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Nutrient and Fertilizer Value of Dairy Manure

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Livestock manure has been an asset to crop production since the beginning of organized agriculture. Because these excretions from cattle contain several essential plant nutrients, they contribute to increased crop yields when properly applied to soils. Thus, dairy and other livestock producers can use manure as a valuable source of fertilizer nutrients for crops.

Manure can benefit a farm fertilization program. Besides providing valuable nutrients to the soil, including many micronutrients, manure also supplies organic matter. The organic matter improves soil tilth, aids in the retention of water and nutrients, lessens wind and water erosion and promotes growth of beneficial organisms.

Nutrient Values for Dairy Manure

Nutrient content of manure from dairy cattle is affected by a variety of factors, many of which are related to a specific farming operation. Some of these factors include method of storage, type of manure application system, housing and bedding system, diet of the cattle and environmental temperature. All of these factors affect the amounts of nitrogen (N), phosphorus (P), potassium (K) and micronutrients in the manure, as well as its net value.

Tables are available that estimate the amount of nutrients in the manure. Since each accumulation of manure is unique, the table values are only meant to be approximate and variations are expected. Table 1 contains values from liquid and solid manure handling systems for dairy cattle. Since several thousand pounds or gallons of manure are applied per acre, small deviations caused by under- or overestimations of the composition of manure can result in significant differences in nutrients for fertilizer.

Table 1. Average nutrient composition of manure from dairy cattle. (Adapted from Midwest Plan Service)

	Nutrients (lbs/ton)		
Handling system	**N**	**P_2O_5**	**K_2O**
Solid system	11	5	11
Semi-liquid	5 (26)[1]	2 (11)	4 (23)

[1]lbs/1,000 gallons

The most reliable and accurate way to determine the nutrient content of a particular farm's manure is to have a sample of the manure analyzed by a laboratory. This method eliminates the numerous approximations made by using table values. Most soil testing laboratories do manure testing for a nominal charge. The ideal time to sample the manure is just prior to

Portions of this fact sheet were adapted from *Manure Management in Minnesota*, AG-FO-3553, Minnesota Extension Service, St. Paul, by Michael A. Schmitt and *Dairy Manure Management: Strategies for Recycling Nutrients to Recover Fertilizer Value and Avoid Environmental Pollution*, Circular 1016, Florida Cooperative Extension Service, Gainesville, by H. H. Van Horn et al.

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or at spreading. For liquid manure systems, it is important that the pit be agitated vigorously before sampling so samples of top water and settled solids are blended, while for solid manure, several cores should be taken throughout the manure. Good sampling procedures are necessary since the nutrients in manure are not distributed evenly between the liquid and solid portions. Dried manure has organic matter and a composition similar to very poor quality hay (Table 2).

Table 2. Composition of dried manure.[1]

Component	% of Dry Matter
Ash	13.3-13.4%
Nitrogen	1.2-1.6%
NDF	77.7-83.5%
ADF	50.5-52.7%
Cellulose (ADF-ADL)	35.4%
Hemicellulose (NDF-ADF)	32.0%

[1]Similar to poor quality hay

Dairy cows excrete 223-260 lbs N, 40-69 lbs P_2O_5 and 88-146 lbs K_2O per year in manure, depending on many factors but primarily on how much they eat. In total, the value may be over $100 per 1,400 lb cow each year (Table 3). However, all of these nutrients are not available for use as nutrients on crops, especially N. Also, nutrients such as P and K may be of adequate levels in the soil, which will decrease their economic value in the manure. Moreover, in select cases, P may exceed recommended levels in the soil and should not be applied to soil, either as manure or commercial fertilizer.

Table 3. Amount and value of manure/dairy cow.

223-260 lbs N @ $0.29/lb	N = $72
40-69 lbs P_2O_5 @ $0.24/lb	P_2O_5 = $14
88-146 lbs K_2O @ $0.14/lb	K_2O = $16
Total value	$102/cow/year potential value

The actual value of the manure is also affected by the degree of handling to get it to the crop and the specific crop grown as crops vary in composition (Table 4). Often, the costs of transporting manure to the crop may be almost equal to the value of the manure as fertilizer. In addition, the value of manure as fertilizer for the crop is affected by the runoff of nutrients from the land, method of storage of the manure (Table 5) and method of applying manure to the land (Table 6). Although N is almost always needed for plant growth, the value of P, and sometimes K, may be limited because of the presence of excessive nutrients in the soil as determined by soil tests.

Table 4. Composition and estimated uptake of nutrients by crops (per ton of dry matter).

