Manure Management in Zero Till Systems

J.J. Schoenau[1] *Ph.D.*, G. Hultgreen[2] and P. Mooleki

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Role of Manure as a Source of Plant Nutrients

Types

Manure is a rather complex and variable by-product of livestock production systems. It is comprised of excreta (feces and urine), bedding materials, wasted feed, and water. Animal manure can be solid, semi-solid or liquid, depending on moisture content. A feature of solid and semi-solid manure is a higher organic matter content than liquid manure.

Liquid swine manure and solid cattle penning manure are two forms commonly land applied in Western Canadian cropping systems. Composting of solid manure may also be done in order to reduce volume, increase product uniformity and handling ease, and reduce or eliminate weed seed and pathogen viability.

Composition

The value of land-applied animal manure lies primarily in its role as a source of plant nutrients in crop nutrition and a source of organic matter to condition the soil and improve tilth. A common denominator in

Manure fertilizer can offer a broader range of nutrients than inorganic products.

most all manure sources is a low and variable nutrient content per unit weight or volume compared to commercial fertilizers. For example, liquid swine manure typically has a total nitrogen (N) content ranging from 0.1 to 0.5%N by weight and fresh cattle penning manure may range from 0.5 to 1.5%N. This is in contrast to a commercial nitrogen fertilizer like UAN solution with 28% N by weight or urea with 46% N by weight.

Low nutrient content of manures makes transportation costs a major factor in dictating how far the manure can be economically moved from its point of production to the field, with economic hauling distances of fresh manure typically being only a few km from the source. However, it is important to account for all the potential benefits of the manure when assigning a value to it. These benefits include the other nutrients: phosphorus, potassium, sulfur, micronutrients that are added in manure in addition to nitrogen, as well as potential longer term benefits to soil tilth from the added organic matter. This is why the "value" of manure is best thought of as the value of the overall crop yield increase over several years associated with the manure addition rather than simply multiplying the nutrients in the manure by the price per pound paid for commercial inorganic fertilizer.

Nutrient Forms and Behavior

As indicated above, manure is not an "off-the-shelf" fertilizer. To properly use it, the nutrient content and forms must be known through a manure analysis. It is important to know the relative amounts of nitrogen, phosphorus and other nutrients contained in the manure, since application according to a requirement for one nutrient may result in over or under application of another nutrient. Therefore, to achieve the desired balance of nutrients in the soil and not overload the soil with any one nutrient, it may be necessary to supplement manure with additions of commercial fertilizer.

Knowing the nutrient forms (organic versus inorganic) in the manure is important in predicting manure behavior. Liquid manures such as liquid swine effluent contain and add relatively low amounts of organic matter to soil in comparison to solid manures. Reflecting this, in a liquid manure a higher proportion of the nutrient is found in immediately plant available inorganic forms

Using manure effectively demands nutrient and soil analyses.

as compared to a solid manure in which much of the nutrient is contained in organic forms which are only slowly rendered available in the soil via microbial decomposition. As an example, it is has been observed that 50% to 90% of the nitrogen applied as liquid swine manure is available for crop use in the year of application, while in the case of solid cattle penning manure with straw bedding, only 10% of the nitrogen was available. Manures that include a high content of carbonaceous materials such as straw or wood chips may release their nitrogen into available forms only very slowly, such that it may take more than one year following application before one sees significant benefits in increased nitrogen availability in the soil.

Crop Responses

Field trials conducted across the soil-climatic zones of Saskatchewan over the past five years have shown large and significant yield increases from applied manure nutrients at rates of manure nutrient application, which match the crops predicted nutrient demand according to soil test. Owing to the high plant availability of nutrients contained in liquid swine manure, crop responses to injected liquid swine manure were often

[1]Department of Soil Science, College of Agriculture, University of Saskatchewan

[2]Prairie Agriculture Machinery Institute, Humboldt, SK.

similar in magnitude to that observed for commercial inorganic nitrogen fertilizers at similar rates of application. Although the plant availability of any individual nutrient in the liquid manure is typically lower than for a commercial inorganic form in the year of application, the combined effect of adding several nutrients (macro and micronutrients) at once in manure was likely responsible for near equivalent yields in comparison to nitrogen fertilizer alone, especially in soils that were deficient in other nutrients such as P and K which the manure supplied. On the other hand, our research showed relatively low yield responses in the year of application from cattle penning manure that contained lots of straw bedding. The low crop response to cattle penning manure in the year of application was attributed to restricted nitrogen availability due to initial tie-up of nitrogen when straw contained in the manure was decomposed. The carbon: nitrogen ratio was identified as an important

Nutrients in cattle manure are released in the second and subsequent years after application.

parameter influencing the pattern of available nitrogen release from solid manures. As the carbon: nitrogen ratio decreased with prolonged decomposition, available nitrogen was eventually released and we observed good yield responses to cattle penning manure in the second and subsequent years after application.

In our field trials, we also observed several problems when manure nutrients were over-applied. Repeated yearly applications of manure at rates, which greatly exceeded the crop nutrient requirements, were observed to result in excessive accumulations of nitrate in the soil profile as well as gaseous denitrification losses to the atmosphere. The accumulation and potential escape of nutrients to ground or surface water as well as emissions to the atmosphere are significant environmental concerns associated with over-applications of manure. There are agronomic concerns as well, as application of manure nutrients at rates two to three times that required by the crop also sometimes caused problems with germination, emergence and lodging. As well, high rates of manure application in dry years sometimes produced a "haying off" of cereal crops, in which heavy vegetative growth early in the season could not be sustained when it turned dry later in the season, resulting in disappointing grain fill and grain yield relative to straw yield.

