



Fertilizing Forages With Manure

Manure is a valuable source of plant nutrients and organic matter and, when used as a fertilizer, will improve annual crop and forage production and soil quality. Livestock manure contains most of the nutrients that crops require, including nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), copper (Cu), manganese (Mn), zinc (Zn), boron (B) and iron (Fe). Forages offer an opportunity for manure application. The result is improved grass production.

Understanding Manure

In general, livestock manure can be classified as solid, semi-solid and liquid. Solid and semi-solid manures have a higher organic content than liquid manure because of the added bedding. Manure types can be differentiated based on moisture content as follows:

Solid: <80 per cent moisture content

Semi-solid: 80 per cent to 90 per cent moisture content

Liquid: >90 per cent moisture content

The nutrient content of manure is highly variable. The actual nutrient content of a manure will depend on the type of livestock operation, moisture content of the manure, whether or not bedding is used, the type of bedding, the age of the animals, the feeds and feed supplements used, etc. (See Farm Facts, *Managing Manure as a Fertilizer and Nutrient Values of Manure*). Manure is an excellent source of N, but the nature of the manure needs to be considered when calculating application rates to achieve the desired agronomic response.

The Total N in manure is primarily made up of two forms, ammonium N and Organic N. Manure contains very little nitrate-N. Nitrates in manured



soils result from nitrification – the conversion of ammonium to nitrate by microorganisms in the soil.

$$\text{Total N} = \text{Ammonium N} + \text{Organic N}$$

Not all of the nitrogen in the manure is readily available. The total available N is the sum of the ammonium N (which is in a form readily available for plant growth) and that portion of the organic N that is decomposed (mineralized) into a form that is plant available.

$$\text{Total Available N} = \text{Ammonium N} + \text{Mineralized Organic N}$$

Liquid manures are low in solids and generally contain the majority of the N in the form of ammonium, which is more immediately available. For example, in swine manure, the total nitrogen (N) content from earthen manure storage units typically ranges from 15 to 50 pounds of total N per thousand gallons (1.5 to 5.0 kg of N/1000 l). Of this total nitrogen, there is generally about 65 per cent

available as ammonium, which is a form that plants can use directly. The rest of the N is organic, and it is estimated that an additional 20 to 30 per cent of the organic N in liquid manure is mineralized into plant-available N in the year of application. This makes liquid swine manure a very readily available form of nitrogen.

Solid cattle manure, on the other hand, has a much higher organic N content due to the large amounts of solid fecal matter and bedding, which raises the carbon to nitrogen (C:N) ratio. Soil organisms use the carbon in the manure bedding mix as a food source. As they consume carbon (C), they also consume N, making it temporarily unavailable to plants. This process is called immobilization (the conversion of inorganic N to organic N). When the organisms die, nitrogen and other nutrients are released back into the soil. This is why cattle manure characteristically behaves as a slow release fertilizer that continues to supply nutrients for some years after application. Typically, only 10 to 20 per cent of the N in solid cattle manure is in the form of ammonium, resulting in low availability in the year of application. Irrespective of what type of manure is being used, producers should use annual manure and soil analysis to calculate their application rate. However, due to the nature of solid manure, meeting the crop N requirement may result in over applying phosphorus (P). In order to manage soil P levels, one alternative is to supplement the manure N with commercial fertilizer N to meet the crop requirement.

Forage Yield Response to Liquid Manure Applications

A number of studies have been completed to determine the yield response of tame grass stands to hog manure. In general, the data clearly shows increased forage yields in response to manure injection with no negative side effects from the injector, particularly with grass species. Some damage from the injection was observed in the crowns of alfalfa stands. Table 1 summarizes the data from a study undertaken by the Prairie Agricultural Machinery Institute (PAMI) over three years using variable rates of manure application and grass species.

Manure was applied every year with a low-disturbance disk injector to plots receiving 3,300 gal./ac. (37,000 l/ha), every second year to those plots receiving 6,600 gal./ac. (74,000 l/ha) and only once in 1997 at the beginning of the project to those plots receiving the 13,000 gal./ac. (148,000 l/ha).

In all species receiving hog manure at a rate of 6,600 gal/acre (approximately 180 lb. available N) yield was increased by three to four times that of the control. A decrease in yield was observed in the third year for all application rates on all plant species. A number of factors may have entered into this yield decrease, including the accumulation of nitrogen in the soil and a lack of adequate precipitation. In general, however, the application of manure resulted in significant forage yield increases when compared to the control plots in all cases.

