

Low Disturbance Liquid Manure Injection

Is Technology Keeping Up?

As hog production continues to expand on the Prairies, so do land requirements for hog manure application. Independent of this need is the fact that more farmland is being converted to low disturbance seeding (LDS) — a management practice similar to zero-tillage. In 1998, 20 to 25% of all seeded acres in Saskatchewan were planted under LDS, up from an estimated 6% in 1990.

Low disturbance manure injection presents an opportunity to meet the hog producer's need for more land and presents the grain grower with an alternative fertilizer application system.

The recommended method of applying hog manure is to inject it into the soil, reducing odour and surface runoff while minimizing the loss of valuable nutrients to the atmosphere. Research has shown that as much as 30% of the nitrogen can be lost through volatilization.

In addition, since nutrients are present in very low concentrations, hog manure must be applied at very high rates — typically 4,000 gallons or more per acre (GPA) (44,800 litres or more per hectare) to optimize crop benefits. However, actual application rates may exceed annual crop requirements due to transportation costs.



Most of today's manure injection systems are not suitable for use in LDS operations because of the excess amount of the soil surface disturbed during the application. Current LDS guidelines are that no more than 30% of the soil surface should be disturbed.

Therefore, the challenge is to develop a hog manure injection system that satisfies both concerns — the ability to inject high volumes of slurry into the soil without pooling on the surface while causing a minimum of soil disturbance.

At a Glance

What: Testing seven different soil openers for their ability to inject liquid swine manure.

When: Fall, 1997, and Spring, 1998

Where: Saskatchewan

Objectives: Measure opener ability to effectively inject high volumes of hog manure while satisfying the 30% soil disturbance guideline for LDS.

Conditions: Typical wheat stubble. Stubble height was not a critical factor affecting performance. Soil type was loam, soil moisture ranged from moist to wet.

Considerations: Readers of this report should keep in mind that only one of the openers tested is designed for high volume LDS swine manure injection. The other commercially available openers are seeding and fertilizing openers that were judged to have potential for LDS swine manure injection. One opener was modified by PAMI; two were designed and built by PAMI for this project. ***Lack of opener performance in high volume LDS manure injection is not a reflection on the opener's ability to seed or band commercial fertilizer.***

Costs: A comparison of costs between the different openers used in this project is not relevant, since only one of the units tested is designed for high volume LDS manure injection.

During the fall of 1997 and spring, 1998, PAMI tested seven openers for their ability to effectively inject high volumes of hog manure while satisfying the 30% soil disturbance guideline for LDS. While most of the openers tested were relatively efficient at injecting manure, only one stayed within the 30% soil disturbance guideline. The wide blade sweep by Haybuster disturbed only 25% of the soil surface, but because of its high degree of subsurface disturbance, it was considered unsuitable for LDS operations.

Readers should note that new and innovative openers are being developed on a regular basis. The following is an assessment of the openers as they performed during the tests.

The Project

The seven openers tested included Bourgault mid-row bander (also in a PAMI-modified version), Dutch coultter, Yetter Avenger coultter, PAMI's inverted "T" and diamond point openers, a hollow wing sweep by Harvest Technologies and Haybuster's 32" (80 cm) wide blade.

The openers were adapted for use on PAMI's field-scale heavy-duty cultivator. A 300 gallon (1 400 litre) tank was mounted on the cultivator and connected to a pump and manifold which delivered the fluid to the openers. Water was used as the liquid.

Some minor modifications were made to most of the openers to adapt them to fluid delivery. The only major modification was the fabrication of a dual delivery manifold for the wide blade sweep to distribute fluid evenly behind the blade.

Each system was tested for a variety of application rates. Flow rates were controlled by a combination of throttling the flow to the openers and by adjusting ground speed. Fluid application rates ranged from 3,000 to 28,000 GPA (33,600 to 313,600 l/ha), although application rates over 12,000 GPA (134,400 l/ha) are generally not recommended due to excessive nutrient application.

Each opener was tested for injection efficiency (the amount of liquid appearing on the soil surface behind the opener), the percentage of the soil surface disturbed, residue retention and residue clearance. Except for the 32" (80 cm) wide blade sweep system, application rates for all openers were calculated based on a 12" (30 cm) spacing.

The tests were conducted on typical wheat stubble near Humboldt and Leroy, Saskatchewan. Residue clearance and trash cutting was not a problem with any of the openers.

