Water Quality Initiative publication WQ312 — Reviewed October 1, 1993

Spreading Dairy Waste Without 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 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. **Applying phosphorus 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, however, is to provide guidance for application of waste without the benefit of a lab analysis but with data from 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 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 that can just be "ordered and spread."

If a laboratory analysis is not available, average values of manure nutrients in similar waste management systems, as reported in the literature, must be used. Table 1 lists values for dairy waste.

Table 1. Average nutrient levels in dairy waste.[1]

Waste type	Nitrogen			P_2O_5 [2]	K_2O [3]
	Total	Organic	Ammonia		
Solid[4] with bedding (pounds/ton)	9	4	5	4	10
Solid[5] without bedding (pounds/ton)	9	5	4	4	10
Lagoon (pounds/acre-inch)	69	23	46	79	144
Liquid (slurry; pounds/acre-inch)	26	16	10	14	26

Notes:

[1] Actual values are highly dependent on dilution, bedding and other factors. Variations of 50 percent from average values are not uncommon.

[2] $P_2O_5 = 2.27 \times P$.

[3] $K_2O = 1.2 \times K$.

[4] 21% dry matter. Source: MWPS-18, Table 10-6).

[5] 18% dry matter. Source: MWPS-18, Table 10-6).

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 2 shows the available ammonia nitrogen as a function of time until incorporation into the soil. Table 3 lists the percent of available organic nitrogen available with time. Table 4 gives the percent of various nutrients available in the growing season after application.

Table 2. 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
0-2	80
2-4	60
4-7	40
more than 7	20

Table 3. Manure organic nitrogen available by year.

Manure applied	Percent organic-N available during current year
Current year	4-60
1 year ago	10
2 years ago	5
3 years ago	5

Table 4. 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

This publication details a procedure for estimating the amount of manure to apply to meet the soil test recommendations for nitrogen, using a dairy manure of unknown nutrient analysis. The soil test may call for more than 100 pounds of nitrogen per acre to be added to satisfy crop needs, thus exceeding the 100 pounds per acre allowed under the "conservative management approach." However, one may wish to use this worksheet with 100 pounds of N/acre applied (conservative approach) to see what happens with P and K. A blank "Manure fertility worksheet" is included for actual applications.

Note: This approach cannot be used (to apply more than 100 pounds of N per acre per year) 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. No laboratory analysis of the manure to be applied is available. The accompanying soil test 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 lbs./acre of N
75 lbs./acre of P_2O_5
140 lbs./acre of K_2O

Given this information, 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?

Since no laboratory analysis of the manure is available, the average values from Table 1 will be used. 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

For the application of solid manure with no bedding, complete the "Solid dairy manure worksheet" below to determine the proper application rate. Assume the soil-plant filter area has not received manure from any source for the past three years. See Table 1 for average nutrients per unit of manure applied.

Liquid manure (slurry)

For the application of liquid manure (slurry) with no bedding, complete the "Liquid manure worksheet" below to determine the proper application rate. The soil-plant filter area received 3,800 gallons of liquid dairy manure per acre two years ago. See Table 1 for average nutrients per unit of manure applied.

Lagoon effluent

For the application of waste from a lagoon, complete the "Lagoon effluent worksheet" below to determine the proper application rate. The soil-plant filter area has received 1.45 inches of dairy lagoon effluent each of the past six years. See Table 1 for average nutrients per unit of manure applied.

Manure fertility worksheet

1. Crop nutrient requirements (from soil test).

   Crop_____
   Yield_____
   N, lbs./acre_____
   P_2O_5, lbs./acre_____
   K_2O, lbs./acre_____

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

   Lagoon: lb NH_4-N/acre-inch x % avail. = lb NH_4-N/acre-inch
   Slurry: lb NH_4-N/K-gal x % avail. = lb NH_4-N/K-gal
   Solid: lb NH_4-N/ton x % avail. = lb NH_4-N/ton

   (Percent available from Table 2)

   _____ x _____ = _____
   Note: K-gal = 1,000 gallons

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

   Lagoon: lbs. N/acre-inch x percent available = lbs. N/acre-inch
   Slurry: lbs. N/K-gal x percent available = lbs. N/K-gal
   Solid: lbs. N/ton x percent available = lbs. N/ton

