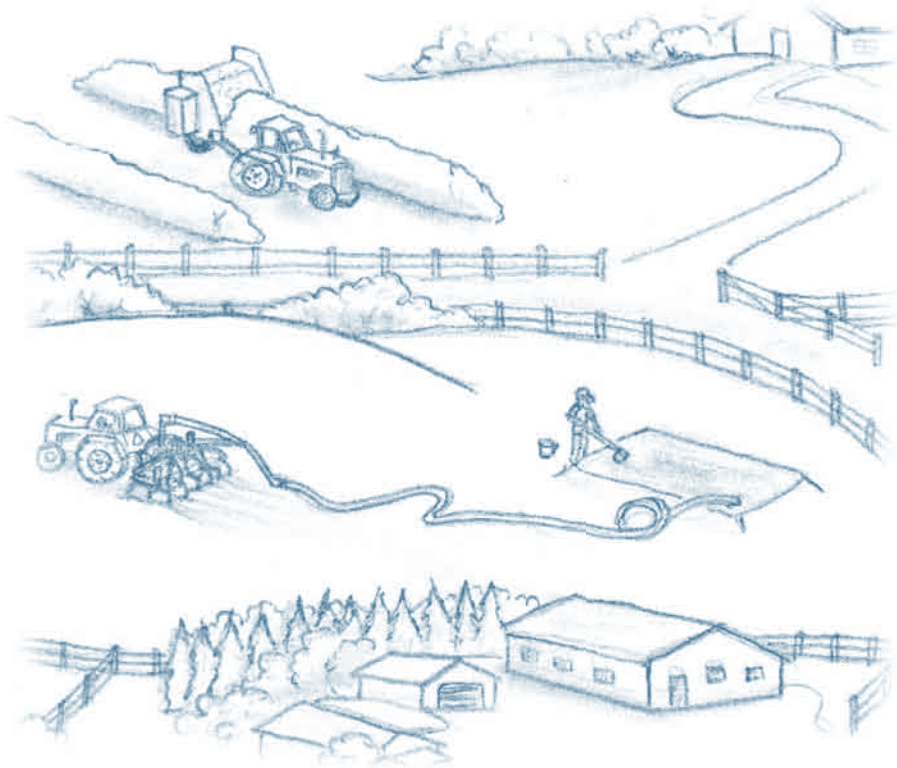


# Chapter 4.5

## Manure Application Equipment



### ➔ learning objectives

- Describe common application systems for liquid and solid manure.
- Characterize the performance of several systems with regards to manure placement, ammonium conservation, odour nuisance, soil compaction and timeliness of application.

## Important Terms

Table 4.5.1 Key Terms and Definitions

Term	Definition
Drag-hose, Dragline or Umbilical Applicator	A liquid manure application system where the application unit (e.g., cultivator) is connected to the manure storage lagoon by a long hose. A pump moves the manure down the hose to the cultivator where it is incorporated or broadcast.
Drop Tube or Drop Hose Applicator	A liquid manure applicator that uses a series of hoses, fitted along a boom at the back of the unit. These hoses apply manure beneath the crop canopy, closer to the soil surface and thereby reduce ammonia loss and odour and improve application uniformity.
Injection	The term is used to describe manure application methods that place the manure directly into the soil, in the same field operation as application.
Manifold	A chamber having several outlets through which a liquid or gas is distributed or gathered.
Opener	A tool used for opening or disturbing the soil such as discs, cultivator shovels or narrow knives.
Splash Plate	A liquid manure tank spreader that pumps the manure from the tank on to or into a metal plate (the splash plate) that deflects the manure creating an application pattern.

There are several options available for applying manure. It is important to recognize that the application system used has several implications for nutrient management, in particular nutrient placement and retention.

In many situations, producers may not have much choice as to the application method or equipment available. The trend in Alberta is towards using custom applicators and, therefore, the choice of application equipment and method is limited to those offered by the contractor. Time constraints and contractor availability often means that manure application happens when it fits into the schedule rather than when ideal weather conditions present themselves.

This chapter will summarize key features of different application options, so that strengths and limitations of each are more clearly understood.

## Manure Application Systems

### Liquid Manure

Liquid manure (less than 12% solids) can be surface applied or directly injected using a number of different systems, which are changing and improving rapidly. Liquid manure is typically stored under anaerobic conditions, which alters decomposition processes and the resulting end products. The result is that liquid manure tends to produce more odour than solid manure. Odour and related nuisance concerns have been the driver for improvements in liquid manure application technology. Injection systems, drag-hose equipment, and other methods of limiting the exposure of the manure to the air have partially alleviated the odour problems. At the same time, these application methods reduce nutrient loss, and therefore, preserve the fertilizer value of manure.