Injection Efficiency and Soil Disturbance Ratings

Rating	Liquid Pooling ¹	Liquid Visible ²	Soil Disturbed ³
Excellent	0	0 to 5%	0 to 30%
Good	0	6 to 50%	31 to 50%
Fair	1 to 10%	51 to 100%	51 to 75%
Poor	more than 10%	51 to 100%	76 to 100%

1. Percentage of the total soil surface covered with liquid immediately after the injection.

2. Percentage of the furrow itself covered with liquid immediately after the injection.

3. Percentage of the soil surface covered by loose soil and lumps after the injector passes.

The Results

Bourgault Mid-Row Bander

This commercial fertilizer banding opener uses a single 19" (48 cm) disc operating at a slight angle to the direction of travel. The disc was set to its maximum soil penetration, which was limited to 3.5 to 4.0 inches (9 to 10 cm) by the amount of tension available from the standard spring.

The opener provided good injection efficiencies at the 3,000 and 6,000 GPA (33,600 and 67,200 l/ha) rates. However, at applications of 9,000 GPA (100,800 l/ha) and above, injection efficiencies were poor with 50% or more of the liquid pooling on the soil surface.

Soil disturbance rated from good to fair (42-75%) depending on ground speed. Residue retention was good, leaving enough standing stubble for good snow trapping.



Bourgault mid-row bander

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Bourgault Mid-Row Bander (Modified)

The standard coulter tension spring was replaced with a heavier spring, allowing soil penetration to 4.75 inches (12 cm). (Readers should note that this modification is not recommended by the manufacturer.) The result was better injection efficiencies: excellent at 3,000 and 6,000 GPA (33,600 and 67,200 l/ha) and good at 9,000 (100,800). It was not tested at higher application rates.

Dutch Coulter

This commercial seeding or fertilizer banding opener uses a single 18" (46 cm) disc that travels at a slight angle to the direction of travel. It is equipped with a rubber closing wheel. Optional packer wheels are available but were not used in this test. The disc was tilted from its vertical axis to maximize the soil opening. The maximum depth of penetration is limited to 4 inches (10 cm) by the disc/hub design.

At 3,000 GPA (33,600 l/ha), injection performance was good; at 6,000 (67,200) performance was only fair with about 10% pooling and 65% of the liquid visible in the furrow. At application rates above 6,000 GPA (67,200 l/ha), injection efficiencies were poor with more than 40% of the liquid pooling on the surface.

Soil disturbance ranged from good to fair, depending on ground speed. Enough stubble was left standing for good snow capture.



Dutch coulter

Metric Conversion Table

Gallons per Acre	Litres per Hectare (Rounded to nearest hundred)
3,000	33,600
6,000	67,200
9,000	100,800
12,000	134,400
14,000	156,800

Rule of Thumb

A typical manure sample contains about 30 lbs/1000 imperial gallons (15 kg/5000 l) of total nitrogen (N). Of the total N, about 50 to 75 per cent is available in the first year. Therefore, assuming an average of 62.5% of N is available in the first year, then 4000 GPA (44,800 l/ha) yields 75 lbs/ac of available N in year one:

$$(30 \times 0.625 \times 4 = 75)$$

Yetter Avenger Coulter

The Yetter Avenger is built specifically for manure injection. It has a large 25" (63 cm) coulter that, in combination with its heavy-duty construction, allows it to penetrate the soil up to a depth of 9 inches (23 cm). However, this opener requires heavy down-force to achieve penetration in excess of 5 in (12.5 cm).

The system uses a rubber closing wheel on the side of the coulter as well as optional paired discs designed to move the soil back over the furrow behind the coulter. Since the injector worked well without the paired discs, they were not used in this evaluation.

The system produced excellent injection efficiencies at all application rates up to, and including 14,000 GPA (156,800 l/ha) when injected at 7 inches (18 cm), and good ratings up to 6,000 GPA (67,200 l/ha) at a depth of 4 inches (10 cm). It was rated as poor at an application rate of 28,000 GPA (313,600 l/ha).

At speeds ranging from 1 to 3 mph (1.6 to 5.0 km/h), soil disturbance was more than the ideal 30% preferred by low disturbance seeders. But at 42%, it was rated good, ranking among the best of all the systems tested in terms of soil disturbance.

Residue retention was good with sufficient stubble standing for good snow trapping.

