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# 6.0 MANURE MANAGEMENT

Manure can be a valuable resource if handled properly. It is an excellent source of nutrients and can improve soil tilth, structure and water-holding capacity. Manure has several advantages over commercial fertilizers, including on-farm availability, nutrient composition and ability to enhance the organic matter of soil.

However, if manure application is not properly managed, excess nutrients may be applied to agricultural land. Micro-organisms (including pathogens), weed seeds and salts are also present in manure.

All agricultural operations that handle manure are required to comply with the *Agricultural Operation Practices Act* (AOPA). The Act sets out standards for manure application and site selection of short-term solid manure storage areas. Producers handling more than 500 tonnes of manure are required to keep records. It is important to note that manure includes bedding material.

**Risks that may be associated with land application of manure and compost include:**

- Excess phosphorus (P) and nitrogen (N) application on land from manure and mineral fertilizers may result in phosphorus and nitrogen runoff to surface water bodies and nitrate leaching to groundwater.
- Excess phosphorus in water bodies may cause excessive growth of aquatic plants. The decomposition of these plants can reduce oxygen to critical levels, which may adversely affect fish survival.
- Organic matter in a water source may cause physical and biological damage, including oxygen depletion.
- Excess nitrates may reduce ground or surface water quality and the water may become toxic to aquatic life, humans and livestock.
- Disease-causing organisms may contaminate water, making it unsuitable for human and livestock consumption.
- Ammonia toxicity can poison fish and other aquatic organisms.
- Nitrogen gases, including ammonia and nitrous oxide (a greenhouse gas), may reduce air quality.
- High salinity in manure may decrease soil quality.

This chapter discusses beneficial management practices (BMPs) related to the land application of manure or compost. Complete nutrient management planning includes the effective use of manure, compost and/or mineral fertilizers as nutrient resources for optimum crop production and minimal impact on the environment.

## 6.1 Nutrient Value of Manure

Manure should be managed as a resource to maximize its benefits and minimize its risks. To use manure as a resource, producers need to understand its composition. Manure is a mixture of water, organic matter, mineral matter, nutrients and other chemicals. The proportion of each component and the nutrient profile of the manure depend on animal age, manure storage and handling, bedding material and diet fed. The nutrients available in manure are nitrogen, phosphorus, potassium, calcium, magnesium, sodium, sulphur, and micronutrients, such as boron, chlorine, copper, iron, molybdenum, zinc, selenium, chromium, iodine and cobalt.

## 6.1.1 Nitrogen and phosphorus in manure

Manure provides the same nutrients for crop production as commercial fertilizers, but the challenge with manure is that the forms and ratio of the nutrients are not easy to change. Nitrogen is present in manure as ammonium or as organic compounds. Generally, the environmental risks associated with nitrogen are losses to groundwater through leaching or losses to air through denitrification and volatilization. Phosphorus is present in manure in organic and inorganic forms and generally the risk to the environment is the movement of phosphorus in surface runoff from spring snowmelt and seasonal rainfall.

**Facts about nitrogen and phosphorus:**

- Only ammonium and nitrate (mineral or inorganic forms of nitrogen) can be used by plants.
- Organic nitrogen must be transformed to ammonium (mineralized) and nitrate (nitrification) forms to be used by plants.
- Phosphorus is generally found in three forms: particulate phosphorus (attached to sediments), dissolved phosphorus (water soluble) and organic phosphorus.

**Proper manure management reduces the risk of:**

- Nitrate leaching.
- Denitrification.
- Phosphorus in surface runoff.
- Ammonia losses to the air.
- Losses by wind and water erosion.

