Title of Research Plan: Fate of Soil Nutrients in Conventional Tilled, No-Till and No-till Plus Cover Cropping Systems with and without Swine Manure in a Corn-Soybean Rotation

Rationale and Significance

In Grand Lake St Marys, the Mississippi River Basin and the Chesapeake Bay region, Eutrophication from excess nitrogen (N) and phosphorus (P) due to runoff from livestock manure is major issue. Dabney et al., (2001) outlined the advantages and disadvantages of using cover crops. Large quantities of N may remain in the soil after harvest even when the economically optimum fertilizer rate has been applied to corn (Magdoff, 1991). Winter cover crops can temporarily immobilize nutrients, especially N, and prevent NO_3-N leaching losses and reduce winter soil erosion during the winter rainfall period (Power and Doran, 1988). Most of the NO_3-N leaching occurs during the fall and early spring months when the soil is fallow in the typical corn-soybean rotation of the U.S. Midwest (Owens et. al, 1995). In a meta-analysis of cropping system nitrogen efficiency, vegetative covers provided a 55-85% reduction in nitrogen losses (Drinkwater et. al. 2005), while Brandi-Dohrn et. al. (1997) reported a 37% reduction.

Cover crops can increase the nutrient use efficiency of farming systems (Lal, 1997; Reicocky and Forcella, 1998; Staver and Brinsfield, 1998; Delgado, 1998). In the Midwest, rye (*Secale cereale*. L.) is the preferred grass winter cover crop because of its winter-hardiness and its exceptional ability to scavenger residual N (Wagger and Mengel, 1988; Ditsch and Alley, 1991; Shipley et. al., 1992; Bollero and Bullock, 1994). Rye N content was highly correlated with soil residual NO_3-N content (Ruffo et. al., 2004). Kessavalou and Walters (1999) and concluded that rye N content was close to the reduction in residual soil NO_3-N content at killing time, and therefore rye N content was considered to be a good estimator of the reduction in potentially leachable NO_3-N. Phosphorus losses are associated with both the sediment and as dissolved reactive phosphorus.

Using grass cover crops with no-till is a sustainable method of reducing both nitrogen and phosphorus losses from the soil from either commercial fertilizer or livestock manure. Methane, carbon dioxide, and nitrous oxide losses associated with greenhouse gases and global warming also need quantified from various tillage systems. Using cover crops with no-till is a system that closely mimics natural systems and has the potential to restore soil quality, improve N and P recycling, and reduce greenhouse gas emissions to the atmosphere.

Hypothesis and Objectives:

The null hypothesis in our experiment is that there is no difference in nitrogen and phosphorus between tillage treatments with and without swine manure. The purpose of our experiment is to measure the fate of both nitrogen and phosphorus and to see how it cycles through the water, soil and atmosphere.

Our objectives are as follows:

1) Measure nutrient cycling of nitrogen and phosphorus in three tillage systems (conventional tillage, no-till, and no-till plus cover crop) using swine manure and commercial fertilizer.

2) Evaluate carbon sequestration and losses in three tillage systems using swine manure and commercial fertilizer.

3) To measure the losses of nutrients (N and P) through the water and the atmosphere as carbon dioxide, methane, and nitrous oxide in three tillage systems using swine manure.

Experimental Approach and Methods

This experiment will be done with lysimeters located at Ohio State University Research Center at South Piketon, Ohio on a Omulga silt loam soil. The 21 lysimeters are 50 feet wide and 100 long. There are seven treatments with three replications each using a randomized design. The seven treatments in a corn-soybean rotation include the following:

1) Control: Conventional tillage with commercial fertilizer (CTC).
2) No-till with commercial fertilizer (NTC).
3) No-till and 5,000 gallons of liquid swine manure (NT5SW).
4) No-till and 7,500 gallon of liquid swine manure (NT7.5SW).
5) No-till and grass cover crop (cereal rye) plus commercial fertilizer (NTCR).
6) No-till and grass cover crop (cereal rye) plus 5,000 gallons of liquid swine manure (NTCR5SM).
7) No-till and grass cover crop (cereal rye) plus 7,500 gallons of liquid swine manure (NTCR7.5SM)

The chemical fertilizer applied to each plot will have 150 pounds of N and 100 pounds of P and K on each treatment. The swine manure will be tested with a standard manure test and will have approximately the same amount of nutrients as the commercial fertilizer. Additional commercial fertilizer will be applied in the spring to equalize all treatments of applied soil nutrients from swine manure and commercial fertilizer. The swine manure will be applied in one surface application after corn to supply nutrients for both the corn and the soybeans which is a common practice in Ohio. The cereal rye cover crop will be drilled after the corn is harvested (October). Glyphosate (1-1.5 quarts) will be used to kill the cereal rye three weeks before the corn is planted. Each lysimeter will be used to measure both surface and subsurface runoff, leachate, and atmospheric losses of soil nutrients.

The following soil measurements will be taken on a bi-monthly basis. 1) Moisture, pH, electrical conductivity 2)bulk density, 3) microbial biomass carbon, 4) active carbon, 5) particulate carbon 6) total carbon 7) Nitrate, 8) ammonia, 9) total nitrogen, 10) total phosphorus, 11) dissolved reactive phosphorus, and 12) basal respiration or carbon dioxide. After rainfall events, water samples from surface, subsurface and the leachate will be sampled for nitrates, ammonia, and phosphorus. Atmospheric samples will be collected for nitrous oxide, methane, and carbon dioxide using a gas chromatograph. Additional data to be collected will include crop yield, water infiltration, and standard weather data including rainfall, precipitation, humidity, soil temperature, and solar radiation.

Expected Results and Outcomes

The research from this site will assist regulators, extension educators, and research scientist in formulating manure runoff best management practices for Grand Lake St. Marys and other distressed watersheds, Lake Erie, and possibly on a national scale the Mississippi River Basin and Chesapeake Bay region. Three journal articles and at least three fact sheets will be generated from this research. The benefits and the disadvantages of the three tillage systems in relation to nutrient recycling of nitrogen and phosphorus in swine manure and commercial fertilizer will be quantified. The benefit/disadvantage of using a no-till system with a grass cover crop like cereal rye to improve soil quality will be measured and quantified as well as the movement through soil, air, and water. Information from this research will be shared in the Grand lake watershed, the Mississippi River Basin, at the Ohio and National Soil and Water Conservation Society. Professional presentations will be made at The American Society of Agronomy, Crop Science Society of America (ASA-SSSA-CSSA), and the American Society of Agricultural and Biological Engineers (ASABE). Presentations will also be made at the National Association of County Agricultural Agents (NACAA), the National No-till conference, and the conservation Tillage and Technology Conference (CTTC). Radio interviews, newspaper articles, internet articles, and numerous farm magazine articles are expected to be generated from this research.

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