Table 1: Yield Response of Forage to Liquid Hog Manure (PAMI, 2001).

Year	Application Rate	crested wheatgrass (lb./ac.)	smooth brome/alfalfa (lb./ac.)	russian wildrye grass (lb./ac.)
1998	Undisturbed check(no N)	890	1469	2003
	100lb. N/ac. (3,300 gal/ac)	2136	2029	2385
	200 lb. N/ac. (6,600 gal/ac)	3907	2456	2990
	400lb. N/ac. (13,000 gal/ac)	3827	2189	2768
1999	Undisturbed check(no N)	1246	4459	1931
	100lb. N/ac. (3,300 gal/ac)	3969	9434	4859
	200 lb. N/ac. (6,600 gal/ac)	2643	7849	4468
	400lb. N/ac. (13,000 gal/ac)	2821	8900	4904
2000	Undisturbed check(no N)	418	1629	1113
	100lb. N/ac. (3,300 gal/ac)	1228	3346	2581
	200 lb. N/ac. (6,600 gal/ac)	2136	3987	2706
	400lb. N/ac. (13,000 gal/ac)	685	2136	1451

Yield data from a study completed in Alberta (Olson and Paworth, 2001) also indicated a positive effect on forage yield with both liquid and solid manure. Yields increased from 2,670 lb./ac. (3,000 kg/ha) of dry matter on the plots that received no manure to 5,340 lb./ac. (6,000 kg/ha) of dry matter on the manured plots.

Likewise, a study at the Western Beef Development Centre showed a significant yield increase on plots receiving solid manure that proved cost effective for the producer.

Table 2: Solid Manure on Old Crested Wheatgrass Stands

	1999	Costs	Pasture production benefits
Control	2558 lb./ac.		
30 Ton/ac.	3893 lb./ac.	\$20/ac.	\$ 0.15 cents/lb.
60 Ton/ac.	4213 lb./ac.	\$40/ac.	\$ 0.24 cents/lb.

Adapted from Livestock and Forage Gazette, March 2003

Forage stands kept in good condition will have a greater response to manure application than stands contaminated with weeds or poorly productive grasses. In healthy grass stands, weed density did not appear to increase with the application of hog manure (PAMI, 2001). In fact, the added vigor of the grass stand provided a competitive advantage against weeds. The inherent productivity of the soil is also a factor that should be accounted for when predicting the forage yields. Stands grown on coarse or gravelly soils will have a poorer response to nitrogen application than stands grown on heavier textured soils.



Forage plots at Spiritwood.

Calculating Application Rates

Soil type, the nutrient demand of various crops and the nutrient content of manure will all affect the manure application rate. In order to calculate the optimal manure application rate, producers need a laboratory nutrient analysis of the manure and a soil test recommendation.



Collecting liquid manure sample.

The importance of a lab analysis is best illustrated by the following example. Two producers each require 115 lb. of N for a forage crop. They each receive 4,000 gal./ac. on their forage crop from two different hog production units. Based on the laboratory nutrient analysis, the application of hog manure from the one unit results in an application of 166 lb. N/ac., whereas the application of hog manure from the second hog barn results in an application of 95 lb. N/ac. One producer is receiving more than he needs; the other producer is not receiving as much as required. However, in the absence of a laboratory nutrient analysis for the manure, book values can be used (See *Farm Facts: Nutrient Values of Manure*). The following example illustrates the calculation of an annual manure application rate. For the calculation, it is assumed that 30 per cent of the organic N will be available during the growing season.

