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G97-1335 Determining Crop Available Nutrients from Manure

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Determining Crop Available Nutrients from Manure

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This NebGuide discusses the availability and utilization of manure nutrients for field crop production.

When managed correctly, nutrients in livestock manure can be a valuable resource. When managed improperly, however, these same nutrients represent a potential environmental pollutant. Accurate crediting of manure nutrients within a total crop nutrient program is fundamental to utilizing manure as a resource. This NebGuide illustrates how to estimate the crop available manure nutrients *(parts c, Figure 1)* and calculate an agronomically based manure application rate. A complimentary NebGuide, G97-1334, discusses total manure nutrients produced *(part a, Figure 1)* and manure nutrients available after storage losses *(parts b, Figure 1)*. To illustrate this process, example calculations are provided and a worksheet is included allowing you to complete the calculations as well.

To accurately credit crop available manure nutrients, a producer needs three pieces of information:

1. Manure nutrient concentration at time of land application - the concentration individual nutrients in manure measured as pounds of nutrient per unit of manure (ton, 1,000 gallons or acre-inch).
2. Manure application rate - the rate at which manure is applied to the land measured as tons, 1,000 gallons or acre-inches per acre.
3. Manure nutrient availability factors - the percentage of nutrients in manure available to the crop in a given year.

Estimating Manure Nutrient Concentration

Knowing the concentration of nutrients in manure is as crucial as knowing those facts about commercial fertilizer. *Table I* provides estimates of typical manure nutrient concentrations. Because manure nutrient content can vary with livestock species, manure moisture, livestock diet and collection and storage losses, a manure analysis is preferable to using table values for an accurate estimate. Where manure is stored outdoors, sampling on a seasonal basis (when significant quantities of manure are land applied) is recommended.

Many soil test laboratories will run a manure analysis. This test should include:

- *Both ammonium-nitrogen and organic-nitrogen* (or total nitrogen). Knowing two of the three values means you can calculate the third.
  Total-N = Ammonium-N + Organic-N
- Nitrogen is excreted in two forms *(Figure 2)*. About one-half of the excreted nitrogen is a stable organic-nitrogen present in the feces. The other half is excreted as urea in urine, which decomposes rapidly to ammonium-N (NH_4^+).
- *Phosphorus and potassium as* P_2O_5 *and* K_2O *equivalents.*
- *Nutrients in the same units of measure as you calibrate your manure application system.* If manure application is measured by tons per acre, request the analysis be reported as pounds of nutrient per ton.
- *Nutrients on a "wet" or "as is" basis* since you are spreading wet manure.

Estimating Manure Application Rate

If manure nutrients are to be managed as a nutrient resource, the application equipment must be managed as a fertilizer applicator. Knowledge of manure application rate, like knowledge of fertilizer application rate, is key to managing nutrients applied to crops. Manure application rate

Figure 1. Three key estimates needed to use manure nutrients as a resource.

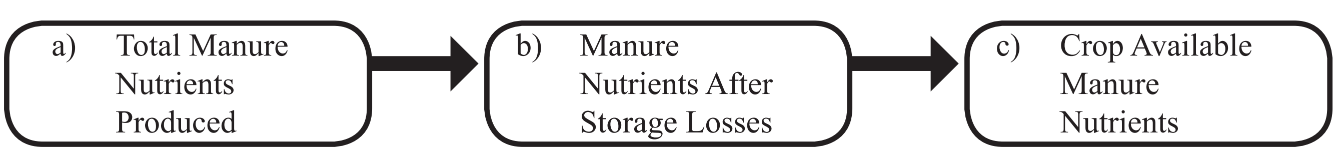


Table I. Typical nutrient content of manure. Because of variability between farms, individual manure analysis is preferable to the estimates below.

Species	*% Dry Matter*	*Nitrogen Ammonium-N*	*Organic-N*	*P_2O_5*	*K_2O*
Slurry Manure (lbs. of nutrient per 1000 gallons of manure)					
Dairy	7	9	13	14	20
Beef	12	14	20	22	31
Swine	5	17	10	19	15
Layer	11	37	20	51	33
Dairy (lagoon sludge)	10	4	17	20	16
Swine (lagoon sludge)	8	6	19	52	76
Beef (runoff pond sludge)	17	10	42	40	17
Solid Manure (lbs. of nutrient per ton of manure)					
Beef (dirt lot)	59	5	20	18	22
Beef (paved lot)	29	5	9	9	13
Swine	18	6	7	13	9
Dairy	22	3	8	7	9
Broiler (litter from house)	79	14	57	69	47
Layer (scrapped)	35	14	14	31	20
Turkey (grower house litter)	73	12	43	63	40
Liquid Effluent from lagoon or holding pond (lbs. of nutrient per acre-inch)					
Beef (runoff holding pond)	0.3	41	4	10	203
Swine (lagoon)	0.25	50	29	17	86
Dairy (lagoon)	0.25	27	18	13	113