**Beneficial management practices for managing manure and compost**

- Do not apply near streams or other water bodies. Manure must not be applied within 10 metres of an open body of water if injection is being used, within 30 metres of an open body of water if the manure is being applied to the surface and incorporated within 48 hours, or within 30 metres of a water well (AOPA).
- Surface application or forages and direct-seeded crops should meet or exceed minimum setback distances in Figure 6.2.
- Surface application of manure on forage, frozen or snow-covered land is not recommended. If it is necessary, refer to Figure 6.2 for setback distances.
- Do not apply manure in low, wet areas.
- Establish grassed waterways in erosion-prone areas to slow water movement from the field.
- Leave some of last year's crop residue on the surface and reduce tillage. This increases water infiltration and reduces nutrient losses through wind-blown sediments and runoff.
- When a high amount of nitrogen is required, split the total amount required into two-thirds manure and one-third mineral fertilizer. Apply mineral fertilizer later in the season or band with seed.

**Figure 6.1** **Nitrogen and Phosphorus Forms and Availability in Manure**

| | Available 1st year | Available 2nd year | Available 3rd year | Environmental risks |
|---|---|---|---|---|
| Nitrogen (N) | **25%** of initial organic N content | **12%** of initial organic N content | **6%** of initial organic N content | • Nitrate in groundwater<br>• Volatilization of ammonia<br>• Denitrification as nitrous oxide |
| Phosphorus (P) | **50%** of initial total P content | **20%** of initial total P content | **6%** of initial total P content | • P in surface runoff (particulate and dissolved)<br>• P leaching into groundwater |

Notes:
- Volatilization is the gaseous loss of a substance (e.g. ammonia) into the atmosphere.
- Denitrification is the transformation of nitrate to gaseous forms (under high moisture or saturated soil conditions), which can be lost to the atmosphere.
- Percentages listed in the figure are only estimates. Availability of nutrients from organic sources, such as manure, depends on biological processes in the soil. These processes are affected by many factors, such as temperature, moisture and soil type.

- Reduce the amount of time between manure application and the highest demand for nitrogen uptake by the crop (e.g. apply in spring while plants are actively growing).
- Do not apply if heavy rain is predicted.
- Apply manure on humid and/or cold, calm days to reduce odour.
- Incorporate fertilizers and manure to avoid losses by runoff in areas adjacent to water bodies or areas that have high runoff potential.
- Test soil phosphorus at least once every three years to avoid over-applying nutrients. Over-application of manure will raise soil phosphorus above recommended agronomic levels (contact a crop adviser or soil laboratory for recommended P levels for each crop).
- Test soils in different landscape locations (e.g. knolls, low spots) to determine if excess levels exist in low areas where runoff collects.
- Apply manure according to soil test recommendations, crop yield goals and manure analyses. If manure is not analysed for nutrient content, published estimates can be used. This will reduce excess nutrients in the soil and minimize buildup.
- When applying manure on forages or direct-seeded crops, minimize the impact on waterbodies and groundwater, and the potential for nuisance odours.
- Surface water that comes in contact with manure must not enter an open body of water or leave the owner's property.

**Figure 6.2** **Minimum Setback Distances for Application of Manure on Forage, Direct-Seeded Crops or Frozen or Snow-Covered Land (AOPA)**

| Mean Slope | Required Setback Distance from Open Body of Water |
|---|---|
| Less than 4% | 30 m |
| 4% but less than 6% | 60 m |
| 6% but less than 12% | 90 m |
| 12% or greater | No application allowed |

## 6.1.2 Salt

Manure can contain considerable amounts of salt that may affect soil quality. High levels of sodium can disperse aggregates, degrade soil structure and reduce water infiltration into soil.

Management of soil salinity is crucial for sustainable crop production. Saline soils can reduce crop production and limit cropping options (contact a crop adviser for information on crop salinity tolerance).

**To control salt:**

- Monitor salt levels in feed rations (contact a livestock nutritionist for recommended levels in feed).
- Monitor electrical conductivity (EC) levels in soil. Electrical conductivity is a measurement of soil salt content and is measured in deciSiemens/metre (dS/m). A change of more than 1 dS/m may indicate a soil quality problem. If the EC is more than 2 dS/m, plant growth and yield may be affected. If the EC is more than 4 dS/m, manure application should not be considered. Check AOPA for EC limitations.
- Monitor the sodium adsorption ratio (SAR) levels in soil. Sodium adsorption ratio is a measurement of sodium in relation to calcium plus magnesium. SAR levels above 8 in soil can reduce soil permeability and increase the likelihood of the soil becoming waterlogged.