Crop	Composition (% DM)			Nutrient Uptake Per Acre (lbs)		
	Crude Protein	P	K	N	P_2O_5	K_2O
Alfalfa [1,2]	20.8	0.34	2.80	333	78	337
Bermuda [1]	14.6	0.21	1.92	234	48	231
Corn Silage [1]	8.3	0.27	1.22	133	62	147
Fescue [1]	9.8	0.30	2.51	157	69	302
Sorghum [1] Forage	7.9	0.32	1.80	126	73	217
Soybean [1,2] Forage	15.8	0.47	1.04	253	108	125
Cotton [3,4]	---	---	---	176	52	154
Rice [3,5]	---	---	---	112	60	168
Soybean Grain [2,3,6]	---	---	---	288	53	188

[1] Assuming 5 ton DM yield/acre
[2] A legume which can fix nitrogen from the air and does not require all N as fertilizer
[3] Plant is usually separated into seed and other products, some of which may be left on the land.
[4] Assuming 1,100 lb yield/acre
[5] Assuming 7,000 lb yield/acre
[6] Assuming 55 bu yield/acre

Note: Figures are estimates for the yield indicated and should be used only as general guidelines.

Table 5. Nitrogen losses in storage.

Method of Storage	% N Loss
Daily scrape and haul	15-35%
Open lot	40-60%
Earthen storage	20-40%
Lagoon	70-80%

Table 6. Nitrogen losses during application.

Method of Application	% N Loss
Broadcast liquid (spread)	10-25%
Broadcast solid	15-30%
Inject in soil	1-5%
Sprinkler-liquid	30-40%

P and K Availability

The total amount of nutrients in manure is not as important as the availability of the nutrients. Nutrients, such as N and P, which are in some organic portions of the manure, are not available until they are transformed into inorganic nutrients. The confusion as to the available versus unavailable, organic versus inorganic and liquid versus solid fractions of manure makes rate calculation difficult. Generalized statements for P and K are straightforward: 70-80% of the P and 70-90% of the K in animal wastes is available the first year. Therefore, when using a generalized table or a laboratory report, multiply the P and K values by these constants to determine your first year's amounts of available fertilizer. If manure is applied each year over a number of years, the full amount of P and K can be assumed available due to mineralization of previously applied nutrients.

N Availability

The availability of N is more complex in manure than it is for P or K. Of all the nutrients in manure, N has the greatest potential both for adversely affecting the environment and for increasing crop yields. It is important to understand all forms of N when using manures since they are continually changing.

The two main forms of N in manure are the organic N, which is also designated unavailable N, and ammonium N, which is the predominate component of available N. Although manure also contains nitrate N and ammonia N, these forms comprise a relatively small fraction of the inorganic N. Sometimes nitrite N and ammonia N can cause germination problems when seeds are planted too close to concentrated zones of manure.

Organic N

When manure is applied to soil, the organic N begins to break down to inorganic N that is available to plants. This process is termed ammonification or mineralization. Between 33-50% of the organic N will be converted to ammonium N each year after the manure is applied. This value is affected greatly by the method of application (Table 5).

The residual capacity of manure's organic N can last for several years. Second and third year contributions from the manure's organic N should be accounted for. If 50% of the organic N will become available each year and if a specific manure sample contains 50% organic N, the second year's N credit should be 12% of the total N and the third year's N credit should be 6%.

Ammonium N

Besides the organic N fraction of manure, the other major portion of the manure N is ammonium N. When organic N is converted to available N, it starts as ammonium N. Ammonium N, which is available to plants, is immobile in the soil and is not subject to any loss mechanisms. However, in very dry environments, most of the N in one year may not be available the following year due to losses discussed below.

One other important N loss mechanism is volatilization. When manure is exposed to the atmosphere, the small amount of ammonia N is quickly lost to the air by volatilization. As time progresses, however, the ammonium N can chemically convert to ammonia N and be lost. This loss is a function of temperature and time. Incorporation of the manure into the soil eliminates this concern.

In addition to the method of application (Table 5) and storage (Table 6), other factors also influence the N loss potential from manure applications. These factors include rainfall amounts and soil characteristics, such as texture and organic matter levels. Application of manure on wet soils will increase potential losses of N from denitrification, and application during periods of high rainfall will increase losses due to leaching. Coarse-textured soils favor leaching losses and fine-textured soils favor denitrification losses.

Time of Application

One other factor regarding N availability from manure applications is the time of application. Many times the logistics of the dairy operations, with their

Table 7. Estimated N availability as a function of soil properties, environment and application time and method for first year after application and assumption that 50% of the N is organic and 50% N is inorganic.

