ENVIRONMENTAL QUALITY

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Land Application Considerations for Animal Manure

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Manure should always be spread or irrigated uniformly on fields with consideration given to the proper application rate. Nutrient losses, pollution potential and odor are reduced if manure is incorporated into the soil as soon as possible after spreading. In the case of irrigated lagoon effluent, incorporation occurs if the soil is dry enough for the liquid to soak in and the application rate does not exceed the infiltration rate of the soil.

When manure is applied to pasture or hay land at proper rates and soil conditions, erosion and runoff are not usually a problem. However, it is important that cultivated land on which manure is applied not be subject to excessive erosion because erosion is an effective mechanism for moving manure nutrients off a field and into a stream. To the extent possible, consideration should be given to the probability of a runoff-causing rainfall event when manure is being land applied.

Application timing

The longer manure is in the soil before plants take up its nutrients, the more those nutrients, especially nitrogen, can be lost through mineralization, volatilization, denitrification, leaching and erosion. Therefore, proper application timing is essential to efficient use of nutrients and pollution prevention.

Spring application is best for conserving nutrients. Manure applied during the spring will release nutrients through mineralization during the growing season of most crops.

Summer application is also acceptable and is most suited to hay and pasture areas rather than row crop or small grains. Application equipment such as tank wagons and injectors cannot be used on row crops or small grains during most of the growing season. Irrigation equipment such as traveling guns or center pivots can generally be used during the growing season of row crops and small grains. Legumes can use manure nitrogen. However, experience has shown that applying manure to legumes tends to stimulate broadleaf weed and grass growth in legume stands. Grasses such as fescue or reed canarygrass, which can use high rates of nitrogen application while tolerating relatively wet soil conditions, are excellent choices for manure utilization areas. Warm-season grasses such as bluestem and switchgrass are also good choices, but they may not uptake as much nitrogen as the cool-season grasses. Grasses or pasture also generally offer the greatest flexibility in terms of crop scheduling and land application operations.

Applying manure in the fall generally results in greater nutrient loss than does spring application, especially if the manure is not incorporated. If the manure is incorporated and soil temperatures are below 50 degrees Fahrenheit, some of the nutrients will be immobilized and tend to remain in the soil until the following spring.

Sometimes fall application is necessary to free up manure storage volume so that manure can be accumulated during the wet months of the year. In these cases, it is best to apply manure to fields that will be planted in winter grains or cover crops. If no winter crops are available, then the next choice should be fields with the most vegetation or crop residue, such as grass or sod.

Winter application is the least desirable because nutrients cannot soak into frozen soil. Manure accumulated on the surface of frozen soil or snow can easily be carried off the field during snow melt or other runoff events. Manure should not be applied to frozen soil, or on top of a snow cover because these conditions are likely to result in runoff of nutrients.

Surface application

Manure spread on the surface and not worked into the soil may lose most of the volatile nitrogen compounds as ammonia gas to the atmosphere. This lost nitrogen is not available for plant growth, and has been identified as a possible air quality contaminant contributing to acid rain.

Manure solids spread on frozen or snow-covered soil have a high potential for runoff and resulting pollution. If manure is surface-spread on long slopes or areas with high erosion potential, strip cropping, diversions and other conservation practices can reduce runoff, nutrient loss and pollution. Manure should not be surface applied to soil near wells, springs, sinkholes, terrace tile inlets, wetlands, or on slopes adjacent to streams, rivers or lakes.

In Missouri, cool-season grasses such as fescue are commonly used as manure utilization areas. Manure is usually surface-applied without incorporation. While this practice does not necessarily maximize nutrient conservation because of volatilization, pollution potential is no greater than with practices involving incorporation as long as manure is applied at the proper rate and soil conditions. However, runoff from a rainfall event immediately following surface application can transport nutrients from the field into surface waters.

Subsurface application

Water pollution potential can be decreased, and the amount of manure nitrogen available to plants can be increased, by working manure into the soil either by tillage or by subsurface injection. A soaking rain with no runoff has approximately the same effect as incorporating manure. Similarly, irrigation of lagoon effluent with no runoff is equivalent to incorporation. When a tillage operation is used to incorporate manure, it should be completed as soon as possible after the spreading operation to reduce nutrient loss from runoff should a heavy rain occur.

Subsurface injection is probably the best incorporation method because it occurs immediately as manure is spread and only minimally disturbs the soil surface. This makes it attractive for reduced till and no-till cropping systems. For injection to be effective, the furrows made by the injector knives must close over the manure following application. Hence soil moisture conditions should be suitable for a tillage operation when injection is used in applying manure.

Disadvantages of injection include equipment cost and maintenance; high power requirements; and time, labor and management involved in the operation. Additionally, injection is not as well suited to pasture and grass programs and areas of the state with shallow, rocky soils. However, equipment manufacturers are developing injection equipment more suited to hay and pasture areas.

Application rate

Manure should be applied to fields at a rate compatible with the nutrient needs of the crop being grown. Supplying an excess of nutrients is a waste of resources, may result in ground or surface water pollution, and may eventually depress crop yields. Determining the rate at which manure nutrients should be applied requires consideration of crop requirements and nutrients already present in the soil.

Manure nutrients, especially nitrogen, are used more efficiently by grain crops than by legumes. However, the use of manure to supply the nitrogen needs of continuous grain crops will result in phosphorus and potassium buildup in the soil. Forage crops (hay), or whole-plant crops (silage) in rotation with grain crops, will help reduce this effect.

The nutrient needs of a crop are determined by crop type and expected yield. Realistic yield goals should be based on previous yield data, yield potential of the soil (type and depth), and management level available. Table 1 provides estimates of the amount of nutrients required for crop growth, and the nutrients removed with various crops.