Tank spreader systems are the most common systems used to apply liquid manure in Alberta (Figure 4.5.1). In warmer and wetter parts of the U.S., irrigation equipment is also frequently used to apply liquid manure.



**Figure 4.5.1 Examples of Common Liquid Manure Application Equipment**

Manure injection involves the use of ground openers, such as discs, cultivator shovels or narrow knives (Figure 4.5.3). Typically, the openers are mounted on a tool bar and a manifold directs manure streams close to the openers, usually just behind them.



#### **The Importance of Agitating Liquid Manure**

During storage, liquid manure tends to settle into different layers within the facility, each with a distinct nutrient profile. By agitating liquid manure, solids are disrupted and re-suspended, which facilitates storage emptying and improves the consistency (i.e., nutrient distribution) of the manure applied.

Liquid manure can be agitated using various types of high volume pumps or propeller-type agitators (Figure 4.5.2). If the storage facility is large, it may be necessary to place agitators at several locations to get adequate mixing. Often the same pump can be used to agitate and load applicators.

#### **more info**



Additional information on drag-hose manure injection systems can be found in the following online publication:

Prairie Agriculture Machinery Institute and AF. 1997. A guide to pipeline manure injection systems. Research update 729. [www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/eng9868](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/eng9868)

#### **more info**



To get more information about sprinkler and irrigation application systems for manure, consult the following online resource:

Koelsch, R. and Humenik, F. Not dated. Selecting the appropriate land application method. Lesson 36 in Livestock and poultry environmental stewardship curriculum. [www.lpes.org/Lessons/Lesson36/36\\_1\\_Selecting\\_Application.pdf](http://www.lpes.org/Lessons/Lesson36/36_1_Selecting_Application.pdf)

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Potentially lethal gases such as hydrogen sulphide ( $H_2S$ ) are released when liquid manure is disturbed. Take special care to ensure adequate ventilation when there are people or animals present, and never enter a confined space where manure is present without a respirator.

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Figure 4.5.2 Example of a pump used to agitate liquid manure prior to application.

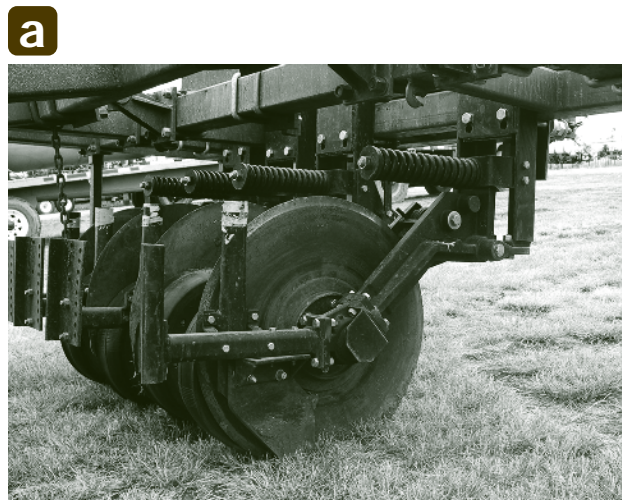


Figure 4.5.3 Four Types of Openers Available to Inject Liquid Manure. (a) Yetter disk opener (b) Sweep opener (c) Knife or Spike opener.

## Solid Manure

Most solid manure (20% or more solids) and compost is spread using broadcasting equipment (Figure 4.5.4), followed by tillage to incorporate the manure into the soil. Delayed incorporation can result in increased odour, risk of nutrient loss in runoff and volatilization losses of manure nitrogen.

Truck-mounted box spreaders improve travel times from storage to field compared to trailer-mounted spreaders, which affects the length of time required to apply stockpiled manure. Soil compaction can be a problem, but is usually reduced by using dual or flotation tires, or by simply delaying application until field conditions are dry.



Figure 4.5.4 Examples of Common Solid Manure Application Equipment

### Manure Incorporation and AOPA

Under AOPA, anyone who applies manure or compost (including composting material) must incorporate within 48 hours of application, except those who are applying manure to forage, direct-seeded crops, frozen or snow-covered ground. Manure or compost may be applied without incorporation in these situations, provided that application is at least 150 m from a residence or regularly occupied building.

### Solid Manure Injection?

The University of Saskatchewan and the Prairie Agricultural Machinery Institute (PAMI) have designed a rear discharge box spreader that can spread solid manure and compost more evenly than present equipment. They are presently testing additional components, such as a flexible auger delivery system, that one day may make it possible to simultaneously incorporate solid manure during application.

