**University of Missouri Extension**

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# Spreading Dairy Waste With Lab Analysis but Without Soil Tests

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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 used by the soil-plant complex and are not allowed to enter the groundwater/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 good measure," can easily lead to adverse impacts on water quality. In general, Missouri waste application regulations are based on the rate of nitrogen application. With this scenario, the phosphorus and potash applied may greatly exceed crop needs. Therefore, optimum use of plant nutrients may necessitate applying less nitrogen from waste than the crop needs and buying supplemental nitrogen to balance crop needs.

**Note**
Applying phosphorus to fields with a Bray 1-P test level exceeding 800 pounds per 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 but without a soil test. Other publications in this series address application of dairy waste with other scenarios.

## Managing manure as a fertilizer

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. 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 in the growing season after application. Table 4 provides a basis for estimating the expected nitrogen release from soil organic matter for major annual crops in lieu of a soil test. Table 5 lists nitrogen credits for crops following various legumes.

**Table 1**
Manure ammonia-nitrogen available by days until incorporated into the soil (unavailable portion is lost to the atmosphere)

| Days until incorporation | Percent of ammonia-N available for crops |
|---|---|
| 0 to 2 | 80 |
| 2 to 4 | 60 |
| 4 to 7 | 40 |
| less than 7 | 20 |

**Table 2**
Manure organic nitrogen available by year

| Manure applied | Percent of organic-N available during current year |
|---|---|
| Current year | 40 to 60 |
| 1 year ago | 10 |
| 2 years ago | 5 |
| 3 years ago | 5 |

**Table 3**
Other minerals and micronutrients available in manure

| Nutrient | Percent available in growing season |
|---|---|
| P | 80 |
| K | 100 |
| S, Mn, Cu, Zn | 80 |
| Ca, Mg | 100 |

**Table 4**
Expected N release from soil organic matter for major annual crops when a current soil test is not available (assumes a cation exchange capacity from 10.1 to 18.0 meq per 100 grams and organic matter content less than or equal to 2 percent (no credit given for N released with perennial crops)

| Expected nitrogen release |
|---|

| | |
|---|---|
| Summer annuals | 40 pounds N per acre |
| Winter annuals | 20 pounds N per acre |

**Table 5**
Nitrogen supplied by legumes for succeeding crops (optimum)

| Legume crop | Nitrogen added (pounds N per Acre) first year after |
|---|---|
| Alfalfa<br>80 to 100 percent stand<br>40 to 60 percent stand<br>less than 50 percent | <br>120 to 140<br>40 to 60<br>0 to 20 |
| Sweet clover (green manure) | 100 to 120 |
| Red clover (pure stand) | 40 to 60 |
| Soybeans (add about 1 pound per bushel) | 15 to 60 |

# Other considerations

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 intervals necessary to prevent overflow, dictate different management than commercial fertilizer that can just be "ordered and spread."

If soil tests are not available for guidance on nutrient application rates, a standard rate of 100 pounds of N per acre per year may be used. This application rate conforms to the regulatory guideline for sizing soil-plant filters under the conservative management approach. This publication, however, details a procedure for estimating the amount of manure to apply to satisfy the projected crop needs for nitrogen, which may exceed the 100 pounds per acre allowed under the conservative management approach. However, one may wish to use this worksheet with 100 pounds of N per acre applied (conservative approach) to see what happens with P and K. A blank "Manure fertility worksheet" is included for actual applications.

**Note**
If the projected crop needs for N exceed 100 pounds per acre, 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 its production level.

# Examples

A fescue hayfield (soil-plant filter) is available for receiving dairy waste. No soil tests have been performed on the soil-plant filter area. How many inches of lagoon effluent, how many gallons per acre of slurry, and how many tons per acre of solid manure should be applied for a yield goal of 3 tons per acre? Tables 7, 8 and 9 outline previous years' application rates and analyses for solid, liquid and lagoon effluent.

Because no soil test is available, the nitrogen requirement for fescue production found in Table 6 will be used and manure will be applied to supply adequate nitrogen for the desired yield goal. For fescue (a perennial), no credit is given for nitrogen release from soil organic matter or from a previous legume crop.

