Spreading Dairy Waste with Lab Analysis and with Soil Tests

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General information

A primary need and concern for most confinement livestock producers is managing manure so that groundwater and surface water are protected, and regulatory requirements are fulfilled. This objective is usually accomplished by applying manure to the land in such a manner that the potential polluting nutrients (N, P, K and organic matter) are utilized by the soil-plant complex, and are not allowed to enter the ground/surface water infrastructure.

Manure is a fertilizer resource

Manure should be viewed as a fertilizer resource and managed similarly to commercial fertilizer in the fertility program. The occasional practice of meeting fertility requirements with commercial fertilizer, then applying manure in addition “for a good measure,” can easily impact water quality adversely. In general, Missouri waste application regulations are based on the rate of nitrogen application. With this scenario, the phosphorous and potash applied may greatly exceed crop needs. Therefore, optimum utilization of plant nutrients may necessitate applying less nitrogen from waste than the crop needs and buying supplemental nitrogen to balance crop needs. Applying phosphorous to fields with a Bray 1-P test level exceeding 800 pounds/acre may aggravate surface water quality problems.

It is highly recommended that a representative sample of dairy waste be analyzed for nutrient values immediately prior to spreading, in addition to soil tests, before determining the land application rate. The purpose of this publication is to provide guidance for application of waste with the benefit of a lab analysis and a soil test. Other publications in this series address application of dairy waste with other scenarios.

Managing manure as a fertilizer

Unlike commercial fertilizers, manure is a highly variable substance, even within a given animal specie, and variations of 50 percent to 100 percent among test samples are not unusual. Other management considerations peculiar to livestock operations, such as lagoon pumping in the fall to provide storage during winter and spring months, or manure storage tank emptying at whatever intervals are required to prevent overflow, dictate different management than commercial fertilizer which can just be “ordered and spread.”

In contrast to commercial fertilizer, manure has the potential for nutrients (primarily nitrogen in the form of ammonia) to be lost to the atmosphere after field spreading. See MU Publication WQ 202 for a discussion of manure nutrient losses. Table 1 shows the available ammonia nitrogen as a function of time until incorporation into the soil. Table 2 lists the percent of available organic nitrogen available with time. Table 3 gives the percent of various nutrients available for crops.

**Table 1. Manure Ammonia-Nitrogen Loss by Days Until Incorporated into the Soil (unavailable portion is lost to the atmosphere)**

<table>
<thead>
<tr>
<th>Days until Incorporation</th>
<th>Percent of Ammonia-N available for Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>80</td>
</tr>
<tr>
<td>2-4</td>
<td>60</td>
</tr>
<tr>
<td>4-7</td>
<td>40</td>
</tr>
<tr>
<td>&gt;7</td>
<td>20</td>
</tr>
</tbody>
</table>
Table 2. Manure Organic Nitrogen Available by Year.

<table>
<thead>
<tr>
<th>Manure Applied</th>
<th>Percent of Organic-N Available during Current Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Year</td>
<td>40-60</td>
</tr>
<tr>
<td>1 year ago</td>
<td>10</td>
</tr>
<tr>
<td>2 years ago</td>
<td>5</td>
</tr>
<tr>
<td>3 years ago</td>
<td>5</td>
</tr>
</tbody>
</table>

able in the growing season after application.

The following soil test report gives the recommended nutrient application rates for a yield goal of 3 tons/acre of fescue hay. This publication details a procedure for estimating the amount of manure to apply to meet the soil test recommendations for nitrogen by applying dairy waste with a known nutrient analysis. A blank worksheet is included (on page 6).

Table 3. Other minerals and micronutrients available in manure.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Percent of Ammonia-N % available in growing season</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>80</td>
</tr>
<tr>
<td>K</td>
<td>100</td>
</tr>
<tr>
<td>S, Mn, Cu, Zn</td>
<td>80</td>
</tr>
<tr>
<td>Ca, Mg</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIELD INFORMATION</th>
<th>Soil Test Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field #</td>
<td>1/4</td>
</tr>
<tr>
<td>Acres</td>
<td>33</td>
</tr>
<tr>
<td>Sample no.</td>
<td>1-5</td>
</tr>
<tr>
<td>Interpreted</td>
<td>NO</td>
</tr>
<tr>
<td>Last test</td>
<td>01/01/93</td>
</tr>
</tbody>
</table>

Some herbicide labels list restrictions based on soil pH in water. Your sample has an estimated pH in water of 5.3. Use this value as a guide to the label. If you wish to have soil pH in water analyzed, contact your dealer or local Extension specialist listed below. To determine limestone needed in tons/acre, divide your EMM requirement by the guarantee of your limestone dealer. When N requirement for cool season grass exceeds 90 pounds per acre, apply two-thirds in the period December through February and the remainder in August. Do not apply nitrogen on spring seedings of legumes after May 1st. Because of potential weed competition, For alfalfa production, apply 1 lb of boron per acre annually.

