Hog Manure - A Dilute Fertilizer With Extra's

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Abstract

Hog manure is valued as a source of plant nutrients but there is concern that land application of large volumes of hog manure applied repeatedly over many years, may deteriorate the quality of local soils, reduce crop production and lead to pollution of the environment. A major field research project has been initiated to determine the long-term impact of hog manure applications on the quality of the soil and to determine optimal application rates of hog manure in Saskatchewan.

Introduction

Manure applied to the soil is a generally accepted practice for improving soil fertility and for improving soil quality. In general, manure has been found to increase soil organic matter, improve soil fertility, improve soil structure (Chater and Gasser, 1970; Sommerfeldt et al. 1988), and increase crop production (Grevers and Schoenau, 1997; Sommerfeldt and Chang, 1985). Repeated applications of high volumes of manure, however, have led to concerns regarding the possibility of exceeding the capacity of the soil-plant system to absorb and re-cycle the nutrients supplied through the manure. Hog manure contains significant quantities of plant nutrients such as nitrogen, and repeated applications of large volumes of hog manure in excess of crop nutrient demand may result in excessive levels of nutrients in the soil and possible groundwater contamination by nitrate leaching. Hog production in Saskatchewan is expected to increase to over 3 million hogs by the year 2005, which is triple the current production, and large intensive hog operations are planned across Saskatchewan. The general public is concerned that large volumes of manure, when applied repeatedly, may deteriorate the quality of local soils, reduce crop production and lead to pollution of the environment in general (Chang et al. 1990; Larson, 1991a,b).

Hog manure applications add considerable amounts of sodium salts to the soil, and this could cause soil structure deterioration (reduced saturated hydraulic conductivity and soil crusting) especially under low electrolyte concentrations (Curtin et al. 1994; Cass and Sumner 1982; Crescimanno et al. 1995; So et al. 1995; Barzegar et al. 1996). Sodic soils are classified as soils with an exchangeable sodium percentage (ESP) of greater than 15 and an electrical conductivity (EC) of less than 4 dS m^{-1} (U.S. Salinity Laboratory Staff 1954). In Australia, ESP values $\geq$6 are used to indicate sodic soil conditions (Rengasamy and Olsson 1991). ESP values as low as 2 can result in soil structure deterioration at low cationic concentrations (Cochran et al. 1994; Crescimanno et al. 1995). The threshold electrolyte concentration (TEC) where the soil structure of sodic soils can be maintained at a steady state varies with soil type and is primarily affected by the soil texture and cationic composition (Rengasamy and Olsson, 1995) The majority of the

Canadian prairie soils contain significant quantities of salts (primarily Na_2SO_4 and $Ca,MgSO_4$), and changes in the electrolytes of these soils by rainfall, irrigation or by farm management practices such as manure applications affect the sodicity of these soils.

Grevers (1998) found that a one-time application of liquid hog manure applied at rates up 90 Ml ha^{-1} did not have an adverse effect on soil sodicity or on soil salinity. Similarly, Charles (1999) found that a single application of 268 Ml ha^{-1} of hog manure or a single application of 73 Mg ha^{-1} of cattle manure did not result in significantly changing the soil sodicity or the soil salinity. However, substantial increases in soil salinity and in soil sodicity have been documented when manure was soil applied repeatedly over many years (Chang et al. 1991). Rengasamy and Olsson (1991) expressed concern about secondary salinization and sodification occurring in Australia as a result of irrigation, inappropriate agricultural practices and land clearing. Curtin et al. (1994) caution on the sodicity hazard of irrigation waters used on the Canadian prairies. They suggest that because of their high Mg/Ca ratios, the dilution of electrolytes in saline-sodic soils by leaching results in increased exchangeable Na levels and the resulting deterioration of soil structure. Rengasamy and Olsson (1995) also indicate that when saline-sodic topsoils are leached by rainwater or by irrigation the balance between salinity is altered and soil structure deteriorates when the electrolyte concentration drops below the TEC.

The long-term impact of hog manure applications on the quality of the soil and that of the environment is not well known in Western Canada, and researchers such as Larney et al. (1993) caution that the residual effect of long-term manure applications needs to be evaluated. For optimal application rates of hog manure in Saskatchewan, improved knowledge is essential regarding the long-term effect of hog manure application on salinity, pH, soil density, aggregation, soil strength, crop quality and on crop production. Furthermore, the influence of long term hog manure application on environmental quality and nitrate pollution is not clear.