**Table 6**
Nitrogen, phosphate and potash removal from soil by various crops

| Crop | Pounds removed per unit production[1] | | | |
|---|---|---|---|---|
| | Units | N | $P_2O_5$ | $K_2O$ |
| Corn, grain | bu | 1.0 | 0.4 | 0.3 |
| Corn, stover | ton | 20.6 | 7.5 | 37.2 |
| Corn, silage | ton | 7.4 | 2.9 | 8.9 |
| Soybeans, grain[2] | bu | 3.4 | 1.0 | 1.5 |
| Soybeans, residue[2] | ton | 15.0 | 6.5 | 15.8 |
| Wheat, grain | bu | 1.3 | 0.5 | 0.3 |
| Wheat, straw | ton | 13.0 | 3.6 | 24.6 |
| Oats, grain | bu | 0.7 | 0.3 | 0.2 |
| Oats, straw | ton | 12.4 | 4.6 | 32.9 |
| Barley, grain | bu | 1.0 | 0.4 | 0.3 |
| Barley, straw | ton | 13.5 | 4.7 | 31.0 |
| Sorghum, grain | bu | 1.1 | 0.4 | 0.3 |
| Sorghum, silage | ton | 7.0 | 2.6 | 10.0 |
| Rye, grain | bu | 1.0 | 0.5 | 0.3 |
| Rye, straw | ton | 10.0 | 6.0 | 16.9 |
| Alfalfa[2] | ton | 49.0 | 11.0 | 50.0 |
| Orchardgrass | ton | 50.0 | 16.6 | 62.5 |

| | | | | |
|---|---|---|---|---|
| Bromegrass | ton | 33.2 | 13.2 | 50.8 |
| Tall fescue | ton | 55.0 | 18.6 | 52.9 |
| Bluegrass | ton | 25.8 | 18.3 | 60.0 |
| Clover-grass[2] | ton | 41.0 | 13.3 | 38.9 |
| Timothy | ton | 37.5 | 13.8 | 62.5 |
| Sorghum-Sudan grass | ton | 39.9 | 15.3 | 55.9 |

**[1]Six sources listing nutrient removal for a given yield were averaged to estimate removal for a unit of production.**
**[2]About 70 percent of the above nitrogen in inoculated legumes is fixed from the air. The percentage goes down when adequate nitrogen is available from the soil.**

From Table 6, for a yield goal of 3 tons per acre per year, we calculate the following nutrient removal by fescue hay:

- 55 pounds of N per ton x 3 tons per acre = 165 pounds of N per acre
- 18.6 pounds of $P_2O_5$ per ton x 3 tons per acre = 56 pounds of $P_2O_5$ per acre
- 52.9 pounds of $K_2O$ per ton x 3 tons per acre = 159 pounds of $K_2O$ per acre

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 following laboratory analysis (in Table 7) 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 dairy manure worksheet" to determine the proper application rate.

**Table 7**
Laboratory analysis for solid manure and rate of past application

| Nutrient | Nutrient level, pounds per ton | | | |
|---|---|---|---|---|
| | This year | 1 year ago | 2 years ago | 3 years ago |
| Total N | 10 | 8 | 11 | 7 |
| $NH_4$-N | 5 | 4 | 5 | 3 |

| | | | | |
|---|---|---|---|---|
| Organic N | 5 | 4 | 6 | 4 |
| $P_2O_5$ (phosphate) | 4 | 3 | 5 | 4 |
| $K_2O$ (potash) | 11 | 8 | 12 | 9 |
| Application, tons | ? | 21 | 19 | 22 |

# Liquid manure (slurry)

The following laboratory analysis (in Table 8) for liquid manure (slurry) is available for present and past years with the rate of application for the past three years. Complete the "Liquid manure worksheet" to determine the proper application rate.

**Table 8**
Laboratory analysis for liquid manure and rate of past application

| Nutrient | Nutrient level, pounds per K-gallons | | | |
|---|---|---|---|---|
| | This year | 1 year ago | 2 years ago | 3 years ago |
| Total N | 30 | 24 | 33 | 21 |
| $NH_4$-N | 10 | 8 | 10 | 7 |
| Organic N | 20 | 16 | 23 | 14 |
| $P_2O_5$ (phosphate) | 14 | 11 | 13 | 14 |
| $K_2O$ (potash) | 28 | 21 | 31 | 23 |
| Application, K-gal[1] | ? | 7 | 6 | 7 |

**[1]K-gal = 1,000 gallons, e.g. 6 K-gal = 6,000 gallons**

# Lagoon effluent

The following laboratory analysis (in Table 9) for lagoon effluent 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.