A soil test report obtained from University Extension's Soil Testing Laboratory.
Table 4. Laboratory Analysis for Solid Manure and Rate of Past Application

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Nutrient Level, lbs/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>this yr</td>
</tr>
<tr>
<td>Total N</td>
<td>10</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>5</td>
</tr>
<tr>
<td>Organic N</td>
<td>5</td>
</tr>
<tr>
<td>P₂O₅ (Phosphate)</td>
<td>4</td>
</tr>
<tr>
<td>K₂O (Potash)</td>
<td>11</td>
</tr>
<tr>
<td>Application, tons</td>
<td>?</td>
</tr>
</tbody>
</table>

for actual applications.

Note: This approach can not be used if the Department of Natural Resources has issued a letter of approval based on the “conservative approach” of applying not more than 100 pounds of nitrogen per year, regardless of the crop and the production level of the crop.

Examples

A fescue hayfield (soil-plant filter) is available for receiving dairy waste. The accompanying soil test

Worksheet for solid dairy manure

<table>
<thead>
<tr>
<th>Step</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Crop nutrient requirements (from soil test).&lt;br&gt;Crop Fescue yield 3 tons/acre&lt;br&gt;N, lb/acre 120&lt;br&gt;P₂O₅, lb/acre 75&lt;br&gt;K₂O, lb/acre 140&lt;br&gt;</td>
</tr>
<tr>
<td>2.</td>
<td>Available ammonia (NH₄-N) nitrogen.&lt;br&gt;( \text{lb NH₄-N/ton} \times % \text{available} = \text{lb NH₄-N/ton} )&lt;br&gt;(Percent available from Table 1)&lt;br&gt; ( \text{5 lb/ton} \times 0.2 \text{ avail.} = 1.0 \text{ lb/ton} )</td>
</tr>
<tr>
<td>3.</td>
<td>Nitrogen available from this year’s organic fraction.&lt;br&gt;( \text{lb N/ton} \times % \text{available} = \text{available lb N/ton} )&lt;br&gt;(Percent available first year from Table 2)&lt;br&gt; ( \text{5 lb/ton} \times 0.5 \text{ avail.} = 2.5 \text{ lb/ton} )</td>
</tr>
<tr>
<td>4.</td>
<td>Residual nitrogen available from previous years’ organic fraction.&lt;br&gt;(From Table 4: One year ago, 21 tons of dairy waste were applied to the field, 19 tons were applied two years ago, and 22 tons were applied three years ago.)&lt;br&gt;( \text{Tons/acre} \times \text{N/ton} \times % \text{available} = \text{lb N/acre} )&lt;br&gt;(Percent available from Table 2)&lt;br&gt;1 yr ago: 21 tons x 4 lb/ton x 0.10 = 8.4 lb/ac&lt;br&gt;2 yrs ago: 19 tons x 6 lb/ton x 0.05 = 5.7 lb/ac&lt;br&gt;3 yrs ago: 22 tons x 4 lb/ton x 0.05 = 4.4 lb/ac&lt;br&gt;Total = 18.5 lb/ac</td>
</tr>
</tbody>
</table>
| 5.   | Manure application rate to supply nitrogen.<br>(crop N requirement) – (residual N) = application rate<br>(available NH₄-N) + (available organic fraction)

\[
\begin{align*}
\text{application rate} & = \frac{120 - 18.5}{1.0 + 2.5} \\
& = 29.0 \text{ tons/acre}
\end{align*}
\]
| 6.   | Phosphate available at calculated application rate for nitrogen.<br>tons/acre x lb P₂O₅/ton x % available = lb P₂O₅/acre<br>(P₂O₅/ton from Table 5 = 4, % available from Table 3)<br>29.0 tons/acre x 4 lb/ton x 0.8 = 92.8 lb/ac<br>(Note: 92.8 lb/ac of P₂O₅ is applied versus 75 lb/ac recommended by the soil test.) |
| 7.   | Potash available at calculated application rate for nitrogen.<br>tons/acre x lb K₂O/ton x % available = lb K₂O/acre<br>(K₂O/ton from Table 4 = 11, % available from Table 3)<br>29.0 tons/ac x 11 lb/ton x 1.0 = 319 lb/ac<br>(Note: 319 lb/ac of K₂O is applied versus 140 lb/ac recommended by the soil test.) |
Table 6. Laboratory Analysis for Lagoon Effluent and the Rate of Past Application.

