6 Calculating Manure Application Rates

Manure is a fertilizer and can be used to meet the fertilizer recommendations on the soil test reports. This is often referred to as manure/nutrient management planning. The end result of a manure/nutrient management plan is the calculation of a manure application rate that will meet the nutrient requirements of the crop.

Worksheets for calculating manure application rates are in **Appendices B and C.** Notes for the worksheets are in **Appendix D**.

6.1 Development of the Manure Application Rate Recommendations

Observations from field trials across the Prairies have been used to develop the recommendation system that is used to determine manure application rates that will meet the nutrient requirements of a crop. The recommended manure application rates vary according to manure nutrient content (manure test), predicted manure nutrient availability (field trials and research data), available soil nutrient content (soil test) and the anticipated crop nutrient requirement (field trials, research and climate data). Crops with high nutrient-demand and -removal potential, such as forage grasses and potentially high-yielding cereals and oilseeds, have shown good yield response to the nutrients provided by manure. Protein content in cereals has also been shown to significantly increase with manure use because the organic manure N mineralizes later in the growing season.

6.1.1 Using Nitrogen as the Basis for Manure Application Rates

Unlike manufactured fertilizer, the nutrients in manure are not balanced for optimal crop growth; therefore, it is difficult to apply manure to meet exact crop requirements for two or more nutrients. When manure is applied based on one nutrient, other nutrients are usually either over- or under-applied. In the Prairie region, nitrogen-based application rates are the accepted practice. If manure is applied to meet nitrogen requirements, then phosphorus and potassium may be applied in excess of crop requirements. If manure is applied to meet P requirements, additional N may be required.

Agronomic Impacts of Over-applying Nutrients: Although many crops have shown significant yield responses to the nutrients provided by manure, it is important not to over-apply nutrients. The over application of nutrients, from any source, can have a negative effect on crop growth and yield (Table 6.1). Lodging is perhaps the most apparent response to high nitrogen applications.

In low moisture areas of the Prairies, high nitrogen applications can produce a large amount of vegetative growth, especially in cereals, but with subsequent poor grain-fill and yield if the weather turns dry later in the season ("haying off").

Forage grasses that receive excess rates of N can have elevated nitrate concentrations. This may be even more prevalent if forage growth is limited by some factor such as drought. Feed testing of forages grown on manured soils is recommended to determine nitrate levels.

Table 6.1 Yield Comparison Showing Crop Response to Various Rates of Injected Liquid Hog Manure in East-Central Saskatchewan

Rate	Canola Yield		Barley Yield		Crested Wheat Grass	
	tonne/ha	bu/ac	tonne/ha	bu/ac	tonne/ha	tons/ac
0	0.56	10	2.04	38	0.96	0.43
84 kg N/ha (75 lb N/ac)	1.29	23	4.03	75	2.46	1.11
168 kg N/ha (150 lb N/ac)	1.74	31	4.30	80	4.52	2.03
337 kg N/ha (300 lb N/ac)	1.62	29	3.98	74	4.43	2.00

Adapted from Schoenau, J.J., P. Mooleki, P. Qian. 2001. Maximizing the Economic and Environmental Benefit of Land Application of Animal Manure. AFIF/Sask Pork Final Report # 96000131. Saskatchewan Agriculture, Food and Rural Revitalization. (Yield Tables modified by Barry Olson, Alberta Agriculture, Food and Rural Affairs, Nov 2001.)

In general, a shift in soil test values should initiate a review of the manure management plan. The review should determine why there is an excess or deficiency of any one, or combination of nutrients, so that decisions can be made on applications for the coming crop year.

6.2 Nutrient Availability to Crops

In order to determine an appropriate manure application rate, estimates of the nutrients that are available in the manure are necessary. The first step in estimating manure nutrient availability is determining the nutrient content of the manure through laboratory manure analysis.

The total amount of the various nutrients provided on the manure test report does not necessarily reflect the amount of nutrients that will be available for crop growth when the manure is added to the soil as fertilizer. Generally, the nutrients in commercial (inorganic) fertilizers are available to plants at the time of application. The nutrients in manure, however, are in both organic and inorganic forms, which differ in their availability for plant uptake. It is important to understand the processes involved in nutrient availability when calculating manure application rates.

6.2.1 Nitrogen

The manure test report should include results for total N and ammonium N.

Available Ammonium N: The amount of ammonium N available to the crop will depend on the spreading method, season and weather conditions. Ammonium can be readily lost to the atmosphere as ammonia through volatilization. The amount of ammonium N lost will depend on how long the manure is exposed to the air. To maximize the economic benefit of the manure N, an application method that minimizes volatilization should be chosen.

Table 6.2 provides estimated % loss of ammonium under varying weather conditions when the manure is surface broadcast (with and without incorporation) or injected. In general, injection and incorporation immediately after application will significantly reduce volatilization losses. Research on N loss from ammonia volatilization shows that losses are highly variable. The values provided in Table 6.2 are estimates for manure application rate calculation purposes.