# 6.2 Manure Management

## 6.2.1 Manure and soil analyses

Manure analysis provides information on nutrient content in manure. The amount of nutrients available for crop growth can be estimated using nutrient analysis information. To estimate crop-available nutrients in manure, consider the chemical makeup of the nutrients in manure, previous manure applications, volatilization, nitrogen fixation and mineralization (breakdown of organic matter into available plant nutrients). When calculating manure application rates, include residual crop-available nutrients from manure applied in recent years.

Accurate manure analysis and application rates are important because problems can result from either inadequate or excessive nutrients in the soil. Manure analysis recommendations are based on the nutrient content in manure, crop to be grown, soil type, soil nutrient levels, climate, soil moisture and other management practices, such as dryland versus irrigation.

**Manure analysis**
Analyse manure for three to five consecutive years and compare the results to the book values. If there is a large discrepancy, do not use the book values. Instead, develop new average values for the operation.

Although the most reliable source of information is from sampling the operation's manure, book values of manure nutrient content are available and are better than not considering the nutrients in the manure at all.

**Manure sampling**
Manure testing helps generate a long-term database for planning and economic evaluation, as well as demonstrating due diligence. It is important that manure samples represent the entire volume of manure, not just the surface layer. Appropriate manure application rate is closely related to how manure samples are collected.

**Collecting manure samples:**
- Collect composite samples that reflect the overall variability of the manure.
- When sampling liquid manure, agitate the manure completely prior to sampling. If the manure is not agitated prior to sampling, take sub-samples from different locations and depths of the storage facility.
- When sampling solid manure containing bedding and other materials, all compounds in the sample should be in the same proportion as they occur in the pile. Solid manure is best sampled directly from the manure truckloads (three to four samples per load).
- Collect about 20 samples from each manure source. Mix the samples together; remove a sub-sample (about 1 kilogram) and place in a sealed container. Keep cool and send to the laboratory as soon as possible.
- Sampling before, but as close to land application as possible, helps to build an accurate database.

**Handling manure samples:**
- Contact the laboratory prior to sampling to obtain specific information on sample size, shipping instructions and costs.
- Avoid any handling that could alter the physical and chemical composition of manure samples (e.g. leakage, nutrient loss to the air, loss in moisture, room/warm temperature).
- Use sealable freezer bags for solid manure. Seal the bag and prevent leakage by putting the bag inside another freezer bag (double bagging).
- For liquid manure, use plastic or glass containers.
- Immediately send the samples to the lab. Otherwise, freeze the samples until delivery.
- In all situations, **fill the container only half full** and label with the name, date and sample identification. The sooner the sample is sent to the lab, the more reliable the laboratory results will be.

**Manure laboratory results:**

- Manure tests should at least include percentage dry matter, total nitrogen, ammonium nitrogen and total phosphorus. If there is a possibility of other soil deficiencies, other nutrients can be measured, such as potassium, sulphur and micronutrients. Analysing EC and the SAR in manure are necessary only to determine if changes in feed rations affect manure quality.
- Request manure test results in the same units used for calibrating the manure application equipment (pounds or kilograms). Take special care when converting units.
- Manure nutrient results should be on a wet (or "as is") basis since manure is spread wet.

**Soil analysis**

Soil analysis is used as an index for nutrient availability in soil. Good nutrient management decisions cannot be made without knowing the nutrients available in the soil and their levels. The higher the nutrients in the soil test, the lower the application rate of fertilizer/manure. An accurate soil test (proper soil sampling and interpretation of soil test) can be an excellent nutrient management tool.