<table>
<thead>
<tr>
<th>Nutrient Level, lb/K-gallons</th>
<th>this yr</th>
<th>1 yr ago</th>
<th>2 yrs ago</th>
<th>3 yrs ago</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N</td>
<td>78</td>
<td>66</td>
<td>70</td>
<td>55</td>
</tr>
<tr>
<td>NH4-N</td>
<td>52</td>
<td>44</td>
<td>45</td>
<td>30</td>
</tr>
<tr>
<td>Organic N</td>
<td>26</td>
<td>22</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>P2O5 (Phosphate)</td>
<td>41</td>
<td>33</td>
<td>39</td>
<td>31</td>
</tr>
<tr>
<td>K2O (Potash)</td>
<td>130</td>
<td>110</td>
<td>122</td>
<td>106</td>
</tr>
<tr>
<td>Application, inches¹</td>
<td>?</td>
<td>2.0</td>
<td>2.5</td>
<td>3.1</td>
</tr>
</tbody>
</table>

¹One acre-inch = 27,154 gallons

contains fertilizer recommendations for a yield goal of 3 tons of fescue hay per year from the soil-plant filter area. From the soil test, the following nutrient applications are recommended:

- 120 lb/acre of N
- 75 lb/acre of P2O5
- 140 lb/acre of K2O

Given this information and the laboratory analysis of the dairy waste, how many inches of lagoon effluent, how many gallons per acre of liquid manure (slurry) and how many tons per acre of solid manure should be applied to meet the nitrogen needs of the fescue?

Tables 4, 5 and 6 outline previous years application rates and analyses for solid, liquid and lagoon effluent.

Assume that the waste applied as solid or liquid will not be incorporated into the soil, therefore the loss of ammonia-nitrogen will be 80 percent. Assume that the waste applied as lagoon effluent will be incorporated into the soil within two days after application (by infiltration into the soil), therefore the loss of ammonia-nitrogen will be only 20 percent.

**Solid manure**

The laboratory analysis (see Table 4) for solid manure is available for present and past years with the rate of application for the past three years. Given this information, complete the solid manure work-

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**Worksheet for liquid dairy manure**

1. Crop nutrient requirements (from soil test).
   
   Crop Fescue Yield 3 tons/acre
   
   N, lb/acre 120
   
   P2O5, lb/acre 75
   
   K2O, lb/acre 140

2. Available ammonia (NH4-N) nitrogen.

   \[
   \text{lb NH}_4\text{-N/K-gal} \times \text{available} = \text{lb NH}_4\text{-N/K-gal} \times 0.2 \text{ avail.} = \text{2 lb/K-gal}
   \]

3. Nitrogen available from this year’s organic fraction.

   \[
   \text{lb N/K-gal} \times 0.5 \text{ avail.} = \text{10 lb/K-gal}
   \]

4. Residual nitrogen available from previous years’ organic fraction.

   \[
   \text{No. of } \text{K-gal/acre} \times \text{lb N/K-gal} \times 0.10 = \text{11.2 lb}
   \]

5. Manure application rate to supply nitrogen.

   \[
   \frac{(\text{crop N requirement}) - (\text{residual N}) + (\text{available NH}_4\text{-N}) + (\text{available organic fraction})}{\text{application rate}} = \frac{120 - 23 + 10}{2} = 8.1 \text{ (K-gal/acre)} = 8,100 \text{ gallons/acre}
   \]

6. Phosphate available at calculated application rate for nitrogen.

   \[
   \text{No. of (K-gal/acre)} \times \text{lb P2O5/K-gal} \times 0.8 \text{ avail.} = 90.7 \text{ lb/ac}
   \]

7. Potash available at calculated application rate for nitrogen.

   \[
   \text{No. of (K-gal/acre)} \times \text{lb K2O/K-gal} \times 28 \text{ avail.} = 226.8 \text{ lb/ac}
   \]

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Page 4
sheet on page 3 to determine the proper application rate.

**Liquid manure (slurry)**

The following laboratory analysis (in Table 5) for liquid manure (slurry) is available for present and past years with the rate of application for the past three years. Complete the worksheet on page 4 to determine the proper application rate.

**Lagoon effluent**

The laboratory analysis for lagoon effluent, appearing in Table 6, for is available for present and past years with the rate of application for the past three years. Complete the lagoon effluent worksheet to determine the proper application rate.