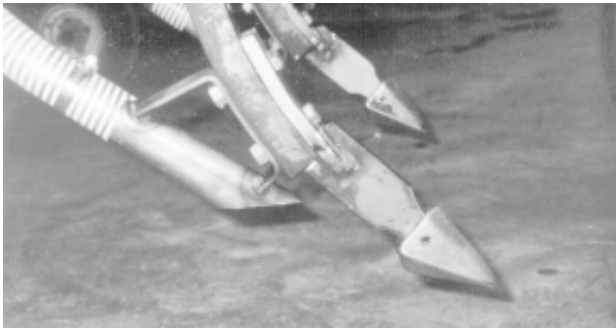


Yetter Avenger manure injector

Diamond Point Opener

This PAMI-fabricated diamond-shaped opener bolts to a standard cultivator shank.

The opener was tested at 9,000 and 14,000 GPA (101 100 and 157 200 l/ha). Injection efficiency ranged from good to fair, respectively. The percentage of soil disturbance rated poor with in excess of 80% of the soil covered with loose soil and lumps. Testing was discontinued due to high soil disturbance.



Diamond Point bolt-on opener

Inverted "T" Opener

This 8 inch (20 cm)-wide shovel opener consists of low-lift wings attached to a Bourgault knife opener. It was also fabricated by PAMI.

While the injection efficiency was excellent at 9,000 GPA (100,800 l/ha), good at 12,000 (134,400) and fair at 24,000 (269,500), soil surface disturbance ranged from 75%, 67% and 58% respectively as a function of travel speed. Because of the amount of soil disturbance, further testing was not conducted.



Inverted "T" opener

Did You Know?

Surface application of manure wastes as much as 30 per cent of the nitrogen found in manure slurry. Injection on the other hand, reduces odour, surface runoff, and minimizes the loss of valuable nutrients to the atmosphere.

Harvest Technologies Hollow Wing

The hollow wing is a bolt-on seeding opener with a 1 inch (2.5 cm) vertical section and a 4 inch (10 cm)-wide hollow shovel. The liquid discharges through the rear of the hollow wing.

The injector was tested at speeds from 0.5 to 4.8 mph (0.8 to 7.8 km/h) with flow rates ranging from 3,000 to 13,000 GPA (33,600 to 145,600 l/ha). Penetration depths varied from 3.0 to 4.75 inches (7.5 to 12 cm).

Injection efficiency was excellent in all cases with no liquid pooling and only minimal, if any, liquid visible in the furrow. However, the degree of soil surface disturbance ranged from 75% to 100%, depending primarily on speed of travel. This is considered too high for LDS.



Harvest Technologies hollow wing

Haybuster Wide Blade

This implement is a 32" (80 cm)-wide, low-lift blade similar to a Noble blade. A dual delivery manifold was fabricated to deliver the fluid along both sides of the blade.

At 1 mile per hour (1.6 km/h), the Haybuster injected 12,000 GPA (134,400 l/ha) at a depth of 4 inches (10 cm) with excellent results. There was no surface pooling or fluid visible in the furrow.

All of the soil above the blade was lifted and then settled as the blade passed. This feature retains surface residue, and is ideal as a means of residue retention with tillage. However, direct seeding systems depend on reduced soil disturbance as a means of preventing weed germination and improving water infiltration rates. For these reasons the



Haybuster Wide Blade sweep

Haybuster wide blade was not tested further, but would work well in a reduced tillage fallow situation.

Recommendations

With the continued expansion of the hog industry and further adoption of LDS, there is a need to develop commercially available low disturbance injection systems. This research project shows that it's possible to inject large volumes of swine manure in a manner consistent with a low disturbance system. Further development of low disturbance manure injection systems will result in commercially available LDS injection equipment.

However, manufacturers are needed to develop a commercially available LDS for high volume manure injection. Based on PAMI's experience with LDS, we suggest manufacturers take into consideration the following recommendations when developing commercially available swine manure injection equipment:

1. Durability is a major factor for soil engaging tools. Injector designs must take into account field speeds and terrain characteristics, such as rocks and stones.
2. Buyers are looking for turn-key systems, as opposed to components. Combining good designs for low disturbance openers, distribution manifolds, and tool bars will allow customers the option of purchasing an equipment package.

Need More Detail?

For a detailed engineering report (22 pages) on this topic, contact PAMI and ask for RH0697. A charge will apply.

Glossary of Terms

GPA: Imperial Gallons Per Acre

Injection Efficiency: A measure of the amount of liquid appearing on the soil surface behind the opener

l/ha: Litres per hectare

LDS (Low Disturbance Seeding): The practice of seeding the new crop directly into the undisturbed stubble of the previous crop with seed-row openers designed to disturb no more than 30% of the soil surface. Very similar to zero-tillage.

