THE OHIO STATE UNIVERSITY EXTENSION

FACT SHEET

Agriculture and Natural Resources

Guidelines for Applying Liquid Animal Manure to Cropland with Subsurface and Surface Drains

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Liquid animal manure is a valuable source of nutrients and organic matter for crop production and can be applied by a variety of methods including spray irrigation, land surface spreading, and shallow subsurface injection. Because of relatively low nutrient concentration, liquid animal manure may be applied at relatively high volumes, but it is generally recommended that it not be applied at rates that exceed the soil infiltration rate, nor exceed the amount needed to bring the soil to field water holding capacity (Johnson and Eckert, 1995). Even when similar guidelines are followed, liquid manure discharges from agricultural drains has been reported in soils with subsurface drainage due to macropore flow (Geohring et al., 2001).

Application of liquid animal manures to soils with subsurface drainage has been linked to contamination of the effluent with nutrients (Cook and Baker, 2001; Geohring et al., 2001), particulate organic matter (Barkle et al., 1999), estrogens (Burnison et al., 2003), bacteria (Bicudo and Goyal, 2003; Cook and Baker, 2001; Dean and Foran, 1992; Jamieson et al., 2002; Joy et al., 1998), and antibiotics (Kay et al., 2004).

Figure 1. Liquid effluent contaminating surface water. (Photo courtesy of Rick Wilson, OEPA)

These findings are not universal, however, as liquid animal manures can be applied without any detectable adverse effects on water quality. For instance, Randall et al. (2000) noted no difference in nitrogen, phosphorus, or fecal indicator bacteria losses in drainage effluent when comparing plots fertilized with liquid dairy manure and mineral fertilizer. The fact that liquid animal manure nutrients can be safely land recycled in some instances, but are discharged in subsurface drainage water under different circumstances, suggests a complex system that needs to be managed. Soil texture, available water holding capacity, tillage history, as well as the type and quantity of manure applied, application method, and timeliness of rainfall after application may all play a role in determining the fate of the manure.

Liquid Manure Applied to Subsurface-Drained Cropland

The available water holding capacity of the upper 8 inches of the soil provides an estimate of the maximum volume of water that can be applied before additional water, manure, and nutrients may begin to move through the soil profile (refer to Table 1). Manure application rates may need to be adjusted the day of application to avoid

Maximum Available Water Holding Capacity of Soils

Table 1: Available Water Capacity (AWC) Practical Soil Moisture Interpretations for Various Soils Textures and Conditions to Determine Liquid Waste Volume Applications not to exceed AWC.

This table shall be used to determine the AWC (upper 8 inches) at the time of application and the liquid volume in gallons that can be applied not to exceed the AWC. To determine the AWC in the upper 8 inches use a soil probe or similar device to evaluate the soil to a depth of 8 inches. The manure application rates should be less than AWC to reduce the potential for contaminated runoff.

Available Moisture in the Soil	Sands and Loamy Sands	Sandy Loam and Fine Sandy Loam	Very Fine Sandy Loam, Loam, Silt Loam, Silty Clay Loam, Clay Loam, Sandy Clay Loam	Sandy Clay, Silty Clay, Clay
< 25% Soil Moisture	Dry, loose and single-grained; flows through fingers.	Dry and loose; flows through fingers.	Powdery dry; in some places slightly crusted but breaks down easily into powder.	Hard, baked and cracked; has loose crumbs on surface in some places.
Amount to Reach AWC	20,000 gallons/acre	27,000 gallons/acre	40,000 gallons/acre	27,000 gallons/acre
25–50% or Less Soil Moisture	Appears to be dry; does not form a ball under pressure.	Appears to be dry; does not form a ball under pressure.	Somewhat crumbly but holds together under pressure.	Somewhat pliable; balls under pressure.
Amount to Reach AWC	15,000 gallons/acre	20,000 gallons/acre	30,000 gallons/acre	20,000 gallons/acre
50–75% Soil Moisture	Appears to be dry; does not form a ball under pressure.	Balls under pressure but seldom holds together.	Forms a ball under pressure; somewhat plastic; slicks slightly under pressure.	Forms a ball; ribbons out between thumb and forefinger.
Amount to Reach AWC	10,000 gallons/acre	13,000 gallons/acre	20,000 gallons/acre	13,000 gallons/acre
75% to Field Capacity	Sticks together slightly; may form a weak ball under pressure.	Forms a weak ball that breaks easily, does not stick.	Forms ball; very pliable; slicks readily if relatively high in clay.	Ribbons out between fingers easily; has a slick feeling.
Amount to Reach AWC	5,000 gallons/acre	7,000 gallons/acre	11,000 gallons/acre	7,000 gallons/acre
100% Field Capacity	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.
Above Field Capacity	Free water appears when soil is bounced in hand.	Free water is released with kneading.	Free water can be squeezed out.	Puddles: free water forms on surface

Ohio-NRCS Conservation Practice Standard 633.