Source: USDA SCS Agricultural Waste Management Field Handbook (1992) and Livestock Manure Nutrient Assessment in North Carolina (1995) by J. C. Barker and J. P. Zublena.

can be estimated by one of the following:

1. Using one of the calibration methods detailed in *NebGuide G95-1267, Manure Applicator Calibration.*
2. Maintaining a record of total manure applied to a field (i.e. total number of loads × average capacity ÷ the field's area).

Estimating Crop Available Nutrients

Manure application rate and a manure analysis provides the information needed to estimate total manure nutrients applied. The "total manure nutrients" available, however, is less important than "crop available nutrients". The process for estimating crop available nutrients is illustrated in *Figure 2*. A worksheet for completing the calculations *(Table II)* will assist in making this estimate.

Some manure nutrients are either undigested or partially digested which become available slowly through mineralization in the soil. Mineralization is a process by which soil microorganisms decompose organic nutrients into a mineral inorganic, or plant available form. An estimate of crop available phosphorus and potassium is reasonably simple. Seventy percent of the phosphorus and 70 to 90 percent of the potassium is available to the crop during the year it is applied.

Determining nitrogen availability, however, is more complex. The availability of ammonium and organic-nitrogen for specific livestock species, application methods and other factors can be found in *Figure 2*. Ammonium and organic-nitrogen originate from the urine and feces respectively. The ammonium fraction's availability to the crop (left-hand box, *Figure 2*) depends upon both the time between manure application and incorporation into the soil and the temperature. If manure is surface applied, ammonium (NH_4^+) is converted over several days to ammonia (NH_3^-) and lost by volatilization. Warmer temperatures accelerate this loss. If manure is mixed into the soil, the ammonium either is directly available to the plants or converts to another plant available form, nitrate-nitrogen (NO_3^-).

Organic-nitrogen is mineralized to ammonium over several years at a rate affected by soil temperature, soil moisture, the characteristics of the manure and other factors. During the cropping season following application, between 25 and 50 percent of the organic-nitrogen is available (middle box, *Figure 2*). Over the next several years, additional organic-nitrogen is mineralized to crop-available forms in decreasing amounts (right hand box, *Figure 2*). For example, mineralization of stored swine manure will be approximately 35 percent, 12 percent, 5 percent and 2 percent of the organic-nitrogen during the year manure is applied, one year later, two years later and three years later, respectively.

Calculating Crop Available Nutrients

At this point, information should have been collected for 1) nutrient concentration of the manure, 2) manure application rate for the current year and the past three years, and 3) availability of organic-nitrogen, ammonium-nitrogen, phosphorus, and potassium. *Table II* can now be used to complete a calculation for crop available nutrients. For crop available nitrogen in *Table II*, follow these steps:

1. Select the units used to measure manure application rate. Replace all "?" within the calculations with either tons, 1,000 gallons or acre-inches of manure or effluent.
2. Enter the manure application rate and nutrient concentration and calculate total nitrogen application.
3. Enter the total nitrogen application and manure nutrient fraction available, and calculate the available nitrogen for ammonium, organic-N and organic-N from past applications separately.
4. Sum the estimated available nitrogen from ammonium, organic-N, and organic-N from past applications.

An example is presented in *Table II* for cattle feedlot manure applied at a rate of 28 t/ac this year and two years ago. Manure is disked into the soil within 24 hours. The producer's manure analysis indicates nutrient concentrations of 5 lb. of NH_4^+/ton, 13 lb. of organic-N/ton, 12 lb. of P_2O_5/ton and 21 lb. of K_2O/ton.

A much simpler estimate of crop available phosphorus and potassium can also be completed in Step 5. The results of these calculations can be summarized in Step 6.

Soil Testing and Crop Monitoring

The previous procedures have provided a "calculated" estimate of nutrient availability from manure. Soil testing provides a "field measurement" of residual nutrients. For a producer who regularly soil tests, is this calculated estimate necessary?

