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1991

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COOPERATIVE EXTENSION SERVICE—GREAT PLAINS STATES

GREAT PLAINS
BEEF CATTLE HANDBOOK

GPE-7601

Fertilization Of Crops With Feedlot Manure

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The application of animal manure to farmland is an appropriate and environmentally sound management practice for most feedlot operators. Land application returns nutrients from manure to the soil and helps build and maintain soil fertility. In addition to containing nitrogen, phosphorus and potassium, manure contains trace elements such as calcium, magnesium, iron and zinc. Manure has also been shown to improve soil tilth, increase water-holding capacity, lessen wind and water erosion and improve aeration. Land application of manure should be viewed as a means to utilize crop nutrients present in the manure for crop production rather than utilizing the land as a means of disposal.

The economic value of feedlot manure as fertilizer is usually calculated on the basis of its N, P_2O_5, and K_2O content. Manure containing significant amounts of runoff or dilution water may also serve as an irrigation water source where needed. Although the nutrient content of this water is usually low, it should be regarded as a fertilizer source. In such cases, calculation of the value of the manure and wastewater for crop production must include both the nutrient and water value.

A number of factors must be considered when determining the amount of manure each soil is capable of handling without damage to the soil and to the surrounding environment. These factors include soil type, topography of the land, cropping system, and the nutrient and salt content of the manure and wastewater to be applied.

The rate of manure and wastewater application depends upon whether one wants to maximize the recovery of plant nutrients or the amount of manure that can be applied per unit of land area. Where an adequate land base exists, all attempts should be made to maximize nutrient recovery by application rates consistent with crop utilization rates. However, where a large concentration of cattle is maintained on a relatively small land base, manure application rates may be designed to maximize the application rate while avoiding any deleterious effects on the land.

Nutrient Content of Manure

The nutrient content of livestock manure is highly variable, depending on type of ration, animal age and species, manure handling method and other factors. Samples of manure should be analyzed immediately prior to land application to determine the level of plant nutrients, and salts as well, and thereby provide a basis for determining suitable land application rates. Private testing laboratories are available to perform analyses of this type. When an actual analysis is not available, the values in Table 1 can be used for estimating the nutrient content of feedlot manure.

Table 1. Chemical Analysis of Manure Samples from 23 Feedlots.

	Range[a] %	Average[a] %	Pounds Per Ton (Dry Weight)
Nitrogen (N)	1.16-1.96	1.34	40.9
Phosphate (P_2O_5)[b]	0.74-1.96	1.22	37.2
Potash (K_2O)[c]	0.90-2.82	1.80	54.9
Calcium (Ca)	0.81-1.75	1.30	39.7
Magnesium (Mg)	0.32-0.66	0.50	15.3
Iron (Fe)	0.09-0.55	0.21	6.4
Zinc (Zn)	0.005-0.012	0.009	0.3
Sodium (Na)	0.29-1.43	0.74	22.6
Moisture Content	20.9-54.5	34.5	—

[a]Based on wet weight as obtained from feedlot (34.5% average moisture content).
[b]To convert P_2O_5 to elemental P, multiply by 0.44.
[c]To convert K_2O to elemental K, multiply by 0.83

Source: Mathers, A. C., B. A. Stewart, J. D. Thomas and B. J. Blair. 1973. Effects of Cattle Feedlot Manure on Crop Yields and Soil Conditions. Technical Report No. 11. USDA Southwest Great Plains Research Center, Bushland, Texas.

The availability of phosphorus and potassium in livestock manure is about equal to that of commercial fertilizer. Nitrogen availability during the year of application varies greatly and ranges from about 30 percent for well-aged manure to as much as 60 to 80 percent for fresh manure. The availability of nitrogen in solids from housed facilities, settleable solids from open feedlot runoff or solids from an open feedlot is about 50 percent of that in mineral fertilizers during the first year of application. The percentages of nitrogen available from beef feedlot manure following application have been estimated and are listed in Table 2. Differences in availability of fresh and stockpiled feedlot manure are primarily due to nitrogen volatilization losses associated with stockpiling.

When feedlot manure is surface spread much of the nitrogen is lost due to the volatilization of ammonia. This is particularly true with manure which has a large percentage of nitrogen in the ammonia form. Research at both Pennsylvania and Wisconsin have suggested nitrogen losses of 25 percent in 1 day and 45 percent in 4 days for surface spread manure. These losses can even be higher under warm, dry weather conditions. Ammonia volatilization is a disadvantage if efficient nitrogen utilization is the goal, but it can be beneficial if there is concern about excessive nitrogen application and potential leaching of nitrate nitrogen into the groundwater. To retain the nitrogen, surface applied manure should be incorporated into the soil immediately. In addition to reducing the nitrogen loss, incorporation also reduces the possibilities of odor, surface water pollution and fly emergence.