**Table 9**
Laboratory analysis for lagoon effluent and the rate of past application

| Nutrient | Nutrient level, pounds per acre-inch | | | |
|---|---|---|---|---|
| | This year | 1 year ago | 2 years ago | 3 years ago |
| Total N | 78 | 66 | 70 | 55 |
| $NH_4$-N | 52 | 44 | 45 | 30 |
| Organic N | 26 | 22 | 25 | 25 |
| $P_2O_5$ (phosphate) | 41 | 33 | 39 | 31 |
| $K_2O$ (potash) | 130 | 110 | 122 | 106 |
| Application, acre-inch[1] | ? | 2.0 | 2.5 | 3.1 |

**[1]One acre-inch = 27,154 gallons**

# Manure fertility worksheet

1. Crop nutrient requirements (from table 6)

   Crop ________
   Yield ________
   N, pounds per acre ________
   $P_2O_5$, pounds per acre ________
   $K_2O$, pounds per acre ________

2. Available ammonia ($NH_4$-N) nitrogen (from lab test).

   **Lagoon**
   pounds $NH_4$-N x percent available = pounds $NH_4$-N per acre-inch
   **Slurry**
   pounds $NH_4$-N per K-gal x percent available = pounds $NH_4$-N per K-gal
   **Solid**
   pounds $NH_4$-N per ton x percent available = pounds $NH_4$-N per ton
   (Percent available from Table 1)

   | |
   |---|
   | **Note**<br>K-gal = 1,000 gallons |

________ x ________ = __________

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

   **Lagoon**
   pounds N per acre-inch x percent available = pounds N per acre-inch
   **Slurry**
   pounds N per K-gal x percent available = pounds N per K-gal
   **Solid**
   pounds N per ton x percent available = pounds N per ton
   (Percent available from Table 2)

   ________ x ________ = __________

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

   **Lagoon**
   inches x pounds N per acre-inch. x percent available = pounds N per acre
   **Slurry**
   K-gal per acre x pounds N per K-gal x percent available = pounds N per acre
   **Solid**
   tons per acre x pounds N per ton x percent available = pounds N per acre
   (Percent available from Table 2)

   1 year ago: ________ x ________ x ________ = __________

   2 years ago: ________ x ________ x ________ = __________

   3 years ago: ________ x ________ x ________ = __________

   Total = __________

5. Manure application rate.

   (crop N requirement, line 1) - (residual N, line 4) - (N from O.M., table 5) - (N from legumes, table 6) = application rate
   (available $NH_4$-N, line 2) + (available organic fraction, line 3)

   (______) - (______) - (______) - (______) = ____________pounds N per acre
   (_____) + (______)

6. Phosphorus available at calculated application rate for nitrogen.

   **Lagoon**

inches x pounds P per acre-inch x percent available = pounds P per acre
**Slurry**
K-gal per acre x pounds P per K-gal x percent available = pounds P per acre
**Solid**
tons per acre x pounds P per ton x percent available = pounds P per acre
(Percent available from Table 3)

________ x ________ x ________ = __________
pounds P per acre x 2.27 = pounds $P_2O_5$ per acre

> **Note**
> Do not perform the conversion from P to $P_2O_5$ if lab results are given in units of $P_2O_5$.

________ x 2.27 = ________ pounds $P_2O_5$ per acre

7. Potassium available at calculated application rate for nitrogen.

**Lagoon**
inches x pounds K per acre-inch x percent available = pounds K per acre
**Slurry**
K-gal per acre x pounds K per K-gal x percent available = pounds K per acre
**Solid**
tons per acre x pounds K per ton x percent available = pounds K per acre
(Percent available from Table 3)

________ x ________ x ________ = __________ pounds K per acre
pounds K per acre x 1.2 = pounds $K_2O$ per acre

> **Note**
> Do not perform the conversion from K to $K_2O$ if lab results are given in units of $K_2O$.

