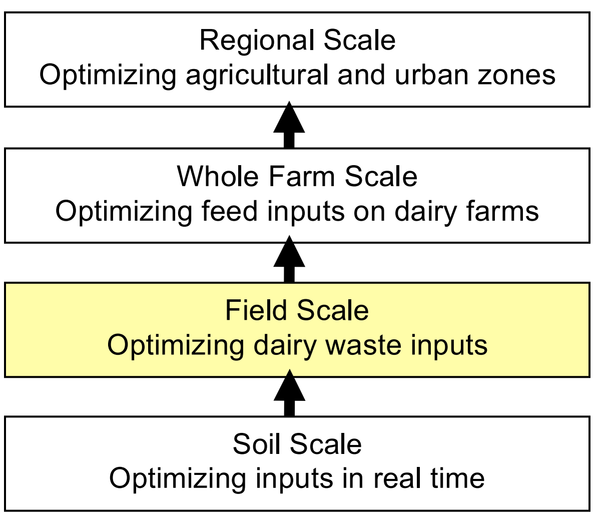

Figure 1: Breakdown of the scales

Field Scale:

To optimize dairy waste inputs, liquid slurry manure from dairy and swine feeding operations is an important nutrient bio-product that can be strategically used to replace chemical fertilizer. Efficacy of slurry manure use for providing crop nutrients has improved but there are still many farms that have excessive amounts of animal manures (Webb et al., 2010; Schröder et al., 2005, Bittman et al.1999a, 2006, 2007, 2010, 2011). These excessive amounts of animal manures are increasing the nutrient concentrations in the soils near livestock operations and thus there is an increasing need to transport manure further from the source.

The nutrients in the animal manures which is in excess consists of phosphorus (P) and nitrogen (N). The excess amounts of P and N and their ratio in manure when applied to crops, leads to the accumulation of P when it is applied to meet the N needs of crops. There is always more P than N in manure because inevitably, N will be lost in housing, storage and spreading due to NH_3 volatilization and denitrification (Sheppard et al. 2010). Due to the increase of P in soils near livestock operations, farmers are paying for their manure to be hauled away (Oseil et al. 2008). Transportation of slurry manure which contains 90-98% water, away from animal housing is very costly, energy intensive and it impacts roadways and traffic which contributes to rural-urban conflict. The best way to reduce transportation costs and pursue sustainability is to find a way to reduce the amount of P in manure so that the manure can be applied without the increase in soil P accumulation. This can be done with solid liquid separation of manure.

The solid fraction of manure consists of faeces, bedding and waste feed whereas the liquid portion is mainly urine and waste water. The nutrient composition of the urine and faeces depends on animal and diet. Inorganic P is particularly prone to leaching but organic forms may also leach if colloidal P sorption sites are saturated by organic matter, while both forms are susceptible to surface runoff (Sharpley and Moyer 2000). Incidentally, manure solids contain the majority of the organic N and both P forms so the liquid fraction often has less nutrients and lower P:N ratio (Vetter et al. 1987). Therefore, removing solids will lower P concentration but it will also remove organic C, altering C:N ratio, but leaving behind soluble carbon, including volatile fatty acids which support denitrification and release of N2O. Removing solids also lowers viscosity, enhancing infiltration and ammonia retention from applied manure, hence reducing the effective P:N ratio for crops (Sommer and Olesen 1991, Stephens and Laughlin 1997, Bittman et al. 2011).

With applying manure, it's important to look at the environmental impacts of it; for example the greenhouse gases. It's been determined that efficient uptake and utilization of N is key to minimizing environmental impact of applied nutrients. Practices that reduce NH_3 emission without improving crop nutrient uptake can lead to other losses such as nitrate leaching. Efficient utilization of manure N for crop production is particularly challenging due to the chemical form of the N and the proportions of other nutrients because plants need a specific amount of each nutrient. To assess crop response to manure, long-term studies are needed to ensure that the residual effects from previous applications are fully accounted (Schröder 2005). Application of slurry to maximize crop production led to accumulation of both P and organic N in the soil. A 3-year study on broadcasting swine slurry on grass in Quebec showed that removing solids by settling/decanting or filtering reduced ammonia volatilization and improved N uptake on sandy loam but not on loam soils (Chantigny et al., 2007). A recent study by Bittman et al. (2011) showed that removing solids from the liquid fraction by settling/ decanting greatly increased the N uptake by a forage crop over multiple years, although even with the low emission spreading technology the N recovery rate of the separated liquid fraction was significantly less than mineral fertilizer. The effect of long-term application of separated liquid fraction on soil N, P, C and P, and other elements, and quality was not yet determined and is the subject of the current study.