Misuse or faulty interpretation of a soil test, on the other hand, leads to increased costs, yield losses, and/or environmental contamination. Soil tests can also indicate nutrient or salt surpluses. If test results suggest an excess, base manure application rate on the excess nutrient; then use inorganic fertilizer to supplement other nutrient levels.

**To prepare a soil sample:**

- Collect a representative sample, based on in-field variations in topography (slope), soil type, cropping management and cropping history.
- Collect soil samples from depth intervals of 0 to 15 centimetres (0 to 6 inches), 15 to 30 centimetres (6 to 12 inches) and 30 to 60 centimetres (12 to 24 inches) at 20 to 30 sites per field or field management area. Place samples from each depth in a separate container. Sample to greater depths (below 1 metre) every three to five years to check for nitrate leaching for fields that receive regular manure application or fields with a history of heavy manure application.
- Mix samples taken from same depth intervals and remove about 0.5 kilogram (1 pound) from each depth. If the field is variable, keep the samples from different areas (variations) separate.
- A soil sampling probe is best for taking samples. While an auger can be used, it can be difficult to accurately separate depth intervals. Tools may be borrowed or purchased from fertilizer dealers or soil testing laboratories.
- Ideally, take samples prior to seeding, but if time is a constraint then fall sampling is the best alternative. Because changes in soil nutrients occur more slowly below soil temperatures of 7°C, collect soil samples at or below this temperature, but prior to freeze-up.
- Analyse soil at the very least for plant-available nitrogen and phosphorus. Analyse for other nutrients (sulphur, potassium, micronutrients) if there is a possibility the soil may be deficient. It is also important to monitor soil salinity (EC) and possibly SAR on a regular basis.

**Soil test interpretations:**

- If nutrient recommendations are included in the laboratory report, there is no need for soil test interpretations.
- If recommendations are not included with soil test results, consult a crop adviser or private consultant for soil test interpretations and recommendations.
- Not all manure has the ideal composition to meet crop requirements. Organic materials do not contain nutrients in the exact proportions that crops require.
- Adjust application rates to meet the requirement for nutrients that will result in the lowest application rate. Inorganic fertilizers can be used to supplement other nutrients to the recommended levels.
- Avoid yearly applications to the same land unless manure and soil tests indicate there is no risk of excess nutrient levels.

## 6.2.2 Crop nutrient requirements

Nutrient requirements vary from one crop to another. Therefore, for the same conditions, application rates will be different, depending on the crop. Targeted yield for a given crop is an important factor in determining the amounts of nutrients to be added. Crop yield targets are used to determine nutrient requirements and the manure rate. To estimate targeted yield, average the yields of the previous four harvests for a given field and add five to 10 percent as an expected improvement factor.

The overall objective for considering manure and soil analyses, as well as cropping system components, is to determine an accurate manure application rate.

**To determine crop nutrient requirements:**

- Apply the manure with the highest nutrient content to crops with the highest nutrient requirements (See Figure 6.3).
- Generally legumes do not require added N. Do not apply high N manure to legumes.
- Apply manure with the lowest nutrient content to fields closest to the manure storage site and the highest nutrient content to the furthest fields. This reduces the cost of hauling because a lower amount of manure is needed when nutrient concentration is higher.