________ x 1.2 = pounds $K_2O$ per acre

# Solid dairy manure worksheet

1. Crop nutrient requirements (from data in Table 6)

Crop Fescue

Yield 3 tons per acre
N 165 pounds per acre
$P_2O_5$ 56 pounds per acre
$K_2O$ 159 pounds per acre

2. Available ammonia nitrogen ($NH_4$-N) nitrogen.

   pounds $NH_4$-N per ton x percent available = pounds $NH_4$-N per ton
   (percent from Table 1)

   5 pounds per ton x 0.2 percent available = 1.0 pounds per ton

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

   pounds N per ton x percent available = available pounds N per ton
   (percent available first year from Table 2)

   5 pounds per ton x 0.5 percent available = 2.5 pounds per ton

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

   (From Table 7: 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.)

   Tons per acre x N per ton x percent available = pounds N per acre
   (Percent available from Table 2.)

| | | | | |
|---|---|---|---|---|
| 1 year ago: | 21 tons | x 4 pounds per ton | x 0.10 | = 8.4 pounds per acre |
| 2 years ago: | 19 tons | x 6 pounds per ton | x 0.05 | = 5.7 pounds per acre |
| 3 years ago: | 22 tons | x 4 pounds per ton | x 0.05 | = 4.4 pounds per acre |
| | | | Total | = 18.5 pounds per acre |

5. Manure application rate to supply nitrogen.

   $$\frac{\text{(crop N requirement) - (residual N) - (N, OM) - (N, leg)}}{\text{(available } NH_4\text{-N) + (available organic fraction)}} = \text{application rate}$$

   $$\frac{165 - 18.5 - 0 - 0}{1.0 + 2.5} = 41.86 \text{ tons per acre}$$

6. Phosphate available at calculated application rate for nitrogen.

   tons per acre x pounds $P_2O_5$ per ton x percent available = pounds $P_2O_5$ per acre
   ($P_2O_5$ per ton from Table 7 = 4; percent available from Table 3)

   41.86 tons per acre x 4 pounds per ton x 0.8 = 134 pounds per acre

   **Note**
   134 pounds per acre of $P_2O_5$ is applied versus 56 pounds per acre removed by crop.

7. Potash available at calculated application rate for nitrogen.

   tons per acre x pounds $K_2O$ per ton x percent available = pounds $K_2O$ per acre
   ($K_2O$ per ton from Table 7 = 11; percent available from Table 3)

   41.86 tons per acre x 11 pounds per ton x 1.0 = 460 pounds per acre

   **Note**
   460 pounds per acre of $K_2O$ is applied versus 159 pounds per acre removed by crop.

# Liquid dairy manure worksheet

1. Crop nutrient requirements (from table 6 data).

   Crop Fescue
   Yield 3 tons per acre
   N, pounds per acre 165
   $P_2O_5$, pounds per acre 56
   $K_2O$, pounds per acre 159

2. Available ammonia ($NH_4$-N) nitrogen.

   pounds $NH_4$-N per K-gal x percent available = pounds $NH_4$-N per K-gal
   (Percent available from Table 1)
   10 pounds per K-gal x 0.2 available = 2 pounds per K-gal

   **Note**
   K-gal = 1,000 gallons, e.g. 5 K-gal = 5,000 gallons

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

   pounds N per K-gal x percent available = pounds N per K-gal
   (Percent available first year from Table 2)
   20 pounds per K-gal x 0.5 available = 10 pounds per K-gal

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

   From Table 8: One year ago, 7,000 gallons of dairy waste were applied to the field, 6,000 gallons were applied two years ago, and 7,000 gallons were applied three years ago.

   Number of K-gallon per acre x pounds N per K-gallon x percent available = pounds N per acre
   (Percent available from Table 2.)

| | | | | | |
|---|---|---|---|---|---|
| 1 year ago: | 7 K-gallon | x 16 pounds per K-gallon | x 0.10 | = 11.2 pounds | |
| 2 years ago: | 6 K-gallon | x 23 pounds per K-gallon | x 0.05 | = 6.9 pounds | |
| 3 years ago: | 7 K-gallon | x 14 pounds per K-gallon | x 0.05 | = 4.9 pounds | |
| | | | Total | = 23.0 pounds per acre | |

5. Manure application rate to supply nitrogen.

$$\frac{\text{(crop N requirement) - (residual N) - (N, OM) - (N, leg)}}{\text{(available } NH_4\text{-N) + (available organic fraction)}} = \text{application rate}$$

$$\frac{165 - 23 - 0 - 0}{2 + 10} = 11.8 \text{ K-gal per acre} = 11{,}800 \text{ gallons per acre}$$

6. Phosphate available at calculated application rate for nitrogen.

   Number of (K-gal per acre) x pounds $P_2O_5$ per K-gal x percent available = pounds $P_2O_5$ per acre
   ($P_2O_5$ per K-gal from Table 8 = 14; percent available from Table 3)
   11.8 (K-gal per acre) x 14 pounds per K-gal x 0.8 = 132 pounds per acre

> **Note**
> 132 pounds per acre of $P_2O_5$ is applied versus 56 pounds per acre removed by crop.

