Benefits of Long-Term Application of Manure

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Introduction

Repeated applications of manure to agricultural lands can significantly influence the quality of the soil as a medium for plant growth and as an environmental filter or buffer. There are many soil chemical, biological and physical properties that can be measured as indicators of soil quality and its potential impact on plant production and the environment. The simple soil properties that are measured in field research trials and reported on in this paper can also be employed by producers as tools for monitoring the effects of manure application on their own land base. This paper explores the effect of repeated hog manure applications on soil quality and plant production in Western Canada using recently published research findings.

Effects on Soil Chemistry and Biology

Manures, such as liquid hog manure, are a source of valuable plant macro- and micro-nutrients. When land-applied, these manure nutrients contribute to substantial yield responses (Mooleki et al., 2002). However, over-application leads to accumulation of excess nutrients such as nitrogen and phosphorus in the soil, increasing the risk of loss of nutrient to the environment (Stumborg et al., 2005). Manures are more challenging to work with than commercial fertilizers as the forms, amounts and availability of plant nutrients in manure are variable, and frequently are not in the correct proportions required by plants. Therefore, manure should be tested, and supplementation with commercial fertilizer considered in order to ensure proper rate and balance of the applied nutrients for maximum crop utilization (Schoenau et al., 2004).

Organic Matter

The composition of manure will have a profound impact on the quality of the soil, as different manures have different organic matter, salt, and element contents. The composition, in combination with the rate of application, can usually be directly related to the effects on a particular soil property. For example, solid manure such as cattle manure is composed of both fecal matter and bedding material such as straw or wood chips, and therefore has a high organic matter content i.e. 50%, compared to liquid hog manure where the organic matter content may be as low as 1 or 2 % by weight. It is not surprising then, that applications of solid manure tend to be more effective in directly increasing the organic matter content of the soil than liquid manure. However, although liquid hog manure contains and directly adds only a small amount of organic matter, the stimulation of plant growth from the nutrients added in the manure will increase organic matter additions via greater amounts of crop residues and roots produced. King (2002) found in Saskatchewan that three years of liquid hog manure injection to forage stands increased the recent, light fraction organic matter levels in the soil (0-15cm depth), but not the total soil organic matter. It would be anticipated that effects of manure addition on increasing soil organic matter content would be more pronounced on soils of lower organic matter content and low fertility, and it may take several years of application before significant differences can be detected.

Salts

Salts are among the chemical constituents of manure and include sodium, calcium, magnesium, potassium, ammonium, chloride, and sulfate salts, along with other cations and anions. The level of salts in manure varies depending on factors such as the type of feed the animals are fed as well as dietary salt supplements. For example, Sutton (1994) reported that dietary salt (NaCl) levels in hog rations directly affect the sodium concentrations in manure, and increases in salt levels in soils that received repeated applications of manure at excessive rates have been reported in several studies (Chang et al., 1991; Assefa et al., 2004). While increases in soil salinity and sodicity associated with repeated manure application do not appear to be of concern when agronomically appropriate rates are used over relatively short time frames in well-drained soils, these properties should be monitored over time in manured fields, especially under dry conditions and in soils with limited downward leaching potential. Attempts to reduce the salt content of manure, particularly sodium content, would be desirable from the standpoint of reducing salinity and sodicity concerns.

pH

Manure also exhibits variation in its pH value. The pH values of hog manure from various types of hog operations in south-eastern Manitoba was reported to range from 6.8 to 8.1 (Malley et al., 1999) and from 7.6 to 8.1 for hog manure in east-central Saskatchewan. The ability of manure application to induce a change in soil pH will depend on its content of buffering agents such as carbonates and organic matter, as well as the production of organic acids and acidity during decomposition. While organic matter added as manure can act to help buffer the soil against a decrease in pH, manure that is low in organic matter and high in ammonium nitrogen (such as many liquid hog manure sources) can result in a significant decrease in pH with repeated application at high rates due to acidity produced when the ammonium is oxidized to nitrate in the soil. Manures of high organic matter and carbonate content would be most effective in raising the pH of an acid soil and also buffering against changes in pH once in the soil.