You can visit PAMI online at: [www.pami.ca](http://www.pami.ca); and the University of Saskatchewan, Department of Agricultural and Bioresource Engineering at: [www.engr.usask.ca/dept/abe/](http://www.engr.usask.ca/dept/abe/).

## more info



Specialists with AF recently completed an evaluation of several liquid manure injection technologies, which looked at characteristics such as manure placement, soil and residue disturbance, draft requirements and odour emissions. An executive summary of the study is available from the **AF publications office**, or downloaded from Ropin' the Web.

- **AF. Liquid manure injection technologies: Performance evaluation. Agdex 743-1.**

Download the complete project report from Ropin' the Web.

- **AF. 2005. Performance evaluation of five liquid manure injection technologies. [www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex10096/\\$FILE/743-1\\_report.pdf](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10096/$FILE/743-1_report.pdf)**



## Key Features of Manure Application Equipment

Five important criteria can be used to compare performance of application equipment:

- Manure placement
- Nitrogen conservation
- Potential for odour nuisance
- Soil compaction
- Timeliness of manure application

The performance of selected application systems in relation to these characteristics is summarized in Table 4.5.2

Table 4.5.2 Performance<sup>1</sup> of Selected Application Systems for Each of the Five Characteristics Discussed

Application system	Uniformity of Application	Ammonium N Conservation	Odour Control	Soil Compaction	Timeliness of Application
<i>Solid spreading systems</i>					
Box spreader (tractor-pulled)	F	VP	F	F	P
Box spreader (truck-mounted)	F	VP	F	F	F
<i>Liquid spreading systems</i>					
Liquid tank spreader (with splash plates)	P	P	P	P	F
Liquid tank spreader (with drop hoses)	F	F	G	P	F
Liquid tank spreader (with knife injectors)	G	E	E	P	F
Liquid tank spreader (with shallow incorporation)	G	E	E	P	F
Drag-hose system (with shallow incorporation)	G	E	E	G	G

<sup>1</sup> VP = Very Poor, P = Poor, F = Fair, G = Good, E = Excellent

From Koelsch, R. and Humenik, F. Not dated.

### Manure Placement

The goal of all application systems is to apply manure in an acceptable pattern where crops will have the greatest access to manure nutrients. When manure is applied and left exposed on the surface, nutrients in the manure are vulnerable to loss through volatilization. Immobile nutrients (potassium and phosphorus) will remain in the top layers of soil, making them largely unavailable to the crop, and more susceptible to loss through runoff. Ideally, manure should be injected or incorporated soon after application (Figure 4.5.5). This reduces the risk of nutrient losses and improves crop access to manure nutrients.


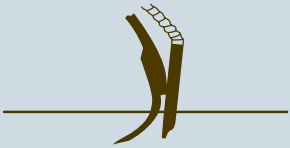
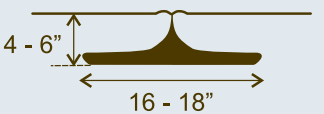


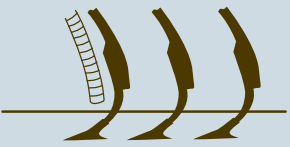

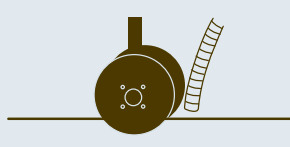

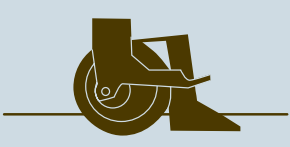

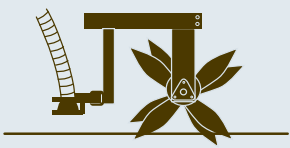

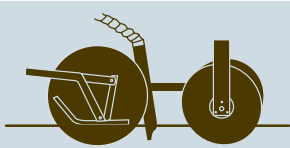
Row Crop Application Method	Placement of Manure (not to scale)	Application Implement (side views)
<p><b>A.</b> Injection: vertical knife/chisel</p>		
<p><b>B.</b> Injection: horizontal sweep</p>		
<p><b>C.</b> Shallow incorporation: s-tine cultivator (staggered)</p>		
<p><b>D.</b> Shallow incorporation: concave disks</p>		
<p><b>E.</b> Injection: slot injection</p>		
<p><b>F.</b> Surface application: aeration technology</p>		
<p><b>G.</b> Injection: offset disk slot injection</p>		



Figure 4.5.5 Placement of Manure Using Different Application Implements

Adapted from Jokela and Cote 1994



Manure placement can also be looked at in terms of the uniformity of spread, which will be discussed in more detail in the next chapter. Achieving a uniform distribution of manure will help to ensure that nutrients are applied uniformly to the field. Uniform application will help prevent nutrient deficiencies that may result in uneven crop growth. If operated properly, most application systems, with the exception of liquid tank spreader systems equipped with splash plates, will provide acceptable application uniformity (Table 4.5.2).