Manure Management Practices

A sound manure nutrient management plan requires: 1) knowing what is in the manure (manure nutrient analyses), 2) availability of nutrients in soil (soil testing), 3) manure nutrients and fertilizer to be applied to meet crop nutrient demand (rate recommendations), 4) strategy for application, and 5) record-keeping and monitoring.

Rates

A sound long-term approach to efficient, economic and environmentally friendly use of manure nutrients is to apply at rates which balance with crop demand and use over time. In the short-term, rates of manure appropriate for next year's crop may be calculated based on analysis of the manure nutrient content and predicted availability of the manure nutrients to be applied along with soil test and required rates for individual nutrients as used for application of commercial fertilizer. Manure software recommendation packages have been developed by commercial soil testing laboratories as well as government agencies which simplify these calculations and in some instances, allow record keeping and provide calibration information.

Timing

With a source of manure such as liquid swine manure in which much of nitrogen is contained in the form of immediately plant available ammonium, similar to commercial fertilizer the application in late fall or spring is most desirable in order to reduce opportunity for conversion of the ammonium to the nitrate form which is more susceptible to losses such as leaching and denitrification. To reduce potential losses, these manures should be applied as

For best results, fertilize with manure when the crop needs it.

close to the time of plant nutrient demand as possible. For solid manures such as cattle penning manure, low availability of nitrogen in the year of application due to the straw in the manure may necessitate a supplemental application of commercial N fertilizer or perhaps a pulse crop in the first year to optimize production, as a lead time is necessary to give the organic nitrogen opportunity to be released into the plant available inorganic forms.

Method of Application

Owing to the dilute nutrient concentration in manure, large volumes must be applied to satisfy the nutrient recommendations. Therefore, application rates of liquid swine manure in the order of a few thousand gallons per acre or cattle manure applications of a few tons per acre are needed in comparison to a few pounds of

commercial fertilizer. This has made effective application strategies challenging. A consistent finding in research trials in Saskatchewan has been that liquid manure that is placed into the soil (injected) provides better crop recovery of nutrients and greater yield response than surface applications, as well as reducing odor.

Strategies for Using Liquid Manure in Zero-Till

Low Disturbance Injection of Liquid Manures

Considerable advances have been made in technology for injection of liquid manure over the past few years. Injection technology has progressed from crude shanks on a wide spacing that simply directed the liquid manure into large channels or trenches, to the development of manifold systems and tool bars to distribute the manure to narrow row spacing shanks with sweep or spike openers that provide closure of the furrow and retention of the manure in place. Most recently, equipment has been developed for low disturbance injection of liquid manure into forage stands and no-till fields. In field research trials in Saskatchewan, large increases in biomass yield have been observed from the low disturbance injection of liquid swine effluent into forage grass stands such as crested wheat and brome grass. The low disturbance injection technology in these trials uses coulters or discs to open a narrow channel into which the liquid manure is injected. Other approaches to low disturbance in-soil placement include the use of a rotating drum to make indentations in the soil into which the manure flows. These techniques are now being used by several commercial applicators and provide an effective link between the desire to effectively recycle manure nutrients and the expansion in direct seeded and forage acres.

Post-Emergent Injection to Boost Yield and Protein of Cereals

Low disturbance, post-emergent injection of liquid swine effluent at low rates to boost yield and protein content of cereal crops is currently being evaluated in a three year research project (2000, 2001, 2002). In this study, low disturbance coulters are used to inject liquid manure in-crop at around the tillering stage. In 2000 in east-central Saskatchewan under good moisture conditions, this approach worked well. At one site the post-emergent injection of liquid swine effluent into a hard red spring wheat crop on June 30 at 2000 gallons per acre (~60 lb total N / acre) increased the yield over the check by 6 bushels per acre and raised the protein content from 14.4% to 15.9%. In 2001, under poorer moisture conditions, some yield reduction from the disturbance during later applications was evident and only protein content was increased. Post-emergent injection methods show promise in opening up the application window for liquid manure application, and are compatible with no-till systems.

Figure 1 **Low disturbance coulter system for injecting liquid manure into forage stands and no-till fields.**

Challenges

Some challenges we still face regarding use of manure as fertilizers and soil amendments include the inherent variability in manure, its low nutrient content and constrictions in transportation and application technology. In the case of solid manure, we still lack good technology to uniformly distribute the solid manure across the field area during application. This poses problems in effective use of solid manures in zero till systems, as considerable soil disturbance is often associated with attempts to distribute and incorporate the solid manure following application. The goal would be to have equipment that allows solid manure to be placed below the surface of the soil during application with minimum soil disturbance. Composted manures and processed manure products fortified with commercial fertilizers to obtain the desired nutrient content, balance and physical properties may allow more effective utilization of solid manures in the future. For liquid manures, further development and refinement of technology for "on-the-go" sensing of manure nutrients should allow for more precise application of manure nutrients in the field and help to account for the potentially high variability in nutrient content from load to load.

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