   (Percent available from Table 3)

   _____ x _____ = _____

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

   Lagoon: inches x lbs. N/acre-inch. x percent available = lbs. N/acre
   Slurry: K-gal/acre x lbs. N/K-gal x percent available = lbs. N/acre
   Solid: tons/acre x lbs. N/ton x percent available = lbs. N/acre

   (Percent available from Table 3)

   1 year ago: _____ x _____ x _____ = _____

   2 years ago: _____ x _____ x _____ = _____

3 years ago: _____ x _____ x _____ = _____

Total = _____

5. Manure application rate.

$$\frac{\text{(crop N requirement, line 1) - (residual N, line 4)}}{\text{(available } NH_4\text{-N, line 2) + (available organic fraction, line 3)}} = \text{application rate}$$

$$\frac{(\quad) - (\quad)}{(\quad) + (\quad)} = \_\_\_\_\_$$

6. Phosphorus available at calculated application rate for nitrogen.

Lagoon: inches x lbs. P/acre-inch x percent available = lbs. P/acre
Slurry: K-gal/acre x lbs. P/K-gal x percent available = lbs. P/acre
Solid: tons/acre x lbs. P/ton x percent available = lbs. P/acre

(Percent available from Table 4)

_____ x _____ x _____ = _____ lbs. P/acre

lbs. P/acre x 2.27 = lbs. P_2O_5/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 = _____ lbs. P_2O_5/acre

7. Potassium available at calculated application rate for nitrogen.

Lagoon: inches x lbs. K/acre-inch x percent available = lbs. K/acre
Slurry: K-gal/acre x lbs. K/K-gal x percent available = lbs. K/acre
Solid: tons/acre x lbs. K/ton x percent available = lbs. K/acre

(Percent available from Table 4)

_____ x _____ x _____ = _____ lbs. K/acre

lbs. K/acre x 1.2 = lbs. K_2O/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 = lbs. K_2O/acre

Solid dairy manure worksheet

1. Crop nutrient requirements (from soil test).

   Crop Fescue
   Yield 3 tons/acre
   N, lbs./acre 120
   P_2O_5, lbs./acre 75
   K_2O, lbs./acre 140

2. Available ammonia (NH_4-N) nitrogen.

   lbs. NH_4-N/ton x % available = lbs. NH_4-N/ton
   (Percent available in Table 2)

   4 lbs./ton x 0.2 available = 0.8 lbs./ton

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

   lbs. N/ton x percent available = lbs. N/ton
   (Percent available first year from Table 3)

   5 lbs./ton x 0.5 available = 2.5 lbs./ton

4. Since no manure was applied in any of the previous three years, no residual nitrogen is available.

5. Manure application rate to supply nitrogen.

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

$$\frac{120 - 0}{0.8 + 2.5} = 36.4 \text{ tons/acre}$$

6. Phosphate available at calculated application rate for nitrogen.

   tons/acre x lbs. P_2O_5/ton x % available = lbs. P_2O_5/acre
   (P_2O_5/ton from Table 1 = 4; percent available from Table 4)
   36.4 tons/acre x 4 lbs./ton x 0.8 = 116.5 lbs./acre
   Note: 116.5 lbs./acre of P_2O_5 is applied versus 75 lbs./acre recommended by the soil test.

7. Potash available at calculated application rate for nitrogen.

   tons/acre x lbs. K_2O/ton x % available = lbs. K_2O/acre
   (K_2O/ton from Table 1 = 10; percent available from Table 4)
   36.4 tons/acre x 10 lbs./ton x 1.0 = 364 lbs./acre
   Note: 364 lbs./acre of K_2O is applied versus 140 lbs./acre recommended by the soil test.