### Nitrogen Conservation

The predominant form of crop available N in many manures is ammonium ( $\text{NH}_4\text{-N}$ ), which is prone to loss through volatilization. The amount of  $\text{NH}_4\text{-N}$  lost is a function of the application and incorporation strategy (both the method and relative timing) and the weather conditions during application (Table 4.5.3).

Application systems that get manure into the soil as soon as possible after application minimize the opportunity for  $\text{NH}_4\text{-N}$  to volatilize. Warm and dry conditions favour greater volatilization compared to wet and cool conditions. Application strategies that help retain  $\text{NH}_4\text{-N}$  will maintain the fertility value of applied manure and therefore, the economic value of the manure.

### Potential for Odour Nuisance

Odour is the principle nuisance concern associated with manure application. Generation and emission of odours from manure is a complex process, but in general, application systems that minimize manure contact with air have fewer odour concerns (Table 4.5.2). For example, liquid application systems where manure is deposited directly on or into the ground (i.e., drop tubes and injection) will produce less odour compared to liquid application systems with splash plates. To minimize odour problems, incorporate manure either during or as soon after application as possible.

### Soil Compaction

Field equipment weighed down by large volumes of manure may increase the risk soil compaction (Table 4.5.2). The risk is further aggravated if manure is applied in late fall or early spring when soils have higher soil moisture and are more vulnerable to compaction. Where possible, avoid applying manure at times when fields are most vulnerable to compaction. Alternatively consider using systems with a lower risk of compaction, such as drag-hose systems for liquid manure. Refer to Chapter 8.2 for additional ways that soil compaction can be minimized.

### Timeliness of Manure Application

CFOs produce large volumes of manure that is typically applied only once or twice per year. Depending on the capacity of equipment, the application rate and the distance of the application area from the storage facility, manure application can take days or even weeks.

Any system that must return to the storage facility to be refilled will take the longest to apply stored manure (Table 4.5.2). Systems that use an intermediary, such as a nurse tank that transports manure from the storage facility to the application field and allows the applicator to stay in the field, will require less time. Liquid drag-hoses are the most time efficient application system because manure is continuously pumped from the storage to the applicator in the field.

A system's ability to get manure out into the field in a timely manner will save the operation money in labour and equipment costs. There is also the opportunity to minimize nutrient losses and nuisance (odour and transportation).



Table 4.5.3 Expected Ammonium Nitrogen Loss (in percent) in Relation to Application Method, Timing and Weather Conditions.

Application and Incorporation Strategy	Weather Conditions During Application				
	Average	Cool-Wet	Cool-Dry	Warm-Wet	Warm-Dry
Surface applied, incorporated within 1 day <sup>1</sup>	25 %	10 %	15 %	25 %	50 %
Surface applied, incorporated within 2 days	30 %	13 %	19 %	31 %	57 %
Surface applied, incorporated within 3 days	35 %	15 %	22 %	38 %	65 %
Surface applied, incorporated within 4 days	40 %	17 %	26 %	44 %	72 %
Surface applied, incorporated within 5 days	45 %	20 %	30 %	50 %	80 %
Not incorporated	66 %	40 %	50 %	75 %	100 %
Injected	0 %	0 %	0 %	0 %	0 %
Cover crop <sup>2</sup>	35 %	25 %	25 %	40 %	50 %

<sup>1</sup> These percentages would also apply to liquid manure broadcast (without incorporation) on bare soils.

<sup>2</sup> These percentages would also apply to liquid manure broadcast (without incorporation) on land with residue, such as direct-seeded fields or forages.

Adapted from AF 2004.



## → summary

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- Liquid manure is either surface applied or injected using tank spreader or drag-hose application systems using several different ground openers.
- Solid manure is typically surface applied using box spreader systems.
- In order to minimize odour and nutrient losses, surface applied manure should be incorporated as soon as possible.
- With the exception of liquid tank spreaders equipped with splash plates, most commonly used application systems will provide acceptable application uniformity when used properly.
- Manure application systems that apply manure to the surface are associated with greater odour concerns and poorer ammonium N conservation. **Ammonium N losses are influenced by the interval** between application and incorporation, as well as climatic conditions.
- To minimize soil compaction, avoid applying manure when soils are most vulnerable to compaction. Alternatively, consider using systems with a lower risk of compaction, such as drag-hose application systems.
- All systems with boxes or tanks that must **be refilled increase the length of time it** takes to apply manure. **Liquid drag-hoses are the most time efficient system because** manure is continuously pumped from the storage to the applicator.