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ENHANCING SUSTAINABILITY OF GRASSLAND SYSTEMS RECEIVING PIG MANURE ON COARSE TEXTURE SOIL

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Executive Summary

Currently there is strong interest in limiting nitrogen (N) and phosphorus (P) loss to surface and ground water. The application of pig slurry to grassland can increase grass productivity and increase the N and P content of soil. Coarse texture soils are particularly challenging in managing nutrients because forms of N, and sometimes P, can move downward in soil to ground water. When N as nitrate and P as plant-available extractable accumulate in the surface of coarse texture soils, there are several potential fates of the nutrients. They can be utilized by plants being tied up in plant residues and removed with hay and grazing removal. They may become incorporated into soil organic matter. In the case of P, it can form soil minerals or tightly held to soil and become unavailable to plants. Mobile forms such as nitrate and water extractable-P may leach to ground water.

The La Broquerie Manure and Livestock Management Research Site in southeastern Manitoba was ideal to examine the fate of pig slurry N and P applied to a coarse texture soil because application had occurred in the three previous years and the site had a seasonally high water table that reached the soil surface. The study involved a further two years of pig slurry application at the N requirement (123 kg plant available N ha^{-1}) of tame grass which was either mechanically harvested for hay (Hay) or grazed by back grounding steers (Grazed). Three manure application treatments were examined; no pig slurry application (Control), a single application in spring (Single) and splitting application to half-rates in spring and fall of each year (Split).

The objectives of the project were addressed in four experiments. Experiment 1) related the accumulation of mobile forms of N (nitrate) and P (Olsen extractable-P) in the soil profile (0-120 cm) to surplus N and P applied; determined if extractable N and P accumulation in surface soil resulted in movement to subsurface soil of Hay and Grazed fields that received pig slurry (Single and Split) treatments; determined if the accumulation of extractable P at the soil surface was linear or exponentially increasing with slurry application. Experiment 2) soil was hand sampled to limit contamination of N and P between soil depth intervals for confirmation that nitrate and extractable P with Single and Split application to Hay and Grazed fields did not move downward in soil. Experiment 3) determined the extent that the P sorption capacity, saturation and fractions in soil were altered with pig slurry by comparing Single and Control treatments of Grazed fields to assess the potential for P nutrient loss. Experiment 4) determined if pig slurry application (Single) and no application (Control) to mechanically harvested Hay fields and Grazed fields affected N and P concentrations in surface groundwater. The last experiment focused on the spring high water table period. The results of the four experiments are summarized below.

Extractable N as ammonium and nitrate did increase slightly in the surface soil (0-30 cm) with application of pig slurry. However, both forms of N did not continue to accumulate with successive annual applications of pig slurry. In contrast, P accumulated in the near surface soil (0-5 cm) as a result of successive years of pig slurry application to the grass. There was no evidence of downward movement of nitrate or P in soil for Hay and Grazed fields for either the Single or Split treatment combinations. Careful hand sampling confirmed lack of evidence of downward movement of nitrate and P in soil for the Grazed fields of Control and Single treatments.

The rate of P accumulation was linear for the 0-5 cm and 5-30 cm depths with the rate of increase being greater for the former depth. The accumulation rate was slightly greater for the Grazed fields compared to the mechanically harvested Hay fields. Grazing with slurry treatment system had a higher net annual P surplus than Hay with slurry because most of the P consumed by the grazing animals was returned to the soil surface in urine and fecal deposits. Further, Single application of pig slurry resulted in slightly faster accumulation of P in the near surface than Split application. More rapid P accumulation with the Single treatment was related to a higher concentration of P in pig slurry used for the applications conducted in spring.

It is likely that pig slurry P was retained at the near soil surface (0-5 cm) due to association with Ca and Mg in soil. All of the P fractions extracted, except for the highly recalcitrant acid soluble (HCl-P) and resistant fraction (residual-P), were stratified at the near soil surface. The acid soluble and residual fractions are highly resistant to release of P and the P present as minerals. These fractions contained P present in parent material at the site. Added P seems to not have contributed to these fractions but did to the more plant available fractions (water, bicarbonate and sodium hydroxide) but was isolated to the near soil surface.

Despite the accumulation of extractable P at the near soil surface (0-5 cm), the soil still had ability to retain P from further slurry additions. The near surface soil did not reach P saturation which would have greatly increased the release of mobile P (water soluble P).

Nitrate and dissolved reactive P and total dissolved P did not seem to be mobilized to the surface groundwater as a result of pig slurry application or groundwater reaching the soil surface. These results of the groundwater analyses confirm those of the soil studies that N and P from pig slurry did not move downward in fields of mechanically harvested Hay and Grazed by back grounded cattle.

Several recommendations are proposed as a result of this study. When applying swine manure, a P budget for the field needs to be established, accounting for P added by the producer and P removed by harvest. This is because P applied in excess of removal will lead to build up in the soil and potential loss to the environment. The budget should include the nutrient content of slurry applied because of differences in spring and fall nutrient profiles. Grazing management should be avoided over the long term if forage land is to receive consecutive applications of slurry to meet the N required of the grass. In the current study surplus N of applied pig slurry could not be accounted for as nitrate in the soil profile or ground water. Nitrogen is a valuable nutrient, knowing the surplus amounts will be available to future growing seasons is important. The yields of grass in Grazed and mechanically harvested Hay fields were likely constrained after the first cut of each year by the rapid drainage and low water holding capacity of the coarse texture soil. Two cuts are often more typical for Manitoba hay producers. It would be useful to know what the P accumulation rates would be in a system in which P removals through hay were higher. Further, the current study was only able to monitor two years of high water table in spring. Even then, only one of the springs had a water table that reached the soil surface. Having more years with the water table reaching the soil surface would further test the lack of N and P movement to groundwater. It will be useful to hay producers to know what the drawdown rate of extractable-P would be with cessation of pig slurry addition at this research site. They would then know how long it will take to remediate very high testing P, coarse texture soils.