Liquid dairy manure worksheet

1. Crop nutrient requirements (from soil test).

   Crop Fescue
   Yield 3 tons/acre
   N, lbs./acre 120
   P_2O_5, lbs./acre 75
   K_2O, lbs./acre 140

2. Available ammonia (NH_4-N) nitrogen.

   lbs. NH_4-N/K-gal x % available = lbs. NH_4-N/K-gal
   (Percent available from Table 2)
   10 lbs./K-gal x 0.2 available = 2 lbs./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.

   lbs. N/K-gal x percent available = lbs. N/K-gal
   (Percent available first year from Table 3)
   16 lbs./K-gal x 0.5 available = 8 lbs./K-gal

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

   No. of K-gal/acre x lbs. N/K-gal x percent available = lbs. N/acre
   (Percent available from Table 3)

   2 years ago: 3.8 K-gal x 16 lbs./K-gal x 0.05 = 3.0 lbs.

5. Manure application rate to supply nitrogen.

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

$$\frac{120 - 3}{2 + 8} = 36.4 \text{ tons/acre} = 11.7 \text{ K-gal/acre} = 11{,}700 \text{ gallons/acre}$$

6. Phosphate available at calculated application rate for nitrogen.

   No. of (K-gal/acre) x lbs. P_2O_5/K-gal x % available = lbs. P_2O_5/acre
   (P_2O_5/K-gal from Table 1 = 14; percent available from Table 4)
   11.7 (K-gal/acre) x 14 lbs./K-gal x 0.8 = 131.0 lbs./acre
   Note: 131.0 lbs./acre of P_2O_5 is applied versus 75 lbs./acre recommended by the soil test.

7. Potash available at calculated application rate for nitrogen.

No. of (K-gal/acre) x lbs. K_2O/K-gal x % available = lbs. K_2O/acre
(K_2O/K-gal from Table 1 = 26; percent available from Table 4)
11.7 (K-gal/acre) x 26 lbs./K-gal x 1.0 = 304.2 lbs./acre
Note: 304.2 lbs./acre of K_2O is applied versus 140 lbs./acre recommended by the soil test.

Lagoon effluent worksheet

1. Crop nutrient requirements (from soil test).

   Crop Fescue
   Yield 3 tons/acre
   N, lbs./acre 120
   P_2O_5, lbs./acre 75
   K_2O, lbs./acre 140

2. Available ammonia (NH_4-N) nitrogen.

   lbs. NH_4-N/acre-inch x % available = lbs. NH_4-N/acre-inch
   (Percent available from Table 2)
   46 lbs./acre-inch x 0.8 available = 36.8 lbs./acre-inch

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

   lbs. N/acre-inch x percent available = lbs. N/acre-inch
   (Percent available first year from Table 3)
   23 lbs./acre-inch x 0.5 available = 11.5 lbs./acre-inch

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

   inches x lbs. N/acre-inch x percent available = lbs. N/acre
   (Percent available from Table 3)

1 year ago:	1.45 inches	x 23 lbs./acre-inch	x 0.10	= 3.3 lbs./acre
2 years ago:	1.45 inches	x 23 lbs./acre-inch	x 0.05	= 1.7 lbs./acre
3 years ago:	1.45 inches	x 23 lbs./acre-inch	x 0.05	= 1.7 lbs./acre
			Total	= 6.7 lbs./acre

5. Manure application rate to supply nitrogen.

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

$$\frac{120 - 6.7}{36.8 + 11.5} = 2.35 \text{ inches}$$

6. Phosphate available at calculated application rate for nitrogen.

   No. of inches applied x lbs. P_2O_5/acre-inch x % available = lbs. P_2O_5/acre

   (P_2O_5/acre-inch from Table 1 = 79, percent available from Table 4)

   2.35 inches x 79 lbs./acre-inch x 0.8 = 148.5 lbs./acre

   Note: 148.5 lbs./acre of P_5 is applied versus 75 lbs./acre recommended by the soil test.

7. Potash available at calculated application rate for nitrogen.

   No. of inches applied x lbs. K_2O/acre-inch x % available = lbs. K_2O/acre

   (K_2O/acre-inch from Table 1 = 144; percent available from Table 4)

   2.35 inches x 144 lbs./acre-inch x 1.0 = 338.4 lbs./acre

   Note: 338.4 lbs./acre of K_2O is applied versus 140 lbs./acre recommended by the soil test.

References

MWPS-18, *Livestock Waste Facilities Handbook*. 1985. Midwest Plan Service, Iowa State University, Ames, Iowa 50011.