One way to apply manure efficiently is to place it close to the seed for silage corn. Silage corn which is frequently grown for dairy feed requires P fertilizer early on in growth so that it may advance ultimately to maturity. Early maturity is valuable for reducing storage losses, enabling use of high yielding hybrids and also enabling early planting of winter cover crops. Even on high P soils, seed placed P generally improves crop maturity and sometimes yield (Bittman et al. 2006; Bittman et al. unpublished on-farm data). The long term effects of injecting manure sludge on soil release and crop capture of P and N from organic manure fractions and the effect of the injected sludge on GHG emissions and soil nutrient loss is not known.

This project contributes to several Environment Canada Program Activities that includes water resources, substances and waste management as well as climate change and clean air. Water resources are affected positively because farmer management and planning are enhanced to better utilize N from manure thereby reducing nitrate leaching to ground water and runoff to surface waters. Substances and water management is improved because the novel technology for efficient use of manure nutrients will inform management decisions and will improve the development and use of environmental farm plans and nutrient management plans reduce nutrient loading to the environment. Finally, climate change and clean air is improved because due to the better utilization of N from manure, the greenhouse gas emissions with be reduced and the environmental performance will be improved.

Figure 3: Manure band placement with single disk opener

Figure 2: Manure bands for precision planting

Materials & Methods:

The novel technology for applying manure to lower greenhouse gas emissions and lower to eliminate the amount of chemical fertilizers used includes the separation of some of the solids from the liquid manure. Over several years the research group at Agassiz has made a number of significant strides to improve this technology and they have found a system that works. This system include the application of the liquid manure on grass because it is a good nutrient source for it. The remaining semisolid fraction of manure is then used as a source of phosphorus for corn through the process of precision injection. In this method the greenhouse gas emissions are collected and analyzed consistently over a long period of time to ensure that the emissions of nitrous oxide does not increase. Nitrous oxide is a potent gas that contributes to greenhouse gas emissions and manure application is a significant source of this gas. Since the proposed methodology for using manure increases uptake of both key nutrients for crops and environment, it addresses the single most important strategy for reducing contamination of waterways, both above and below the ground surface.

General Duties Performed:

During the internship, the duties performed consisted of general field management work, plant and soil sample collection, and measurement of emissions of nitrous oxide from the field and laboratory analyses (extractions, flow injection analyzers and gas chromatograph). Soil water and soil temperature were also monitored through the use of data loggers. Also, data was compiled, processed and run through statistical analysis.

Specific Scientific Learning Experiences:

Learning experiences from the internship included a variety of duties that took place inside and outside the laboratory. Environmental research was conducted in the field which included the collection of samples. Nitrous oxide gas samples were collected from vented chambers. These gas samples would then be run on the gas chromatograph which was operated by the students. Soil temperatures and soil samples were also collected. Soil temperatures were measured by placing temperature probes in the soil at different depths. During the field work, good practices and detailed record keeping and observational skills were learned. Some soil samples were weighed into the oven and drying room to determine the amount of moisture content; other soil samples were used to find the pH, thus the pH meter was used. Other soil samples were extracted for nutrients by mixing it with a salt solution and filtering. The soil samples which came from the drying rooms were ground into a fine powder and left to be tested for nutrients. Manure application and corn/grass harvests also took place during the internship in which the students helped out. Some of the corn and grass samples were used to determine their amount of P. This was done through the process of digestion, dilution and analysis with a spectrophotometer. Weekly, resin strips, which act like plant root systems, were implanted and extracted from the soil. These resin strips were extracted with a salt solution and analysed for nutrients to represent what nutrients were being absorbed by the plants. The data collected was inputted into excel and organized into its respective folder. Overall a good understanding of hypothesis and hypothesis testing was learned as well as good research practices related to replication and randomization.

Conclusion:

In this internship greenhouse gas emissions of nitrous oxide from manure and fertilizer applications, which was applied with a more efficient technology, were measured. This technology includes separating the liquid and solid fractions of the manure and applying the different fractions to different fields where it is the most useful. This system includes the application of the liquid manure on grass because it is a good nutrient source for it. The remaining semisolid fraction of manure is then used as a source of phosphorus for corn through the process of precision injection. The idea is to be able to completely replace fertilizer with manure as well as decrease the amount of greenhouse gas emissions of nitrous oxide. Lots of samples, including gas samples and soil samples, were collected throughout this internship but the results have not yet been determined/summarized.

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