**References**


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**Worksheet for lagoon effluent**

1. Crop nutrient requirements (from soil test).
   
   
   \[
   \text{Crop} \_ \text{Fescue} \quad \text{Yield} \_ 3 \text{tons/acre}
   \]
   
   \[
   \text{N, \, lb/acre} \_ \text{120}
   \]
   
   \[
   \text{P}_2\text{O}_5, \, \text{lb/acre} \_ \text{75}
   \]
   
   \[
   \text{K}_2\text{O}, \, \text{lb/acre} \_ \text{140}
   \]
   
   \[
   \text{application rate} = \frac{(\text{crop N requirement}) - (\text{residual N})}{(\text{available NH}_4\text{-N}) + (\text{available organic fraction})}
   \]
   
   2. Available ammonia (NH$_4$-N) nitrogen.
   
   \[
   \text{lb NH}_4\text{-N/acre-inch} \times \text{ % available} = \text{lb NH}_4\text{-N/acre-inch}
   \]
   
   \[
   (\text{Percent available from Table 1})
   \]
   
   \[
   52 \text{ lb/acre-inch} \times 0.8 \text{ avail} = 41.6 \text{ lb/acre-inch}
   \]
   
3. Nitrogen available from this year's organic fraction.
   
   \[
   \text{lb N/acre-inch} \times \text{ % available} = \text{lb N/acre-inch}
   \]
   
   \[
   (\text{Percent available first year from Table 2})
   \]
   
   \[
   26 \text{ lb/acre-inch} \times 0.5 \text{ avail} = 13.0 \text{ lb/acre-inch}
   \]
   
4. Residual nitrogen available from previous years' organic fraction. (From Table 6: One year ago, 2.0 inches of dairy lagoon waste water were applied to the field, 2.5 inches were applied two years ago and 3.1 inches were applied three years ago.)

   \[
   \text{inches} \times \text{lb N/acre-inch} \times \text{ % available} = \text{lb N/acre}
   \]
   
   \[
   (\text{Percent available from Table 2})
   \]
   
   \[
   1 \text{ yr ago: } 2.0 \text{ inch} \times 22 \text{ lb/ac-in} \times 0.10 = 4.4 \text{ lb/ac}
   \]
   
   \[
   2 \text{ yrs ago: } 2.5 \text{ inch} \times 25 \text{ lb/ac-in} \times 0.05 = 3.1 \text{ lb/ac}
   \]
   
   \[
   3 \text{ yrs ago: } 3.1 \text{ inch} \times 25 \text{ lb/ac-in} \times 0.05 = 3.9 \text{ lb/ac}
   \]
   
   \[
   \text{Total} = 11.4 \text{ lb/ac}
   \]
   
5. Manure application rate to supply nitrogen.
# Manure fertility worksheet

1. Crop nutrient requirements (from soil test).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield</th>
<th>N, lb/acre</th>
<th>P2O5, lb/acre</th>
<th>K2O, lb/acre</th>
</tr>
</thead>
</table>

2. Available ammonia (NH4-N) nitrogen (from lab test).

- **Lagoon**: lb NH4-N/ac-in × % avail. = lb NH4-N/ac-in
- **Slurry**: lb NH4-N/K-gal × % avail. = lb NH4-N/K-gal
- **Solid**: lb NH4-N/ton × % avail. = lb NH4-N/ton

(Percent available from Table 1)

3. Nitrogen available from this year's organic fraction (from lab test).

- **Lagoon**: lb N/ac-in × % avail. = lb N/ac-in
- **Slurry**: lb N/K-gal × % avail. = lb N/K-gal
- **Solid**: lb N/ton × % avail. = lb N/ton

(Percent available from Table 2)

4. Residual nitrogen available from previous year's organic fraction.

- **Lagoon**: inches × lb N/ac-in × % avail. = lb N/ac
- **Slurry**: K-gal/ac × lb N/K-gal × % avail. = lb N/ac
- **Solid**: ton/ac × lb N/ton × % avail. = lb N/ac

(Percent available from Table 2)

| 1 yr ago | | | | |
|----------|----------|----------|----------|
| 2 yr ago | | | | |
| 3 yr ago | | | | |

5. Manure application rate.

\[
\text{application rate} = \frac{(\text{crop N reqmt., line 1}) - (\text{residual N, line 4})}{(\text{avail. NH4-N, line 2}) + (\text{avail. organic fraction, line 3})}
\]

6. Phosphorus available at calculated application rate for nitrogen.

- **Lagoon**: inches × lb P/ac-in × % avail. = lb P/ac
- **Slurry**: K-gal/ac × lb P/K-gal × % avail. = lb P/ac
- **Solid**: ton/ac × lb P/ton × % avail. = lb P/ac

(Percent available from Table 3)

\[
\text{lb P/ac} \times 2.27 = \text{lb P}_{205}/ac
\]

7. Potassium available at calculated application rate for nitrogen.

- **Lagoon**: inches × lb K/ac-in × % avail. = lb K/ac
- **Slurry**: K-gal/ac × lb K/K-gal × % avail. = lb K/ac
- **Solid**: ton/ac × lb K/ton × % avail. = lb K/ac

(Percent available from Table 3)

\[
\text{lb K/ac} \times 1.2 = \text{lb K}_{20}/ac
\]

Note: Do not perform the conversion from P to P205 if lab results are given in units of P205.

Note: Do not perform the conversion from K to K20 if lab results are given in units of K20.