Bioavailable Nutrient Metals

Manures contain plant functional nutrient metals such as copper, zinc, manganese, iron, and may contain trace amounts of non-functional elements. A recent study in Saskatchewan (Qian et al., 2003) showed that three to five years of annual hog and cattle manure applications at low (~100 kg N/ha) and high (~400 kg N / ha) rates resulted in only small increases in total and bioavailable copper and zinc in surface soils at three study sites. As with phosphorus, prairie soils have a high capacity to fix metals like copper and zinc into relatively insoluble forms due to high pH, high content of calcium carbonate and high clay content. However, as fixation sites become saturated with repeated additions, more of the metal will remain in a soluble form. For non-functional metals, recent work in Saskatchewan showed that following five to seven annual additions of hog or cattle manure, there was no significant influence of manure additions on soil or plant cadmium, arsenic or mercury concentrations compared to commercial inorganic fertilizer (Lipoth and Schoenau, 2004).

▪ Effects on Soil Physical Properties

In a study using two field sites in the Peace River region of Alberta, Assefa (2002) found that a single application of hog manure on the Gray Luvisolic soils increased the aggregation of the soil at one site. Cattle and hog manure applications both increased the water infiltration rates over the unmanured control treatments, but the cattle manure had the greatest effect on enhancing the rate of water entry into the soil. Japp et al (2004) reported reduced surface soil strength in the field with application of hog manure in east-central Saskatchewan. Overall, manure of high organic matter content is anticipated to be most beneficial in improving the physical condition of the soil. However, the potential deleterious effect of adding sodium, which can induce dispersion and subsequent deterioration of surface structure, needs to be considered especially for manures of high sodium and low organic matter content.

▪ Crop Growth

Significant enhancement of crop grain and straw yields, and grain protein content, are consistently observed in field trials when agronomic rates of hog manure are applied (**Figure 1**). These yield responses are attributed mainly to the effect of the manure in overcoming deficiencies in the macronutrients: nitrogen, phosphorus and potassium, but a beneficial effect associated with enhanced availability of some minor elements can also be a factor. Injection of liquid hog manure has consistently been shown to result in greater crop nutrient recovery and yield compared to broadcast and incorporate applications (Mooleki et al., 2002; Schoenau et al., 2004). The development of low disturbance injection equipment has allowed the expansion of efficient liquid hog manure application into forage and zero-till fields.

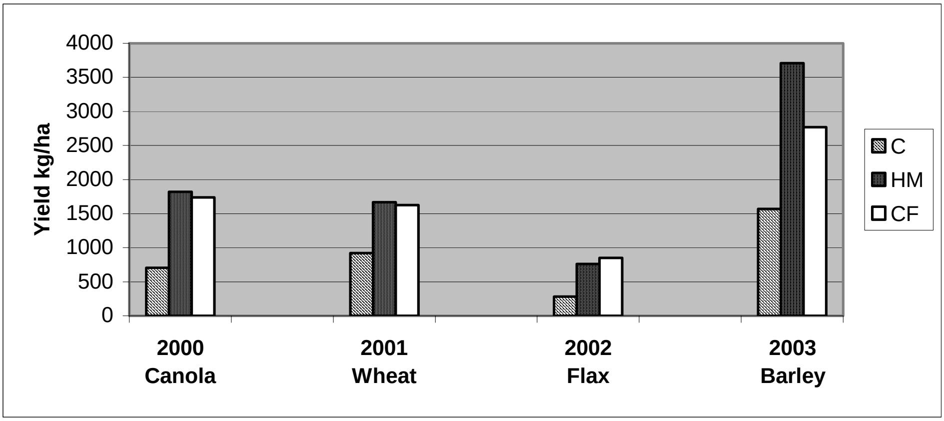

Figure 1. Crop yields (kg/ha) in **C**: unfertilized control; **HM**: 3300 gallons per acre per year (~50 kg/ha available N/yr) injected liquid hog manure; and **CF**: commercial fertilizer urea (50 kg N/ha/yr as urea) over four years at a field research site near Dixon, SK.

Conclusions

Additions of manure nutrient to soil at an agronomic rate that matches the crop nutrient requirement and removal over time is expected to have a positive impact on soil and environmental quality. This approach will maintain or improve soil fertility while avoiding nutrient overloading. The benefit of increased soil organic matter is perhaps the most significant factor, as organic matter plays a major role as a long-term storehouse of carbon and nutrients, and promotes microbial activity, soil structure, water relations and chemical buffering. However, salinity impacts and overloading of both functional and non-functional elements can negate these benefits when hog manure is over-applied or applied to soils with limitations in drainage and buffering capabilities.

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