Available Ammonium N = Ammonium N x [100 – Volatilization Loss (%)]

Table 6.2 Volatilization losses (%) associated with different application methods and weather conditions

Application Methods	Cool Wet	Cool Dry	Warm Wet	Warm Dry	Average Losses
Injected	0	0	0	0	0
Incorporated within 1 day	10	15	25	50	25
Incorporated within 2 days	13	19	31	57	30
Incorporated within 3 days	15	22	38	65	35
Incorporated within 4 days	17	26	44	72	40
Incorporated within 5 days	20	30	50	80	45
Not incorporated	40	50	75	90	64
Irrigated	Above factors +10%	Above factors +10%	Above factors +10%	Above factors +10%	
Applied to cover crop	25	25	40	50	35

Adapted from MARC 1998. Manitoba Agriculture and Food.

Available Organic N: Organic N is not measured in the laboratory. Organic N is calculated as follows:

Organic N = Total N – Ammonium N

The amount of organic N that will be available to the crop is estimated to be 25% to 30% in the first year after application.

Available Organic N = Organic N x 0.25 Year 1

Organic N will continue to be released in the years following application. The amount of organic N mineralized in the second and third years after application is significantly less than in the first year.

The amount of N that is available at the beginning of the second and third cropping years following manure application will be determined by the soil nitrate test. If a soil nitrate test is not available, the amount of organic N available in the second and third years following application can be roughly estimated. As a "rule of thumb", about 25% of manure organic N will be available in the crop year following application, 12% will be available two years later, and 6% will be available three years later. Annual manure application, particularly in the case of solid manure, can result in a significant organic N pool, which can provide a considerable amount of available N. Use of the soil nitrate test to estimate the available N is strongly recommended.

Total Available N: The total N available to the crop is the amount of N that will be mineralized from the organic N plus the ammonium N remaining after volatilization losses.

Total Available N = Available Organic N + Available Ammonium N

6.2.2 Phosphorus

The manure test report will generally provide a total P analysis. Manure P can be in both inorganic and organic forms, but the organic P must be mineralized before it can be used. Inorganic P is considered to be available to the crop. Approximately 50% of the total P is considered to be available to the crop in the year of application.

> In general, P does not move much in soil. This is because P can be strongly bound by Al, Fe, Ca and Mg. Of the total amount of P applied, the crop will only take up a fraction. A large portion of the P applied will be bound by the soil and become unavailable for plant uptake. For chemical fertilizer P, placement with the seed has increased the probability of the crop accessing the P before it is bound by the soil. In the case of manure, both broadcasting or injection are less effective than seed-placed fertilizer P.

Manure application rates are often based on N. Depending on the manure nutrient analysis, this may result in applications of P above crop nutrient requirements. Alternatively, manure application rates can be calculated based on the P content of the manure and the crop requirement for P.

6.2.3 Potassium

The manure test report will provide a total K analysis. Manure K is considered to be as available as fertilizer K with estimates ranging from 90 – 100%.

Repeated yearly applications of manure can result in elevated soil K levels. Although this is not considered to be of environmental concern, high soil K can produce elevated levels of K in forages, which is of particular concern to dairy producers. High K levels in dry cow diets predispose cows to several metabolic disorders including milk fever and udder edema. The feeding of forages with less than 1.5% K (dry matter basis) is therefore recommended for dairy cows prior to calving.

6.3 Soil Suitability and Establishing Land-base Requirements

Manure nutrient management is based on the premise that an adequate amount of suitable land is available for long-term application of manure at agronomic rates. The land-base must be comprised of soils that are productive and that minimize the risk of nutrient losses via leaching, denitrification, runoff and erosion.

Soils with low agricultural capability, according to the Canada Land Inventory (CLI), have lower yield potential and, therefore, limited nutrient uptake by plants. When these soils are located in landscapes where there is high risk of nutrient loss to surface and/or groundwater, manure applications should be controlled according to Beneficial Management Practices specific to that region. In extreme situations, these lands may have to be excluded from the land-base that is to receive manure applications.

Sometimes not all of the lands within a planned spreading area will be suitable for manure application, and some of the land may have to be removed as part of setback distances outlined in local guidelines and regulations (wetland, bush, saline areas). All of these factors should be considered when determining the actual area suitable for spreading.

The suitability of the land-base for manure spreading is based on a number of criteria in addition to the soil test information. Individual provinces evaluate soil suitability in the context of detailed soil survey information and other defined criteria. These criteria can vary, but may include soil type, slope, topography, nutrient levels, erosion risk, climate, management practices, distance to surface water, and depth to ground water or bedrock. Crop productivity data according to soil type can be obtained from provincial crop insurance agencies and used as a starting point in determining whether a specified target yield is attainable or reasonable for a given situation.