Organic Matter	Time of Application	Soil Texture	Rainfall	Application Methods			
				Broadcast w/o Incorporation	Broadcast w/Incorporation	Knife Injection	Sweep Injection
				- % of N -			
Low	Fall	Coarse	Low,Norm	30	55	45	55
			High	20	45	40	45
		Fine	Low,Norm	35	60	50	60
			High	30	55	45	55
	Spring	Coarse	Low,Norm	40	55	50	55
			High	35	50	45	50
		Fine	Low,Norm	45	55	45	55
			High	45	55	40	50
High	Fall	Coarse	Low,Norm	30	35	50	60
			High	25	40	40	50
		Fine	Low,Norm	35	55	45	55
			High	35	50	40	50
	Spring	Coarse	Low,Norm	40	50	50	55
			High	35	45	45	50
		Fine	Low,Norm	40	50	45	55
			High	40	50	40	50

unique handling systems, etc., determine when the manure must be applied to the soil. **Always be a good neighbor and consider events in the area and wind velocity and direction when spreading manure.**

Fall applications of manure, either injected or broadcast, allow more time for the organic portions of the manure to degrade before the plant needs the nutrients. However, fall applications provide more time for potential loss of N from any of the processes. Fall applications of manure should be avoided on coarse-textured soils where leaching can be a threat to the environmental quality of the region.

Manure applied in the spring has the least amount of time for loss potential to occur. However, the rapid breakdown surge in the spring is more likely to temporarily bind up some of the otherwise available N in the soil, thus creating some short-term N imbalances.

Table 7 shows estimated N availability by season and method of application. While application of manure to frozen cropland or pasture may be required at times, the practice is not encouraged. It also is essential that application of manure to coarse, sloping land, which is typical of Northwest Arkansas, be conducted to maximize uptake by crops and minimize runoff.

Demonstrations With Wet and Dry Manure Systems

Demonstrations were conducted to determine the economic value of manure from two dairy farms in Arkansas. One dairy had a wet manure management system with a lagoon. It had 120 milking cows, which were held in the holding pen for 3 hours per day or 1 1/2 hours per milking. The other dairy had a dry waste management system with 80 cows that were either in the holding pen or adjacent feeding floor for about 6 1/2 hours per day.

In the wet system, the 120 dairy cattle produced $1,091.70/year in value of manure in 3 hours in the holding pen (Table 8). However, if 20% of the N is lost in applying the manure (20% of $626.40 = $125.28) and the P is not needed (value of $194.40), then the net value of the manure as fertilizer is $772.02 for 120 cows in 3 hours ($1,091.70 - $125.28 - $194.40). **Over 24 hours, this value would be $6,176.16 or $51.47/cow/year (Table 10).**

Table 8. Value of wet manure from 120 cows in 3 hours = $1,091.70/year.

Nutrient	Gallons (x 1,000)	Lb/1,000 gallons	$ per lb	Value ($)
N	450	4.8	$0.29	$626.40
P_2O_5	450	1.8	$0.24	$194.40
K_2O	450	4.3	$0.14	$270.90

In the dry waste management system, the 80 dairy cattle produced $1,610.23/year in value of manure in 6 1/2 hours in the holding pen and feeding floor (Table 9). If 20% of the N is lost in application (20% of $1,610.23 = $154.42) and the P is not needed (value of $496.70), the net value of the manure or fertilizer is $959.11 ($1,610.23 - $154.42 - $496.70). **For 24 hours, the value becomes $3,541.33 or $44.27/cow/year, assuming that the 80 cows produced manure uniformly throughout the day as they did for the 6 1/2 hours near the milking center (Table 10).** These values do not consider the costs of handling the manure for storage or application to the crops.

Table 9. Value of dry manure from 80 cows in 6 1/2 hours = $1,610.23/year.

Nutrient	Gallons (x 1,000)	Lb/1,000 gallons	$ per lb	Value ($)
N	52	51.2	$0.29	$772.10
P_2O_5	52	39.8	$0.24	$496.70
K_2O	52	46.9	$0.14	$341.43

Table 10. Value of manure produced on a dry or wet manure management system.

Values	Wet System w/120 Cows for 3 Hours	Dry System w/80 Cows for 6 1/2 Hours
Total value	$1,091.70/year	$1,610.23/year
Total value/cow	$9.10/year	$20.13/year
Net value[1]	$772.02/year	$959.11/year
Net value[1]/cow	$6.43/year	$11.99/year
Projected total value for 24 hrs[2]	$8,733.60/year	$5,945.46/year
Projected total value/cow for 24 hrs[2]	$72.78/year	$74.32
Projected net value for 24 hrs[1,2]	$6,176.16	$3,541.33
Projected net value/cow for 24 hrs[1, 2]	**$51.47**	**$44.27**

[1]Assuming 20% loss of N in application and no value for phosphorus.
[2]Assuming that manure production is similar throughout the 24 hrs.

Summary

The use of manure as fertilizer has been beneficial to forage and crop production. However, the type of manure and method of application determine the quantity of nutrients available to the plant. In general, about 50% of the value of the nutrients or about $50 per cow may be useful as fertilizer. There are also costs associated with storing and applying the manure. In some circumstances, dairy manure may be of greater value on cropland that has not traditionally been fertilized with manure.

When applying the manure to a field, always consider environmental conditions and be considerate of your neighbors.

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