Figure 2. Control structures and tile stops reduce surface water contamination if properly installed. (Image courtesy of Agri-Drain, Adair, IA)

reaching the available water holding capacity of the soil and is one factor determining the maximum volume that should be applied. Application rates should not exceed the lower of the nutrient restriction, available holding capacity of the soil or 13,000 gallon/acre. Smaller multiple low applications allow the soil to absorb liquid animal manures better than one large application.

Additional suggested guidelines to minimize the downward movement of liquid manure are:

a. Identify subsurface drain outlets, and control or regulate discharge prior to application, or have on-site means of stopping the discharge from subsurface drains. Subsurface drainage outlets should be monitored before, during, and after application for potential liquid manure discharge. Drainage control structures and inline tile stops are recommended control practices to reduce the risk of a discharge, while tile plugs may be used in emergency situations but have been known to fail (Hoorman, 2004). Use caution not to back-up water where it may impair the functioning of an adjacent subsurface drainage system. Develop a contingency plan to handle situations when liquid manure discharges to ditches or streams.
b. Liquid manure should not to be applied on soils that are prone to flooding, as defined by the National Cooperative Soil Survey (or in the Flooding Frequency Soil List posted in Section II eFOTG), during the period when flooding is expected. Manure can be applied if incorporated immediately or injected below the soil surface during periods when flooding is not expected.
c. Avoid applying manure when rainfall is predicted, eminent, or directly after a rainfall event. After a significant rainfall event, the site should be allowed to drain to below field capacity, so that the soil has the capacity to absorb additional water or liquid animal manure. As part of the manure application recordkeeping, maintain a log of weather forecasts and actual weather conditions 24 hours before and after a manure application event.
d. Repair broken drains and blowholes prior to application, and follow recommended/required minimum setback requirements (setback distances vary from state to state) for surface inlets. See fact sheet on Liquid Manure Application Rates for Subsurface and Surface Drained Cropland.
e. Liquid manure should not be applied to subsurface drained cropland if the drains are flowing. Generally, flowing subsurface drain indicate soil moisture levels that are near or exceeding the soil water holding capacity. The addition of liquid manure under these conditions will increase the probability of manure moving downward and discharging through these drains or moving overland as surface runoff.
f. Application rates should be closely tied to nutrient requirements and available holding capacity of the soil. The method of application can influence application rates. For example, with an injection toolbar with four nozzles on 30-inch spacing, each knife and nozzle produces a concentrated application to a small area. Under these concentrated flow conditions, the effective rate differs considerably from an average application

Figure 3. Field prone to flooding. (Photo courtesy of Norm Widman, NRCS)

Figure 4. Avoid applying liquid animal wastes to saturated soils. (Photo courtesy of Rick Wilson, OEPA)

Figure 5. For the most effective application, liquid manure should be applied shallow and uniformly into the soil surface. (Photo courtesy of Jon Rausch, The Ohio State University).

Figure 6. A Paulding clay soil with high shrink swell capacity may need to be tilled before application, and/or smaller initial liquid applications to help close the cracks. (Photo courtesy of Jim Lopshire, The Ohio State University).

rate. The effective rate is calculated as the volume of manure applied per unit area per nozzle. For example, assume a 10,000 gallon/acre application rate, an injection toolbar with 30-inch spacing and 6-inch sweeps, the effective rate is 50,000 gallon/acre, five times greater than a uniform even distribution over an acre.

g. Liquid manure should be applied in a manner that will not result in ponding, or runoff to adjacent property, drainage ditches, or surface water regardless of crop nutrient need; and should be uniformly applied at a known rate. Liquid animal manure applications using irrigation or surface application equipment tend to have a greater risk of ponding.