Pooling: The accumulation of the injected liquid on the soil surface. In these tests, pooling was measured as the percentage of the total soil surface area covered by liquid.

Soil Disturbance: The percentage of the entire soil surface area disturbed by the opener plus the area covered with loose soil and lumps thrown from the opener.

Volatilization: The vaporization of a liquid, similar to evaporation.

Manure Management and PAMI

PAMI has an nine year history of research and development work in swine manure management issues. A list of highlighted projects appears below. An additional nine new manure related projects are in progress. Consult our web site (www.pami.ca) for a complete up to date listing.

Lagoon Odour Control:

RH0290, Development of Application Methods for Manure Lagoon Coverings

RH0390, Straw Flootation Methods

RH0391, Lagoon Covering Feasibility Study

RH0292, Lagoon Covering Field Study

RH0193, Bale Applicator

RH0493, Bubble Pack Lagoon Cover

Research Update #698, Hog Lagoon Odour Control (a summary report of RH0390, RH0391, & RH0292 above)

Manure Removal:

RH0293, Development of Agitator Pumpout Device

RP0494, Manure Lagoon Sampling and Fertilizer Determination

RH0896, Development and Demonstration of a Pitsweep Manure Agitator

Manure Application:

RP0394, Pipelining Manure

Research Update #729, A Guide to Pipeline Manure Injection Systems

RP0995, Hog Manure Application Techniques

DH5794, PAMI Manure Injector

Research Update #732, A Slurry Injection System for an "Off-the-Shelf" Cultivator

RH1096, Sustainable Application of Manure for Crop Production (in progress)

AP2397 and **RH0397**, Shallow Injection of Hog Manure on Grassland (in progress)

AP2797, Manure Management Manual (for producers, in progress)

Research Update #730, A Guide to Swine Manure Management Methods

General Manure Management:

DH0391, Economic Analysis of Manure Disposal

AP2297, APMETHCO, a Manure Management Module, a computerized decision making tool for determining whether to hire a manure contractor or buy manure management equipment.* (\$25.00 CDN)

Summary of Results

Only one of the openers PAMI tested is designed for high volume Low Disturbance Swine (LDS) manure injection. The other commercially available openers are seeding and fertilizing openers that were judged to have potential for LDS manure injection. One opener was modified by PAMI; two were designed and built by PAMI for this project. ***Lack of opener performance in high volume LDS manure injection is not a reflection on the opener's ability to seed or band commercial fertilizer.***

Bourgault Mid-Row Bander

Injection: good at 3,000 and 6,000 GPA (33,600 and 67,200 l/ha); poor at 9,000 GPA (100,800 l/ha) and higher.

Soil disturbance: measured at 42 to 75%, rated fair to good, depending on ground speed.

Bourgault Mid-Row Bander (Modified)

Modified to allow deeper soil penetration.

Injection: excellent at 3,000 and 6,000 GPA (33,600 and 67,200 l/ha); good at 9,000 (100,800). Not tested at higher rates.

Soil disturbance: same as the unmodified version, 42 to 75%, rated fair to good, depending on ground speed.

Dutch Coulter

Injection: good at 3,000 GPA (33,600 l/ha), fair at 6,000 (67,200) and poor above 6,000 (67,200).

Soil disturbance: measured at 42 to 58%, rated fair to good, depending on ground speed.

Yetter Avenger Coulter

Designed specifically for manure injection.

Injection: excellent for all rates up to and including 14,000 GPA (156,800 l/ha).

Soil disturbance: measured at 42%, rated good.

Inverted "T" Opener

This opener was fabricated by PAMI

Injection: excellent at 9,000 GPA (100,800 l/ha), good at 12,000 (134,400) and fair at 24,000 (268,800).

Soil disturbance: measured at 58 to 75%, rated fair, depending on ground speed.

Diamond Point Opener

This opener was fabricated by PAMI

Injection: good at 9,000 GPA (100,800 l/ha); fair at 14,000 (156,800).

Soil disturbance: measured in excess of 80%, rated poor.

Harvest Technologies Hollow Wing

Injection: excellent at rates up to 13,000 GPA (145,600 l/ha).

Soil disturbance: measured at 75% to 100%, rated poor.

Haybuster Wide Blade

Tested only at 12,000 GPA (134,400 l/ha)

Injection: excellent

Soil disturbance: While only 25% of the actual soil surface was disturbed, the entire soil column above the blade was disturbed. Rating: poor.

Acknowledgments

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