Methods of Reducing Odors by Plowing or Injecting Liquid Manure into the Soil

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Although some people might claim that the odor from one type of manure or another during land spreading is not overly unpleasant, there are people who may or may not be familiar with manure odors, that do not agree with these claims. The prolonged odor from manure spread on the land surface can be unpleasant, and in some cases, an intolerable nuisance to nearby rural and urban neighbours of medium to large scale livestock farms (and sometimes to the farmers wife and family). The odor problem from animal manure has therefore received considerable attention recently and three principal courses of action to alleviate this problem are recognized:

1. Provide adequate separation distance between neighbours and the land spreading area to allow dilution of unavoidable odors.

2. Aerobic processing of stored manure to produce an essentially odor-free product for land spreading.

3. Direct incorporation of odorous manure into the soil from an enclosed transport vehicle to allow natural processing in the soil.

This paper is limited to two methods of placing liquid manure into the soil as quickly as possible from an enclosed tanker to minimize the odor nuisance during the land application operation. Methods and equipment have not been developed to minimize the odor nuisance during the land application of solid and semi-solid manure to the same degree as they have for liquid manure; spreading when the wind direction is away from nearby neighbours and plowing under these types of manure, for example, during the same day that they are spread on the land, is the best available recommendation for odor control. An additional benefit to be gained from rapid placement into the soil is the reduced potential for manure washing from fields when surface runoff occurs.

There are two major objectives that should be met by any soil incorporation method:

1. The provision of adequate coverage of manure to ensure odor control, and

2. limiting the rate of manure application (in tons per acre) to avoid the pollution of local groundwater supplies.

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Rapid Cover by the Plow-down Method

This method was introduced several years ago by C. H. Reed, Department of Agricultural Engineering, Rutgers University, New Brunswick, New Jersey. In Reed's system, the liquid manure flows from the tanker into a plow furrow and is then covered by a mold board plow mounted on the tanker or pulled separately. Placement of manure in a single furrow results in a slow field operation and slow rate of manure disposal, unless high application rates are made by placing a considerable depth of manure in the furrow. Reed was able to cover one and one half to two inches of manure in the furrow which is equivalent to a land application rate of 170 to 225 tons per acre. The two main disadvantages with this particular system are the requirements for considerable modifications to existing tankers and the excessively high rates of application that would be necessary to maintain a reasonably high rate of manure disposal.

A comparable type of system was developed in 1970 by the Engineering Research Service for the Animal Research Institute (ARI) Greenbelt Farm as a solution to the odor nuisance to the nearby urban populace created by conventional spreading methods. Neighbours seem satisfied with this improved method of land application. A simple metal hood (Figure 1) is fitted to the rear outlet pipe of a tractor-drawn, vacuum-type tanker to deflect the manure downward into a 48 to 50-inch swath. A second tractor with wheels set 60 inches apart to straddle the swath of manure, tows a 4-bottom, 16-inch mold board plow (64-inch coverage) immediately behind the tanker and covers the manure swath within several seconds. The swath width is purposely less than the plow width to ensure coverage of manure that tends to spread out to some degree.

This system minimizes the modification of existing equipment. The tractor and plow require no modification other than setting the tractor wheel tread. An inexpensive hood is attached to each vacuum tanker using the same type of fitting as on the filler hose. No excessive time delays in the manure handling operation are caused by this equipment. For the ARI Greenbelt Farm operation where the majority of manure from 800 dairy cattle, 1500 sheep and 40,000 poultry is exclusively handled by this system, 4 to 5 tankers are used which can make a round trip in about fifteen minutes to field adjacent to the barns. This time increases when the transport distance increases and when there are other causes for delay at the barn. One limitation of this system for the majority of farm operations smaller than those at the Greenbelt Farm, is the greater amount of tractor and plow operating time lost while waiting in the field for a lesser number of tanks. However, this problem can partially be minimized by pooling the equipment from two or three neighbours.

The width of the manure swath and hence the width of plowing is set by the maximum width that the tractor wheels can be set to straddle the manure. Concentration of manure within a 64 inch width results in higher

application rates than those with conventional spreading. However, as shown in Table I, by decreasing the flow (smaller tanker outlet and less tanker pressure) and spreading the same material over more area (greater ground speed), a presently acceptable application rate below 40 tons per acre can be achieved.

TABLE I. MANURE APPLICATION RATES FOR PLOW-COVER SYSTEM, TONS PER ACRE (BASED ON 64-IN. PLOW WIDTH)

Tanker outlet size and pressure	Tanker forward speed		
	2 mph	3½ mph	5 mph
6-in. outlet:			
full pressure	160	90	65
low pressure	115	65	45
4-in. outlet:			
high pressure (3½ psi)	130	75	52
low pressure (2¼ psi)	100	55	40
3-in. outlet:			
high pressure (3 psi)	80	45	32
low pressure	56	32	22
gravity flow (impractical)	37	21	15

From "A Plow-down method for rapid cover of liquid manure" by M. Feldman and F. R. Hore. Can. Agr. Eng. Vol. 13, No. 2, Dec. 1971, pages 65-68.