h. Fields with a history of downward movement of manure and/or bare/crusted soils may require some tillage to improve infiltration and absorption of the applied liquid. Prior to manure application, use shallow tillage to disrupt the continuity of worm holes, macropores and root channels (preferential pathways) to reduce the risk of manure reaching drain lines, or till the surface of the soil 3 to 5 inches deep to a condition that will enhance absorption of the volume of liquid manure being applied. This is especially important if shallow drains are present (< 2 feet deep). Any pre-application tillage should leave as much residue as possible on the soil surface to minimize soil erosion.

i. Clay soils with a high shrink swell capacity tend to have larger deeper cracks during dry conditions. These soils may require tillage to disrupt the cracks and macropores, and a lower initial application rate applied to the soil to help close the cracks. Cover crops may be planted to improve soil structure and absorb available manure nutrients. Determine the most limiting application rate based on the field conditions and nutrient limitations (may vary from state to state).

j. Shallow injection is recommended for liquid manure. Till the soil at least 3 inches below the depth of injection prior to application, and/or control outflow from all drain outlets prior, during, and after manure application.

k. For perennial crops (hay or pasture) or continuous no-till fields where tillage is not recommended, all subsurface drain outlets from the application area should be monitored, and if manure laden flow should occur, all effluent should be captured. Crops with deep tap root systems (alfalfa) tend to have more problems than hay crops with fibrous roots (grass) because liquid animal manures may flow along the tap roots to subsurface drains and outlet to surface water.

These criteria may be waived if the producer can verify there is no prior history of manure discharge via subsurface drains, or if a system is in place to capture the discharge. However, if there is a discharge, the producer is liable for damages and is subject to being classified as a Concentrated Animal Feeding Operation (CAFO).

Liquid Manure Applied to Systematic Surface Drained Fields

Fields or areas of fields that have systematic "surface drainage" systems (e.g., shallow surface drains spaced 100 to 200 feet apart—NRCS Surface Drainage-Field Ditch Practice Standard 607) are considered concentrated flow areas. However, if special precautions are taken, manure can be applied in the surface drains with minimal risk of surface runoff. This does not apply to the collector surface drains (mains, ditches, etc.) or drains bordering the fields.

Figure 7. Till the soil 3 to 5 inches deep or 3 inches below the depth of injection to disrupt macropores. (Photo courtesy of Jon Rausch, The Ohio State University)

The following special manure application techniques shall be used:

a. Till the soil surface at least 3 to 5 inches deep ***prior*** to liquid manure surface application. Pre-till within 7 days of application.
b. Surface-apply liquid manure ***uniformly*** over the entire soil surface on the freshly tilled soil (3 to 5 inches) to allow the liquid manure to be absorbed into the soil surface.
c. For fields with no subsurface drainage, liquid manure can be injected directly without prior tillage. If subsurface drainage is present as well as surface drains, then the above recommendations for subsurface drained cropland apply as well.
d. Manure application rates should be adjusted to consider the most limiting factor and include the ability of the soil to accept, store and hold liquid manure, water, and nutrients.

Follow recommended/required setbacks from environmentally sensitive areas for surface inlets. See fact sheet on Liquid Manure Application Rates for Subsurface and Surface Drained Cropland.

Summary

Improved management is a key issue in greatly reducing the potential of liquid manure reaching our surface water. While climate and some environmental conditions cannot be controlled, producers can better manage and control when and how they apply liquid manure. These recommended practices are intended to help producers apply liquid manure in a manner that minimizes the potential to impact water resources through the downward movement of manure into subsurface (tile) drains. These recommendations incorporate the best available knowledge.

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Related Publications

Ohio State University Extension, *Ohio Livestock Manure Management Guide*, Bulletin 604.

Liquid Manure Application Rates for Subsurface and Surface Drained Cropland.

USDA, Natural Resources Conservation Service, Practice Standard 633, Waste Utilization

Livestock and Poultry Environmental Stewardship (LPES) Program, http://www.lpes.org/les_plans.html

http://www.ianrpubs.unl.edu/epublic/live/ec778/build/ec778.pdf

http://www.wy.nrcs.usda.gov/technical/soilmoisture/soilmoisture.html

http://www.ext.colostate.edu/pubs/crops/04700.html

http://www.mt.nrcs.usda.gov/technical/ecs/agronomy/soilmoisture/index.html