A deep soil test measures soil nitrate-N at the time of sampling. The above calculations estimate organic and ammonium nitrogen accessible to the crop through the growing season. Although most manure nitrogen will eventually be converted to nitrate nitrogen, this has not happened at the time soil samples are typically taken (fall, winter, or early spring). A soil test for nitrate nitrogen will not account for the nitrogen available from manure. Thus, the "field measured" and "calculated" values are independent sources of nitrogen and should be added together.

The amount of manure nitrogen credit is an estimate based on average conditions. An alternative strategy is the presidedress nitrate test (PSNT) which may be a more accurate predictor of when manure release is sufficient to produce maximum yields in corn. The PSNT test is a one-foot soil sample taken in early June or at the 6 to 8 leaf stage. The soil is analyzed for nitrates. By this time of the growing season, manure nitrogen is mineralizing to nitrate. In Iowa and other states a soil nitrate level of over 25 ppm is usually sufficient for maximum corn production.

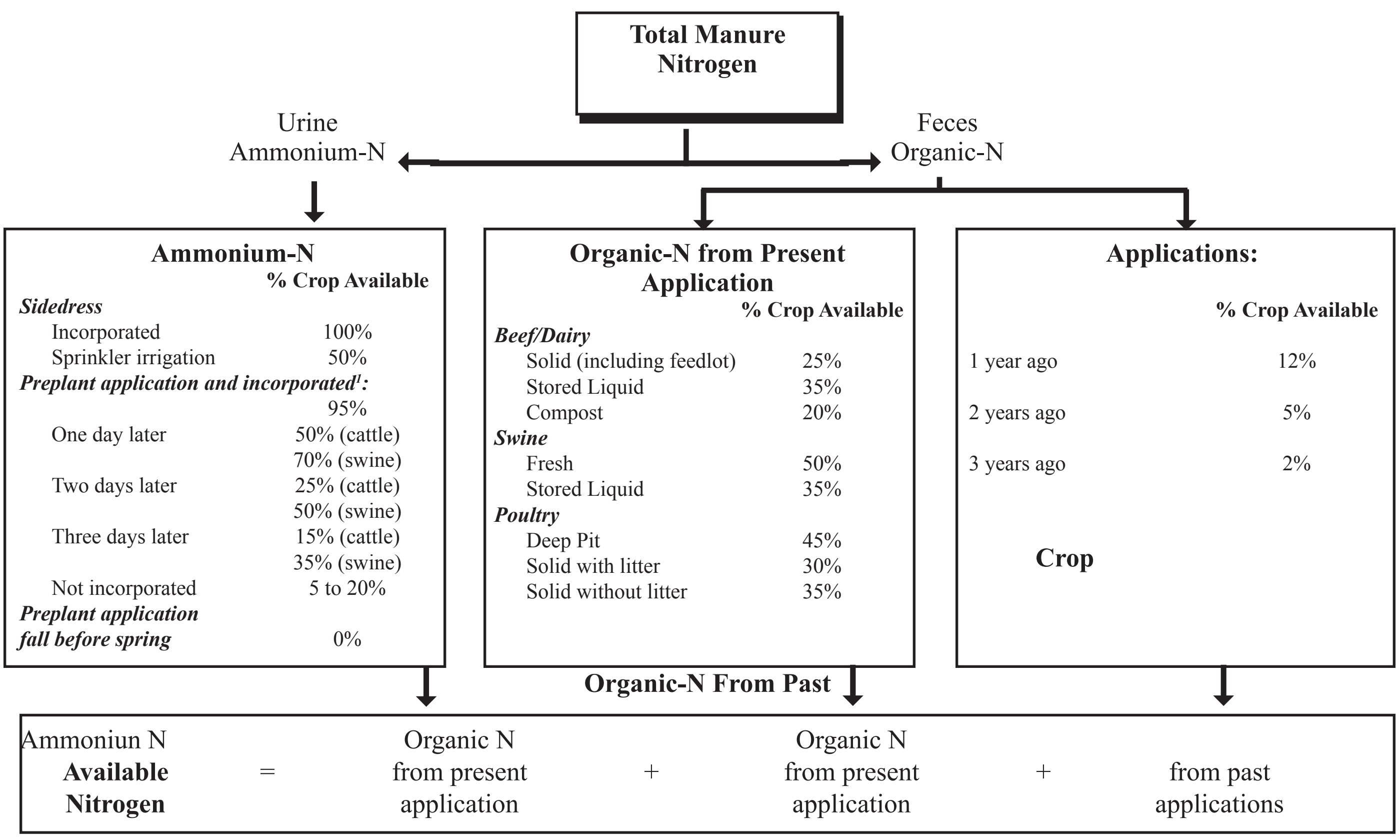
Corn can be monitored to determine if a nitrogen deficiency is developing by use of a chlorophyll meter (see *NebGuide G93-1171, Using a Chlorophyll Meter to Improve N Management*). Under irrigated conditions additional nitrogen can be applied when needed with the irrigation system. In the near future remote sensing may allow monitoring of nitrogen status without the need to sample individual plants.