### Figure 6.3 Nutrient Uptake and Removal by Various Crops

| Crop | | Yield | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|---|
| | | Tonne* or kg/ha | kg/ha | | |
| Spring Wheat | Removal [1] | 2,690 | 67 | 27 | 20 |
| | Uptake [2] | 2,690 | 95 | 36 | 82 |
| Winter Wheat | Removal | 3,360 | 55 | 29 | 19 |
| | Uptake | 3,360 | 76 | 35 | 80 |
| Barley | Removal | 4,300 | 87 | 38 | 29 |
| | Uptake | 4,300 | 124 | 50 | 120 |
| Oats | Removal | 3,810 | 69 | 29 | 21 |
| | Uptake | 3,810 | 120 | 46 | 164 |
| Rye | Removal | 3,450 | 66 | 28 | 22 |
| | Uptake | 3,450 | 103 | 52 | 147 |
| Corn | Removal | 6,280 | 109 | 49 | 31 |
| | Uptake | 6,280 | 171 | 71 | 145 |
| Canola | Removal | 1,960 | 76 | 41 | 20 |
| | Uptake | 1,960 | 126 | 58 | 91 |
| Flax | Removal | 1,510 | 57 | 18 | 17 |
| | Uptake | 1,510 | 80 | 22 | 49 |
| Sunflower | Removal | 1,680 | 61 | 18 | 13 |
| | Uptake | 1,680 | 84 | 29 | 41 |
| Potatoes | Removal | 45* | 143 | 41 | 242 |
| | Uptake | 45* | 255 | 75 | 334 |
| Peas | Removal | 3,360 | 131 | 39 | 40 |
| | Uptake | 3,360 | 171 | 47 | 154 |
| Lentils | Removal | 1,290 | 68 | 21 | 37 |
| | Uptake | 1,290 | 103 | 28 | 86 |
| Alfalfa | | 11* | 103 | 28 | 86 |
| Clover | | 9* | 255 | 75 | 334 |
| Grass | | 7* | 242 | 63 | 226 |
| Barley Silage | | 10* | 115 | 34 | 146 |
| Corn Silage | | 11* | 174 | 59 | 138 |

[1] Total nutrient taken up by the crop.
[2] Nutrient removed in harvested portion of the crop.

* Conversion of yields to metric units assumed the following bushel weights (in pounds per bushel): wheat = 60; barley = 48; oats = 34; rye = 56; corn = 56; canola = 50; flax = 56; sunflower = 30, peas = 60; and lentils = 38.
$P_2O_5$ x 0.4364 = P
$K_2O$ x 0.8301 = K
kg/ha x 0.8924 = lbs./ac.
tonne/ha x 0.4461 = ton/ac.

Source: *Canadian Fertilizer Institute (Modified)*

## 6.2.3 Manure transportation

Moving manure from the pen to the field is an important part of a manure management system. It requires not only an economically sound system, but also one that is safe and responsible.

It is important to recognize the nuisance and risks associated with manure transportation. These include dust, spillage and physical impact on roads. Traffic from hauling manure can be very intense for short periods of time. Traffic on gravel roads during dry, windy periods can generate considerable dust. If these conditions exist in "sensitive areas," dust suppression or detouring may be necessary. Beware of manure spills on the road as these may be in violation of the *Transportation Act* and *Alberta Environmental Protection and Enhancement Act.*

Manure is considered a biodegradable product; however, direct spillage from manure trucks must be kept to a minimum. Manure spillage may be a result of seepage, overloading or blowing. Use appropriate management techniques and equipment to prevent manure spillage onto roads and ditches. In the event of excessive spillage, cleanup measures, such as sweeping, are required.

If the spillage of manure appears to have a high risk to the environment, i.e. in a waterway, Alberta Environment must be contacted through their Environmental Response Centre at 1-800-222-6514.

**Figure 6.4 Manure Hauling**

## 6.2.4 Manure storage and treatment

For specific information on short-term solid manure storage, see Section 4.2.1.

Cattle produce solid manure that is high in nitrogen and phosphorus, which makes it an excellent fertilizer resource if handled properly. To use manure more economically, the volume of water in solid manure must be reduced. Manure can be stockpiled or composted. Place stockpiles in areas that will have minimal impact on water and turn the pile once or twice before moving it to a planned and managed site. A true compost system requires turning a manure pile, based on the moisture and temperature condition of the material in the pile, to produce a well-balanced product.

## 6.2.5 Time of application

It is best to apply manure before the early stages of crop growth. Spring application is the most desirable for Alberta operations because high nutrient availability matches crop uptake. However, in the spring there are usually fewer opportunities for application because of inclement weather, risk of soil compaction and the time required for other activities. Manure can also be applied in the fall. But, the longer the time between application and the stage at which the crop uses the nutrients, the higher the risk of nutrient losses.