Table 3: Calculating Manure Application Rates for Your Forage Stand

<i>Example: Injected Hog Manure on a crested wheatgrass stand requiring 113 lb. of N based on a soil test recommendation. Average nutrient values are taken from Farm Facts: Nutrient Values of Manure, SAF, 1999. (Imperial units)</i>	
A – Soil test N recommendation*	113 lb./ac.
B – Total manure nitrogen	30 lb./1,000 gal. (average nutrient value)
C – Ammonium (NH ₄) in manure	20 lb./1,000 gal. (estimate 65 per cent of total N)
D – Estimated retention factor after Volatilization ** (Table 4)	1.0
E –NH ₄ available in growing season: C x D	20 x 1.0 = 20 lb./1,000 gal.
F - Organic nitrogen: B-C	30 – 20 = 10 lb./1,000 gal.
G – Organic nitrogen available in growing season: F x 0.30	10 x 0.30 = 3 lb./1,000 gal.
H – Total nitrogen available in growing season: E + G	20 + 3 = 23 lb. /1,000 gal.
Z = Calculated manure application rate (gallons/acre)	
Z = (A ÷ H) x 1,000 gal	
Z = (113 ÷ 23) x 1,000 gal.	
Z = 4.913 x 1,000 gal.	
Z = 4,913 gal. per acre	
Rounded off to 5,000 gal./ac.	

* Soil testing is generally done prior to manure application in order to determine the nutrient requirements. However, knowing that nutrient release rates from solid manures are often slow, a second soil test could be done after application at the onset of grass growth in May-June to check N availability. If N availability is low, a topdress of N might be warranted.

*Volatilization occurs when ammonium is converted to ammonia gas. When applying manure, the losses increase when manure is broadcast and not incorporated. In the case of liquid manure, injection removes the opportunity for volatilization to occur.

Table 4: Estimated Nitrogen retention factor during application

Application Method	Retention Factor
Injection	1.0
Broadcast (incorporation in 24 hr.)	0.85
Broadcast (no incorporation)	0.75



Collecting Solid Manure Sample

Considerations for Applying Manure to Mixed Stands and Native Prairie

When fertilizing a mixed stand consisting of about 50 per cent legumes, a good rule of thumb is to manage for the legumes. Legumes obtain their required nitrogen through symbiotic nitrogen fixation if active nodules are present on the roots; therefore, lower nitrogen levels and higher phosphorus levels are needed to maintain legumes in a mixed stand. However, if the stand is pre-dominantly grass species, then the intended fertilizer program should favour the grass species. In this case, higher nitrogen rates would be applied and less phosphorus.

Application Methods

Low-disturbance injection of liquid hog manure to grasslands provided a low-cost alternative to fertilization, resulting in increased seed and forage yields. In addition, injection results in fewer odours during application and more efficient nutrient utilization, as nutrients are placed where the plants can use them.

A study recently completed in southern Alberta on good condition tame and native pasture indicates increased nitrogen retention with low disturbance manure injection (Lambert and Bork, 2003). In native stands, nitrogen retention was improved with low disturbance injection over the surface application. This improved retention was attributed to both the injection and the presence of a well developed root system, good litter development and healthy soil microbial populations in the native stands. A more dramatic response was observed on tame pasture between the low disturbance injection and the surface application. In the absence of litter and a well developed rhizosphere, injection greatly improved nitrogen retention.

Recent research has shown that alfalfa stands which are deficient in sulphur, phosphorus, and potassium will see a marked increase in yield following liquid manure injection with a low-disturbance coulters system. Alfalfa stands with sufficient nutrients do not show a yield increase, however, and may actually see a decrease in yield due to crop damage by the coulters.

If broadcasting either solid or liquid manure to forages, producers need to be aware that broadcasting results in a greater potential loss of nutrients through volatilization. In order to reduce losses, apply in cool, still conditions, below the plant canopy or as close to the ground as possible. As a general recommendation, livestock should not be allowed to graze any forage within 30 days of broadcasting to avoid exposing the animals to contaminated plant material (Manitoba Agriculture and Food, 1998).

Application Timing

In terms of nutrient utilization, spring applications of manure are the most beneficial. Temperatures are low, the possibility of precipitation is high, and plants can efficiently use nutrients present in the manure for growth. High nutrient uptake during this growth period reduces the losses associated with leaching and runoff. However, current farming practices often make it difficult to apply in the spring, but applying manure after the first cut in summer has proven viable for a number of producers.

Split applications (one in spring and one in fall) may be beneficial in encouraging regrowth with high moisture situations, where two or more cuts per season are desired. Low disturbance injection methods now make summer application into standing forage crops a practical option.



Low-disturbance injection into standing soil.

Application Frequency

Applying manure annually is not always possible. The studies that have been done to date indicate that applications made to meet a two year nutrient requirement result in a good response. The nutrient carryover, particularly in the case of solid manure applications, will increase forage production in subsequent years, thereby improving profitability over a longer period of time.