Phosphorus and potassium application needs can be determined by soil testing. Regular soil testing of fields receiving manure will document phosphorus and potassium status.

Using any one of these techniques or a combination will allow more accurate crediting of manure nutrients with confidence. The "calculated" estimate of manure nitrogen will remain an important pre-growing season planning tool for manure nutrient sources.

Once the available nutrients are determined, the next step is to fit this information into a nutrient management plan. The *NebGuide G74-174, Fertilizer Suggestions for Corn*, details how to determine the total nutrients needs based on soil tests and yield expectation. The *NebGuide G94-1178, Fertilizer Nitrogen Best Management Practices,* details how to give credit for irrigation water, previous crop and organic amendments.

Figure 2. Crop available nitrogen is a sum of available organic-N from present and past applications and ammonium-N.



Crop available P_2O_5 = P_2O_5 Manure Analysis X 0.7 Crop available K_2O = K_2O Manure Analysis X 0.8

[1]Incorporation can be accomplished by tillage or rainfall of one-half inch or greater.

Table II. Planner for estimating crop available nutrients. An example is presented for cattle feedlot manure. Enter your own numbers in the boxes provided.

Step 1. Is manure measured in:

_____ ton (solid or semi solid manure)?
_____ 1,000 gallons (slurry or liquid)?
_____ acre-in (lagoon or holding pond effluent)?
(**Replace "?" with appropriate unit of measure**.)

Step 2. Calculate total manure nitrogen applied

Total Ammonium-N

Manure Rate (?/acre)	X	NH_4 From Analysis (lb./?)	=	Total (lb/acre)
	X		=	

Total Organic-N from Present Application

Manure Rate (?/acre)	X	Organic-N From Analysis (lb./?)	=	Total (lb/acre)
	X		=	

Total Organic-N from Past Applications

	Manure Rate (?/acre)	X	Organic-N From Analysis (lb./?)	=	Total (lb/acre)
1 year ago:		X		=	
2 years ago:		X		=	
3 years ago:		X		=	

Step 3. Calculate crop available nitrogen applied.

Part 2. Crop Available Ammonium-N

Total (lb/acre)	X	Fraction Available[a]	=	Available (lb/acre)
	X		=	

[a]Left box of *Figure 2*

Part 2. Crop Available Organic-N From Present Application

Total (lb/acre)	X	Fraction Available[b]	=	Available (lb/acre)
	X		=	

[b]Middle box of *Figure 2*

Part 2. Crop Available Organic-N From Past Applications

	Total (lb/acre)	X	Fraction Available[c]	=	Available (lb/acre)
1 year ago:		X	0.12	=	
2 years ago:		X	0.05	=	
3 years ago:		X	0.02	=	

[c]Right box of Figure 2

Step 4. Sum crop available nitrogen applied

Part 3. **Crop Available Manure Nitrogen Applied**

Ammonium	+	Organic-N	+	Residual Organic-N	=	Crop Available Nitrogen
	+		+		=	lbs. N/acre
						lbs. N/acre

Step 5. Calculate available phosphate and potash at known manure application rate.

P_2O_5 concentration in manure: __________ lb/?

K_20 concentration in manure: __________ lb/?

lb P_2O_5/?	X	?/acre	X	% available	=	lb P_2O_5/acre
	X		X	0.7	=	

lb K_20/?	X	?/acre	X	% available	=	lb K_20/acre
	X		X	0.8	=	

Step 6. Summarize crop available manure nutrients for selected application rate: __________ ?/ac.

Available Manure Nitrogen	Available Manure P_2O_5	Available Manure K_20
lb/acre	lb/acre	lb/acre
lb/acre	lb/acre	lb/acre

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