**Figure 6.5** **Environmental Risks and BMPs for Manure Application at Different Times of the Year**

| Season | Watch For | BMP |
|---|---|---|
| Winter | • Runoff that can pollute surface water.<br>• Sensitive areas.<br>• Sloping topography.<br>• Saturated frozen ground with slope or no infiltration. | • Manure should go into storage.<br>• Avoid application on frozen or snow-covered ground.<br>• Avoid spreading on land with a history of floods or heavy runoff. |
| Spring | • Wet soils that are prone to compaction.<br>• Denitrification that happens in cold, wet soils.<br>• Excessive application that can create a pollution hazard.<br>• Very dry soils with large cracks.<br>• Heavy surface residue that slows the drying process of seedbeds.<br>• Planting too soon after heavy manure application, which can create ammonia toxicity and reduce germination and growth. | • Apply to land before seeding annual crops.<br>• Incorporate manure into soil within 48 hours of application.<br>• Apply to well-drained soils.<br>• Apply to pasture early to avoid trampling re-growth. |
| Summer | • Loss of nitrogen if there is no rainfall within 72 hours. Rain will help manure soak in but excess rain will increase runoff.<br>• Mature crops that are not growing and don't need nutrients. | • Compost manure to reduce odour and break up clumps. |
| Fall | • Denitrification in cold, wet soils.<br>• Manure that soaks into wet fields slowly; excess water will run off.<br>• Wet soils that are prone to compaction. | • Apply to annual cropland before ground freezes and incorporate within 48 hours.<br>• Base application rates on soil tests and crop rotation for next year.<br>• Apply to well-drained soils. |

### 6.2.6 Record keeping

Recording and keeping all documents related to nutrient management is important. Documents can provide information on how nutrient management is implemented on the farm, and where and when changes are needed. Records also help generate accurate on-farm data that can be used to formulate site-specific information. Under AOPA, anyone who applies, receives or transfers control of 500 tonnes or more of manure per year must keep records for a minimum of five years.

**Records that need to be kept, if more than 500 tonnes, include:**

- Manure production
  - Volume produced
  - Source of manure
- Manure transfer
  - Who transferred the manure
  - From where
  - To where
  - Date of transfer
  - Volume of manure transferred
- Manure application
  - Soil tests (at least ever three years)
  - Name of receiver
  - Location spread
  - Amount received
  - Total N application rate
  - Total crop N application rate
  - Total P application rate
  - Application methods used for each field

## 6.3 Manure Management Tools

### 6.3.1 Nutrient management plan

Livestock operations should develop and implement comprehensive, site-specific manure and nutrient management plans. Nutrient management is defined as a system that balances nutrients in fertilizers, manure and soil with the requirements of the crop, thus enhancing the economic and environmental sustainability of farming operations. An efficient nutrient management plan is one that is environmentally sound, minimizes nutrient losses during collection, storage and application, and maximizes nutrient use.

The seven critical steps in building a nutrient management plan are:

1. Determine manure amount.
2. Determine manure nutrient value.
3. Determine soil nutrient levels.
4. Determine nutrient requirements based on manure and soil nutrient levels, and crops and expected yields.
5. Determine field limitations.
6. Prioritize fields.
7. Determine manure and inorganic fertilizer needs for each field.

## 6.4 For More Information

Contact the following offices for the publications listed or for more information.

**Alberta Agriculture, Food and Rural Development (AAFRD)**
Agriculture Information Centre 1-866-882-7677
Publications 1-800-292-5697
www.agric.gov.ab.ca

- *Beneficial Management Practices: Environmental Manual for Feedlot Producers in Alberta.*
- *Nutrient Management Planning for Livestock Production.*

Contact your local agricultural service board for information on nutrient management courses.