Because the rate at which manure should be applied depends on the amount of nutrients already in the soil, soil tests should be conducted to determine the amounts of residual available nutrients. In determining the application rate, consideration should be given to all sources of nitrogen. Manure organic nitrogen mineralized in the current growing season from previous years' applications should be estimated. If manure is continuously applied to the same field year-after-year (at approximately the same rate), 45 to 75 percent of the applied organic nitrogen will be available the current year, depending on manure type and soil and weather conditions. See the Missouri Department of Natural Resurces (DNR) "Plant-Available Nitrogen Approach" for details on mineralization of organic nitrogen. If a legume crop is plowed down, followed by grain or another crop, credit should be given to the nitrogen made available from the legume crop. Table 2 gives estimates of the amount of nitrogen available following various legume crops. For production facilities with a Missouri DNR permit or letter of approval, the manure application rate is determined from either the conservative approach (100 lb applied nitrogen per acre), or the "Plant-Available Nitrogen Approach." The latter is a detailed procedure accounting for such factors as manure type, crop uptake characteristics, soil type, field losses, and method of application.

Responsible management of manure nutrients requires that consideration be given to nitrogen, phosphorus, and potassium in a "whole farm" approach. Imported nutrients in the form of feed and fertilizer, as well as exported nutrients in the form of meat, milk, eggs, or manure solids should be considered in developing a total nutrient management plan. Phosphorus is increasingly a nutrient of concern where long-term application of manure has resulted in high levels of soil test phosphorus.

The following MU publications provide information on phosphorus in Missouri soils, and the use of manure as a source of phosphorus:

- G9182, *Managing Manure Phosphorus to Protect Water Quality*
- G9181, *Agricultural Phosphorus and Water Quality*
- G9180, *Phosphorus in Missouri Soils*

Table 1. Estimates of nutrients required for crop growth, and nutrients removed from the field with various crops. For example, a corn crop requires more nitrogen than is removed from the field in the grain because some nitrogen is required for growth of the plant itself.

		Required for growth			Removed from field		
Crop	**Yield unit**	**N**	**P_2O_5**	**K_2O**	**N**	**P_2O_5**	**K_2O**
Corn, grain	bu	1.34–1.96	0.55–0.70	1.23–1.48	0.90	0.36–0.45	0.27–0.30
Soybeans, grain	bu	4.84–6.32	1.06–1.44	2.14–2.79	3.75–4.84	0.87–1.06	1.37–2.14
Wheat, grain	bu	1.62–2.05	0.75–0.96	1.24–1.70	1.25–1.26	0.60–0.84	0.30–0.37
Barley, grain	bu	1.17–1.32	0.47–0.52	0.85–1.23	0.87–1.18	0.34–0.37	0.25–0.34
Rye, grain	bu	1.48–1.66	0.60	1.16	1.16–1.18	0.33–0.34	0.33–0.34
Sorghum, grain	bu	1.38–2.01	0.63–0.80	1.40–1.85	0.78–0.93	0.34–0.46	0.28–0.52
Corn, silage	ton	7.19–9.00	2.66–4.00	7.02–9.20	7.19–9.00	2.66–4.00	7.02–9.20
Sorghum, silage	ton	8.64–13.0	2.58–4.60	7.34–10.0	8.64–13.0	2.58–4.60	7.34–10.0
Alfalfa, hay	ton	45.0–50.6	10.0	44.9–52.5	45.0–50.6	10.0	44.9–52.5
Cool–season grass, hay	ton	32.6–40.0	9.00–15.5	34.0–57.2	32.6–40.0	9.00–15.5	34.0–57.2
Warm–season grass, hay	ton	21.2–24.0	2.00–38.6	14.6–37.8	21.2–24.0	2.00–38.6	14.6–37.8
Sudan, hay	ton	39.9–40.0	6.90–15.3	19.0–58.4	39.9–40.0	6.90–15.3	19.0–58.4
Cool-season pasture	cd	0.60	0.13	0.51	0.6	0.05	0.17
Warm-season pasture	cd	0.36	0.03	0.22	0.36	0.01	0.07
Sudan pasture	cd	0.60	0.1	0.29	0.60	0.03	0.09

Note: cd = cow-days

Data sources:

- MWPS-18. *Livestock Waste Facilities Handbook,* 2nd ed. 1997. Midwest Plan Service, Iowa State University, Ames.
- *Agricultural Waste Management Field Handbook.* Natural Resources Conservation Service, United States Department of Agriculture.
- *Soil Test Interpretations and Recommendations Handbook*, rev. 12/92. Department of Agronomy, University of Missouri.

For further information

MWPS-18. *Livestock Waste Facilities Handbook*, 2nd ed. 1997. Midwest Plan Service, Iowa State University, Ames.

Agricultural Waste Management Field Handbook. Natural Resources Conservation Service, U.S. Department of Agriculture.

Plant-Available Nitrogen Procedure, 4/10/2000. Water Pollution Control Program, Missouri Department of Natural Resources, Jefferson City, Mo.

Soil Test Interpretations and Recommendations Handbook, rev. 12/92. Department of Agronomy, University of Missouri.

Table 2. Nitrogen supplied by legumes for a succeeding crop (optimum).

Legume crop	**Nitrogen added (lb/acre)**
Alfalfa	
80–100% stand	120–140
50–80% stand	40–60
less than 50%	0–20
Sweet clover (green manure)	100–120
Red clover (pure stand)	40–60
Soybeans	50–60

Source: MU publication G9174, *Nitrogen in Missouri Soils*

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