Forages, relative to some field crops, have high nutrient requirements. Applications should be calculated to meet the forage nutrient demand based on potential yield. If the manure is in short supply, it maybe better to apply appropriate rates to one field, correcting nutrient deficiencies, rather than lower rates to several. The application of excess nutrients may result in losses from runoff or leaching, and so it is important to consider the site specific nature of soils and the opportunity for runoff.

Manure, Nitrates, Potassium and Feed Management

Most forage plants have the ability to accumulate nitrogen, particularly annual forage. Nitrate levels in forage plants can be affected by various factors and environmental conditions, including drought, frost, soil fertility levels, herbicide injury or sulphur or phosphorus deficiencies.

Repeated yearly applications of manure can also result in elevated soil K levels. Although this is not considered an environmental concern, high soil K can produce high K forages when K is out of balance with Ca and Mg. High K forages can

cause milk fever or tetany in cattle, so feed testing is encouraged for ration balancing.

In general, nitrate content of 0.0 to 0.15 per cent in the forage is considered to be safe under all conditions. Nitrate levels of between 0.15 and 0.5 per cent are generally safe; with no adverse effect on performance expected. Levels above 0.5 per cent are potentially toxic and producers are encouraged to feed with caution, as growth or milk production can be affected and abortions may result. If feed tests indicate high nitrate levels, producers may be able to use the feed by diluting the high nitrate forage with other forages or feedstuffs that are low in nitrates. This can bring the nitrate level of the diet down to safe feeding levels.

Table 5

Site # and Location	Soil Zones	Number of sites	Grass Species
1. Central Butte	Brown	1	• Alfalfa/Crested Wheatgrass mix
2. Lanigan 3. Lanigan	Black	2	• Russian Wild Rye • Crested Wheatgrass
4. Humboldt	Black	1	• Alfalfa/Brome/Crested Wheatgrass mix
5. Spiritwood 6. Spiritwood 7. Spiritwood	Moist Black	3	• Alfalfa/Brome/Russian Wild Rye/ Triticale with wild Foxtail and Quackgrass • Alfalfa, Crested Wheatgrass mix • Alfalfa, Timothy, Brome mix
8. Goodeve	Black	1	• Mixed grasses (unclassified)
9. Outlook	Brown	1	• Irrigated Timothy

A study by PAMI (2000) indicated that the application of high rates of manure resulted in a carryover of nutrients in the years following application that may have contributed to a concentration of nitrates in the forage. As a follow up to this work, PAMI and SAF set up plots in the summer of 2002, on nine sites located across the brown, black, and moist black soil zones to survey for nitrate levels following the application of hog manure (Table 5 – previous page). The objective of the survey was to determine if high nitrate levels commonly occurred in forages receiving hog manure. At each plot there was a check (no manure), a 6,000 gal./ac. rate (approximately 180 lb. N/ac.) and a 9,000 gal./ac. rate (approximately 270 lb. N/ac.). The sites were sampled at three and five weeks following manure application.

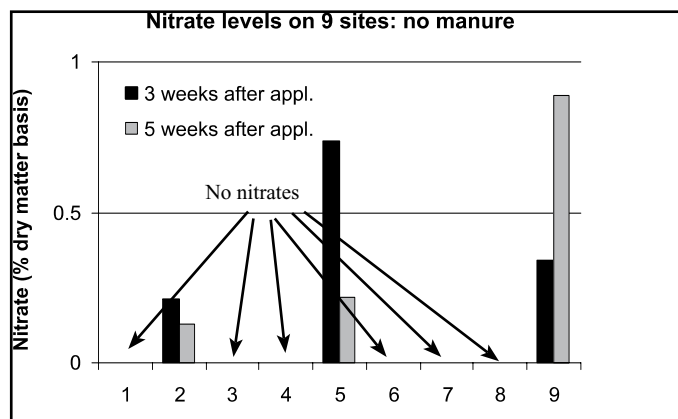
Graphs 1, 2 and 3 show the results of the survey for the three application rates. Overall, nitrate levels were in the safe to generally safe category. The check plots receiving no manure had the lowest nitrate levels. Site #5 at Spiritwood had high nitrates at the three week sampling period, and the irrigated timothy site at Outlook had nitrate levels in excess of 0.5 per cent at the five week sampling period.