Soil Injection of Liquid Manure

The injector system holds the greatest potential for odor control, for prolonging the time period of application in the spring (such as inter-row application in corn), for achieving an acceptable rate of application, and as a method of incorporating manure into hay and pasture without completely destroying the crop.

Work with soil injectors by the Engineering Research Service has been concerned with evaluating the operation of two manufacturers injectors under local conditions at the ARI Greenbelt Farm. Basic work on injection was not considered necessary since researchers at Pennsylvania State University and Rutgers University and several equipment manufacturers have actively developed such units. Table II lists seven known North American manufacturers of injector units. All of these units are designed for mounting at the rear of the tanker except the Grose Welding Co. machine which is a trail-behind unit. The liquid manure, usually under some pressure, flows from the tanker through flexible tubing leading to rigid

tubes attached to the rear of the soil opening shank.

Initial work was done in 1970 with a Sahlstrom trailing type, 4-row injector which was modified for 3-point hitching to a tractor. This unit was not equipped with a leading coulter to cut plant roots nor with rear-mounted covering devices. Operating trials with this unit revealed the following problems:

1. Draping of fibrous plant material over the soil-engaging portion of the injector, particularly in moist soil conditions, caused wide furrows in the soil and left the manure uncovered. Adaption of coulters helped considerably, but they could not be of adequate size due to space limitations with the three-point hitch set-up.
2. Coverage of the manure was imperfect due to the soil that was pushed aside by the passage of the shank. Makeshift covering devices were adapted that brought enough soil back into the furrow to give adequate coverage.
3. Penetration in firm soil conditions was not possible. Stiffer shanks, with a release mechanism for stones, would offer potential usage in a wider range of soil conditions. These observations indicated that successful operation would require a front cutting coulter, rear covering devices, and sufficient weight on relatively rigid shanks to achieve soil penetration.

TABLE II. MANUFACTURERS OF SOIL INJECTORS FOR LIQUID MANURE

Avco New Idea Farm Equipment Div., Coldwater, Ohio. 45828.
Badger Northland Inc., Kaukauna, Wisc.
Clay Equipment Corp., Cedar Falls, Iowa. 50613.
Grose Welding Ltd., Alma, Ont.
Lely Ltd., P. O. Box 5023, Burlington, Ont.
Pearson Bros. Co. Inc., P. O. Box 192, U.S. Rt. #34 East, Galva, Ill. 61434.
Sahlstrom Mfg. Co., 422 Main St., Box 589, Bennington, Vermont 05201.

As indicated above, there is usually a limited amount of time available for manure application in the spring before crop seeding time; a unit that would successfully inject manure between corn rows after seeding would prolong the period of application by two to possibly four weeks.

A series of injection trials in a corn crop were therefore conducted in the spring of 1972 using the Grose trail-behind, 3-row injector. The unit is not equipped with front coulters nor rear covering devices, and the injector shank spacing of 36 inches is non-adjustable. The purpose of these trials was to determine the manure application rate, and to further investigate additional equipment requirements for operation mainly in a corn crop grown in both medium and fine textured soils. During these trials, front coulters were not used, but different covering devices were mounted behind each of the three injector shanks to evaluate their performance. These devices were two types of paddles commonly used on anhydrous ammonia applicators, and the third was a pair of discs. Early trials showed that soil penetration was a problem in clay soil even with the abundance of soil moisture present this year; therefore, 200 pounds of additional weight were added to the unit.

It is difficult to draw sound conclusions from the limited number of trials that could be performed during the early stages of corn growth, but observations showed the following:

1. Injection can be done up to the time that the corn is 12 to 15 inches in height using this injector.

2. In 1972, injection in a corn crop could be performed over a 5 week period, from May 26, when the corn rows were clearly seen, to June 30, when the corn was 12 to 15 inches high.

3. There is no apparent difference between corn that received injected manure and corn that received commercial fertilizer. This could be due to the near high record for rainfall this summer.

4. This trail-type injector would require considerable additional weight to achieve penetration under dry clay soil conditions.

5. Front coulters to slice an opening for the injector shank were not required under these field conditions.

6. Once the three types of covering devices were properly adjusted, they all provided adequate cover, but the pair of discs appeared to be more positive in their covering action than the paddles.

7. It will likely be difficult to obtain proper coverage when the injection depth is less than 5 to 6 inches. Also, with a 3-row injection unit, the tractor and tanker wheels compact the two outside injection rows; the soil level of these rows will dictate the level at which the injector unit should be set.

8. Three-row injectors will match corn rows planted with a four-row planter, but if this match is maintained, one inter-row space out of four will not receive injected manure. If injection in every row is attempted, there is danger of ripping out or covering

portions of some unevenly spaced rows because of the difficulty in maintaining a uniform spacing between the "four-row multiples".