Table 2. Percentage of Nitrogen That Becomes Available Each Year Following Application.

	Manure Type	
Year of application	*Beef Fresh*	*Beef Feedlot Stockpiled*
	(%)	
1	50	35
2	15	10
3	5	5
4	4	3
5	4	2

Source: R. G. Hoeft. 1977. Guidelines for applying animal waste to land. Proc. 1977 Livestock Waste Mgt. Conf. Univ. of Ill. at Ubrana-Champaign.

Land Application Rates

Feedlot manure is beneficial to most crops. Silage crops (corn or sorghum) recycle nutrients well because they produce more plant material and harvesting the silage removes more nutrients from the land application area than other crops. Annually cultivated crops are well adapted to manure application because the manure can be incorporated into the soil before planting or after harvest.

To make efficient use of the crop nutrients in feedlot manure, application rates should not exceed the agronomic nitrogen rate, which is defined as the annual application rate of available nitrogen that is required for a reasonable anticipated crop yield. In most cases the phosphorus applied will exceed the crop requirements if the agronomic nitrogen rate is met. Thus, in order to make the best use of phosphorus resources it may be advisable to apply manure at the agronomic phosphorus rate. In the event that phosphorus rates are used, supplemental nitrogen from commercial fertilizer will generally be needed to meet the agronomic nitrogen requirement. Agronomic fertilization rates for various crops are given in Table 3.

Table 3. Agronomic Fertilization Rates for Various Crops.

	Pounds of Nutrient		
Crop	*Available N*	P_2O_5	K_2O
Corn for grain	1.3/bu	.55/bu	0.28/bu
Corn silage	7.5/T	3.1/T	9.4/T
Wheat (1)	2.3/bu	0.68/bu	2.0/bu
Oats (1)	1.1/bu	0.40/bu	1.5/bu
Barley (1)	1.5/bu	0.55/bu	1.0/bu
Rye (1)	2.2/bu	0.69/bu	1.8/bu
Grain sorghum for grain	2.0/100 lbs	0.75/100 lbs	0.38/100 lbs
Grain sorghum for silage	7.5/T	3.1/T	9.4/T
Tall fescue	39/T	19/T	53/T
Bromegrass	33/T	13/T	51/T
Sorghum-Sudan	40/T	15/T	59/T
Orachard Grass	50/T	17/T	63/T
Timothy	38/T	14/T	63/T
Reed Canary Grass	55/T	13/T	50/T
Alfalfa	(2)	10/T	60/T
Clovers	(2)	15/T	60/T
Soybeans	(2)	1.1/bu	2.4/bu

(1) If straw is removed.
(2) Legumes can obtain most of their N from the air and are normally not fertilized with N. However, if included in a crop rotation with nitrogen using crops, they wcll use the available N in the soil and not fix N from the air. Therefore, it can be assumed they will remove as much N as corn for grain in the same rotation. This information is general in nature and may not reflect an accurate recommendation for all areas or soil types of the Region. In order to obtain more accurate recommendations for phosphorus and potassium, soil testing should be done.

Source: Illinois Environmental Protection Agency, 1976. Design Criteria for Field Application of Livestock Waste. WPC-2.

Feedlot manure application rates are generally calculated on a dry weight basis. Normally feedlot manure contains from 10 to 60 percent water depending on whether the material has been stockpiled or taken directly to the field. For a given nitrogen concentration in the manure, a higher moisture content means that more wet manure must be applied than dry manure to obtain the desired nitrogen application rate. If a moisture analysis is unavailable, a simple method of estimating water content is to weigh wet manure and then spread it on a sheet of plastic to air dry. When it has dried, weigh it again and calculate the original moisture content as follows:

$$\text{Percent moisture} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$

The application rate of feedlot manure to cropland can be calculated as follows:

Assume: Beef feedlot manure:
1.0% N, dry weight basis (Use

Table 1 if an analysis is unavailable)
20% moisture
Crop to be grown and expected yield
Corn
120 bushels/ac

a) Amount of nitrogen needed = expected yield × agronomic fertilization rate (Table 3)
= 120 bu/ac × 1.3 lb/bu
= 156 lb/ac

b) Tons of dry manure to obtain required nitrogen = pounds nitrogen needed divided by nitrogen content, divided by 2000 lb/ton

$$= \frac{156 \text{ lb/ac}}{0.01 \times 2000 \text{ lb/ton}}$$
= 7.8 ton/ac

c) Adjustment for percentage of available N = Tons needed divided by percent N available the first year (Table 2)

$$= \frac{7.8 \text{ ton}}{0.50}$$
= 15.6 tons dry manure

d) Adjustment for moisture content = dry weight needed divided by 100 percent minus the moisture content

$$= \frac{15.6 \text{ ton}}{1.00-0.20} = \frac{15.6}{0.8}$$
= 19.5 tons of manure

This one-time application of 19.5 tons of manure per acre will also supply approximately 47 pounds of nitrogen during the year following application (15.6 ton × 2000 lbs/ton × .01 × .15 = 46.8 lb), 16 pounds the second year following application and 13 pounds the third year following application. These calculations assumed that the manure is to be incorporated soon after application so nitrogen volatilization losses will be minimal.

Since the decay process affecting the availability of nitrogen is influenced by a number of factors, soil tests, in addition to a manure analysis, are recommended for determining the amount of nitrogen to be applied. If tests are unavailable, Table 4 lists annual manure application rates to obtain desired nitrogen avplication rates.

Table 4. Dry manure application rates to insure 50, 100, 150 or 200 pounds of available nitrogen per acre.

Available Nitrogen (lb/ac)	Nitrogen in Manure (% d.b.)	Year of application* 1	2 (ton/ac)	3	4
50	3	1.7	1.2	1.2	0.9
	2	2.5	1.8	1.7	1.6
	1	5.0	3.5	3.5	3.2
100	3	3.3	2.3	2.3	2.1
	2	5.0	3.5	3.5	3.2
	1	10.0	7.0	6.9	6.4
150	3	5.0	3.5	3.5	3.2
	2	7.5	5.3	5.2	4.6
	1	15.0	10.5	10.4	9.7
200	3	6.7	4.7	4.6	4.3
	2	10.0	7.0	6.9	6.4
	1	20.0	14.0	13.8	12.8

* Percentage of nitrogen that becomes available each year following application is assumed to be 50, 15, 5, 4 for the first four years. Actual availability of nitrogen will vary depending on initial nitrogen concentration, climatic conditions and cropping practices.

Figuring the Value of Manure

The value of the manure should be calculated on the basis of the needed plant nutrients supplied plus some allowances for improving soil properties such as tilth and water intake rate. Thus, the value of manure varies with its nutrient content and the land need.

The value of nutrients needed and supplied by the manure should be the price that the nutrients would cost when purchased as commercial fertilizer. Assuming unit prices for nitrogen, phosphate and potash of 19, 19 and 7 cents per pound, respectively, dry feedlot manure having average N-P-K concentrations illustrated in Table 1 would be worth about $18 per dry ton. However, many soils in the Great Plains Region derive practically no benefit from phosphorus and potassium additions. If phosphorus and potassium are not needed then the value of manure is approximately $7.70 per dry ton.

Precautions

As feedlot manure undergoes microbial decomposition, many types of salts are released. Some are absorbed by the soil while others remain in the soil solution. Salt accumulation from high application rates can adversely affect seed germination and plant growth by reducing the plant's capacity to utilize soil water. Soluble salts from feedlot manure can also build up to high concentrations in the seed zone in the upper lister bed following furrow irrigation. On the other hand, rainfall or sprinkler-applied irrigation water tends to move the salts deeper into the profile, thus reducing the salinity hazard. Winter and spring rains will generally reduce the salinity problem with fall applied manure. However, some additional nitrogen loss should be anticipated with fall application of manure.

Applications of manure at agronomic rates generally will not create salinity problems. Although crops have been grown on land receiving large manure applications, annual application rates in excess of 20 dry tons per acre can only be routine recommended in unusual situations accompanied by manure and soil analyses.

Weed infestations have frequently been credited to manure use. The number of viable weed seeds in feedlot manures is greatly reduced by the heating and cracking processes involved in grain ration processing. However, roughages may contain weed seeds that could eventually be carried to the fields in viable condition. The hazard of weed seed dissemination in manure is lessened when manure is stockpiled and allowed to undergo heating and some degree of decomposition before field application.

Summary

Land application of feedlot manure at agronomic rates generally results in high utilization of manure nutrients. At the same time, potential environmental problems are minimized. Feedlot manure analyses in addition to soil analyses are recommended for determining correct application rates. Other variables which influence the manure application rate are percentage of available nitrogen, moisture content and manure incorporation practices.

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