Out of 34 samples taken from all nine sites where manure was applied, only four samples exceeded safe nitrate levels at the five week sampling period: site # 3 at Lanigan at both the 6,000 and 9,000 gal. application rates, and site #9 at Outlook at both the 6,000 and 9,000 gal. rates. These two sites are in different soil zones, had very different grass species and moisture conditions.

The results of the sampling illustrate that a number of factors can influence the accumulation of nitrates. **Given this variability, it is recommended that forages (cut for hay or grazed) that have received manure as a source of nutrients should be feed tested to determine nitrate levels and for ration formulation.**

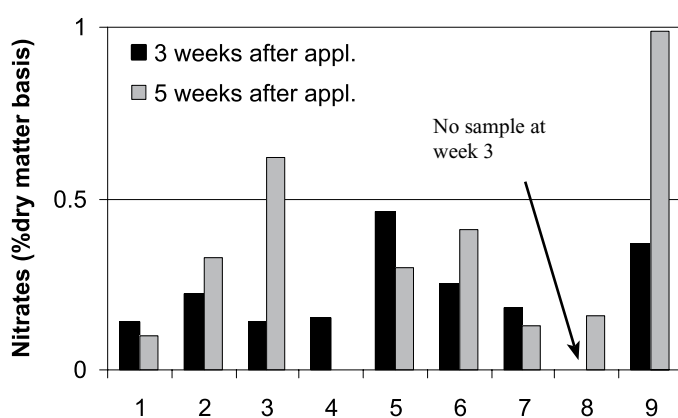
**For more information contact the:
Agriculture Knowledge Centre
1-866-457-2377, or
Livestock Development Branch,
Saskatchewan Agriculture and Food
(306) 787-9183.**

Graph 1



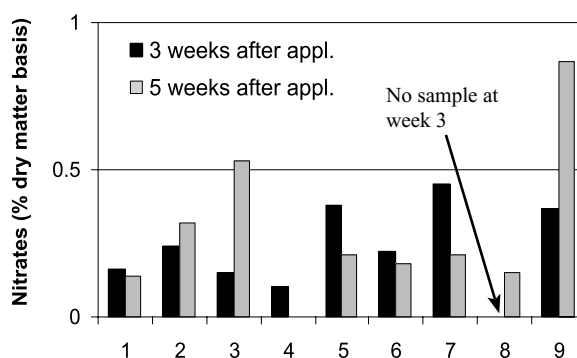
Graph 2

Nitrate levels on 9 sites: 6,000 gal./ac. (180lb. N/ac.)



Graph 3

Nitrates levels at 9 sites: 9,000 gal./ac. (270lb. N/ac)



Metric Conversion Factors* (approximate)

Metric Unit	Metric to Imperial Multiply By	Imperial Unit	Imperial to Metric Multiply By	Metric Unit
LINEAR centimetre (cm)	0.39	inch	2.54	LINEAR centimetre (cm)
AREA square metre (m ²)	1.2	square yard	0.84	AREA square metre (m ²)
hectare (ha)	2.5	acres	0.4	hectare (ha)
VOLUME litre (l)	0.22	gallon	4.55	VOLUME litre
PRESSURE kilopascals (kPa)	0.14	psi	6.9	PRESSURE kilopascals (kPa)
WEIGHT WEIGHT gram (g)	0.04	oz.	28.35	gram (g)
kilogram (kg)	2.2	lb.	0.454	kilogram (kg)
AGRICULTURAL litres per hectare (l/ha)	0.089	gallons/acre	11.23	AGRICULTURAL litres per hectare (l/ha)
litres per hectare (l/ha)	0.357	quarts/acre	2.81	litres per hectare (l/ha)
litres per hectare (l/ha)	0.71	pints per acre	1.41	litres per hectare (l/ha)
millilitres per hectare (ml/ha)	0.014	fl.oz. per acre	70.22	millilitres per hectare (ml/ha)
kilograms per hectare (kg/ha)	0.89	lb. per acre	1.12	kilograms per hectare (kg/ha)
grams per hectare (g/ha)	0.014	oz./acre	70	grams per hectare (g/ha)
<p>*EXAMPLE: To convert centimetres to inches, multiply by 0.39; conversely, to convert inches to centimetres, multiply by 2.54. CAUTION: Herbicide labels are in metric units only. Conversion between the Metric and Imperial system may result in confusion. It is recommended to use metric units only.</p>				

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