The specific research hypothesis of this research project is: repeated applications of high rates of liquid hog manure under dryland conditions in Saskatchewan results in a) soil salinization, and b) soil sodification. The research project objective is to determine hog manure application rates for different soils/regions in Saskatchewan that can be maintained without deteriorating soil quality.

Methodology

Field Plot Locations

Site	Soil Classification	Texture
1. Beechy	Brown Chernozem (Aridic Boroll)	heavy clay
2. Riverhurst - I	Brown Chernozem (Aridic Boroll)	very fine Sa L to loam
3. Riverhurst -II	Brown Chernozem (Aridic Boroll)	very fine Sa L to loam
4. Plenty	Dark Brown Chernozem (Typic Boroll)	heavy clay
5. Humboldt - B.	Black Chernozem (Udic Boroll)	very fine Sa L to loamy Sa
6. Humboldt - D.	Black Chernozem (Udic Boroll)	Loam

Experimental Design

The hog manure plots are arranged in replicated blocks. Main treatments consist of:

- different rates of hog manure ranging from 40 Ml ha^{-1} to 268 Ml ha^{-1})
- 2 rates of commercial fertilizer N (1 x and 2 x soil test recommended levels of N)
- 1 control (not manured and not fertilized)
- 6 levels of manure application sequences (sites 1-4 only)

3. once only (1998)
4. two consecutive applications (1998 and 1999)
5. three consecutive applications (1998, 1999, 2000)
6. four consecutive applications (1998, 1999, 2000, 2001)
7. two applications over a 3-year period (1998 and 2000)

- 3 replicated blocks (4 replicated blocks for sites 5 & 6)

Soil and crop monitoring are carried out over a four year period (1999, 2000, 2001, and 2002).

Manure Application

The hog manure is soil injected to a depth between 10 and 15 cm by pumping the manure through hoses mounted behind a sweep type opener on a heavy duty cultivator. Injection is desirable to increase nutrient retention and minimize odors during application.

Soil and Manure Analysis

Manure samples are collected during the field application and analyzed for nutrient content and salinity. Soil moisture content and structure (aggregation and density) are measured during each growing season.

Plant and Crop Yield Analysis

Crop biomass samples are collected by square meter sampling prior to harvest. Total and grain weights are determined and the samples are analyzed for nutrient content.

Growth Chamber Study

Surface soil samples are collected from the field plots. Six rates of hog manure equivalent to the nitrogen typically added in 0, 34, 68, 100, 134, and 168 Ml ha^{-1} are applied to soil in containers as well as 4 rates of fertilizer (50%, 100, 150 and 200% of fertilizer N & P recommendations). The containers are seeded to Canola and incubated at room temperature for 12 weeks with the soil moisture content kept at or near 60 % of field capacity . Crop yield and plant nutrient uptake is determined. Soil pH, salinity and sodicity are measured during the experiment. At the end of the incubation period, soil strength, soil aggregation, soil density and soil shrinkage potential (COLE index) are measured. The experiment is repeated three times, with barley grown after the 2nd application, Canola after the 3rd application and Barley after the 4th application.

Nitrous Oxides Emission Study

Nitrous oxides (N_2O) emission from manure injected soils is studied at two sites, Riverhurst - D and at Beechy. Gaseous losses of N_2O are measured during the growing season immediately following rainfall events when the emission of N_2O is considered to be substantial enough to be measurable.

Soil Quality - Soil Chemistry

Soil reaction (pH), Electrical Conductivity (dS m^{-1}) and Sodicity (Sodium Absorption Ratio) are measured throughout the experiment.

Soil Quality - Soil Structure

Soil bulk density (Mg m^{-3}), soil aggregation (Mean Weighted Diameter in mm) and soil crusting strength (Modulus of Rupture in kPa) are measured throughout the experiment

Summary

Hog Manure is a valuable source of plant nutrients and can also improve soil quality in general. There is concern that repeated applications of high rates of hog manure results in

- Nutrient overloading in soils
- Soil pollution
- Environmental pollution
- Soil structure deterioration

The specific research hypothesis of this research project is as follows:

Repeated applications of high rates of liquid hog manure under dryland conditions in Saskatchewan results in a) soil salinization, and b) soil sodification. The research project objective is to determine hog manure application rates for different soils/regions in Saskatchewan that can be maintained without deteriorating soil quality

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