7. Potash available at calculated application rate for nitrogen.

   Number of (K-gal per acre) x pounds $K_2O$ per K-gal x percent available = pounds $K_2O$ per acre
   ($K_2O$ per K-gal from Table 8 = 28; percent available from Table 3)

11.8 (K-gal per acre) x 28 pounds per K-gal x 1.0 = 330.4 pounds per acre

> **Note**
> 330.4 pounds per acre of $K_2O$ is applied versus 159 pounds per acre removed by crop.

# Lagoon effluent worksheet

1. Crop nutrient requirements (from table 6 data).

   Crop Fescue
   Yield 3 tons per acre
   N, pounds per acre 165
   $P_2O_5$, pounds per acre 56
   $K_2O$, pounds per acre 159

2. Available ammonia ($NH_4$-N) nitrogen.

   pounds $NH_4$-N per acre-inch x percent available = pounds $NH_4$-N per acre-inch
   (Percent available from Table 1)
   52 pounds per acre-inch x 0.8 available = 41.6 pounds per acre-inch

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

   pounds N per acre-inch x percent available = pounds N per acre-inch
   (Percent available first year from Table 2)
   26 pounds per acre-inch x 0.5 available = 13.0 pounds per acre-inch

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

   From Table 9: 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.

   inches x pounds N per acre-inch x percent available = pounds N per acre)
   (Percent available from Table 2)

| | | | | |
|---|---|---|---|---|
| 1 year ago: | 2.0 inches | x 22 pounds per acre-inch | x 0.10 | = 4.4 pounds per acre |
| 2 years ago: | 2.5 inches | x 25 pounds per acre-inch | x 0.05 | = 3.1 pounds per acre |

3 years ago: 3.1 inches x 25 pounds per acre-inch x 0.05 = 3.9 pounds per acre

Total = 11.4 pounds per acre

5. Manure application rate to supply nitrogen.

$$\frac{\text{(crop N requirement)} - \text{(residual N)} - \text{(N, OM)} - \text{(N, leg)}}{\text{(available } NH_4\text{-N)} + \text{(available organic fraction)}} = \text{application rate}$$

$$\frac{165 - 11.4 - 0 - 0}{41.6 + 13.0} = 2.8 \text{ inches}$$

6. Phosphate available at calculated application rate for nitrogen.

Number of inches applied x pounds $P_2O_5$ per acre-inch x percent available = pounds $P_2O_5$ per acre
($P_2O_5$ per acre-inch from Table 9 = 41, percent available from Table 3)
2.8 inches x 41 pounds per acre-inch x 0.8 = 91.8 pounds per acre

> **Note**
> 91.8 pounds per acre of $P_2O_5$ is applied versus 56 pounds per acre removed by crop.

7. Potash available at calculated application rate for nitrogen.

Number of inches applied x pounds $K_2O$ per acre-inch x percent available = pounds $K_2O$ per acre
($K_2O$ per acre-inch from Table 9 = 130; percent available from Table 4)
2.8 inches x 130 pounds per acre-inch x 1.0 = 364 pounds per acre

> **Note**
> 364 pounds per acre of $K_2O$ is applied versus 159 pounds per acre removed by crop.

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## Related MU Extension publications

- MWPS18, Livestock Waste Facilities Handbook
  http://extension.missouri.edu/publications/DisplayPub.aspx?P=MWPS18
- WQ309, Spreading Dairy Waste Without Lab Analysis or Soil Test
  http://extension.missouri.edu/publications/DisplayPub.aspx?P=WQ309
- WQ310, Spreading Dairy Waste With Lab Analysis and Soil Test
  http://extension.missouri.edu/publications/DisplayPub.aspx?P=WQ310
- WQ312, Spreading Dairy Waste Without Lab Analysis and With Soil Test

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