9. The field trials in a sod field indicated that coverage was inadequate without the covering devices.

10. Manure application rates below 40 tons per acre were readily achieved. Similar factors to those given for the plow-down method (the forward speed and the tanker pressure) affect the application rate. In clay soils and under the same tanker pressure conditions, the rate could be varied from about 30 tons per acre at a forward speed of 2 3/4 miles per hour down to less than 20 tons per acre at 4 1/4 miles per hour. Reduction in tanker pressure by reducing the tanker pump speed, reduced the application rate to below 10 tons per acre. Similar results were obtained in sandy soil except that the application rate was about 40 tons per acre at a forward speed of 2 3/4 miles per hour.

11. A 95-horsepower tractor was used for all these trials. This amount of power was adequate, and although it was not possible to check the actual horsepower utilized, it is estimated that 70 to 75 horsepower would have been sufficient.

In summary, observations to date indicate that considerably more field experience with existing injector units is needed to establish the range of soil and moisture conditions for which each unit is suitable. A comprehensive field testing program is required to establish facts and show where modifications and new developments are required. Once any needed refinements have been made and the successful operation of injectors demonstrated for a wide range of conditions, greater farmer acceptance can be expected.

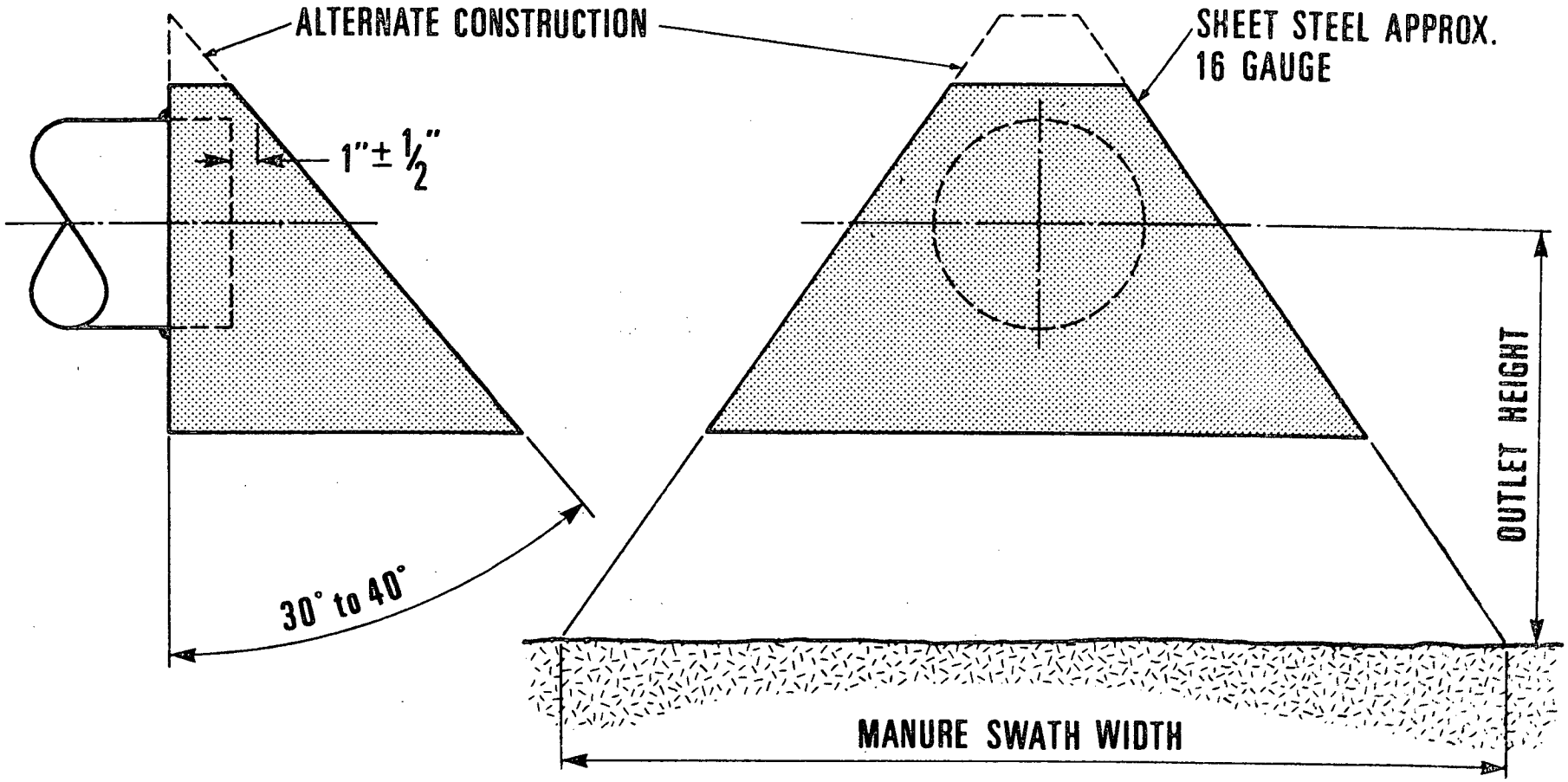

FIGURE 1. SPREADER HOOD DESIGN

(From "A Plow-down method for rapid cover of liquid manure" by M. Feldman and F. R. Hore. Can. Agr. Eng., Vol. 13, No. 2., Dec. 1971, pages 65-68.)