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Determining Crop Available Nutrients from Manure

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This NebGuide discusses the availability and use 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 *(part c, Figure 1)* and calculate an agronomically based manure application rate. 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 of concentration at time of land application — the concentration of 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.
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.

A manure analysis 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 calibrating application equipment on a wet manure basis.

Additional information on manure sampling is available from *Sampling Manures for Nutrient Analysis* (NebGuide G1450) and *Manure Testing: What to Request?* (NebFact NF507).

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.

	% Dry Matter	*Nitrogen*			
		Ammonium-N	*Organic-N*	*P_2O_5*	*K_2O*
Slurry Manure		(lbs. of nutrient per 1,000 gallons of manure)			
Dairy	8	12	13	25	40
Beef	29	5	9	9	13
Swine (finisher, wet-dry feeder)	9	42	17	40	24
Swine (slurry storage, dry feeder)	6	28	11	34	24
Swine (flish building)	2	12	5	13	17
Layer	11	37	20	51	33
Dairy (lagoon sludge)*	10	4	17	20	16
Swine (lagoon sludge)	10	6	16	48	7
Solid Manure		(lbs. of nutrient per ton of manure)			
Beef (dirt lot)	67	2	22	23	30
Beef (paved lot)*	29	5	9	9	13
Swine (hoop barns)	57	4	13	20	
Dairy (scraped earthen lots)	46	3	14	11	16
Broiler (litter from house)	70	15	60	27	33
Layer	40	18	19	55	31
Turkey (grower house litter)	70			15	30
Liquid Effluent from lagoon or holding pond		(lbs. of nutrient per acre-inch)			
Beef (runoff holding pond)	0.25	71	8	47	92
Swine (lagoon)	0.40	91	45	104	189
Dairy (lagoon)	2	317	362	674	1082

Value based upon ASAE, 2005, D384.2; Manure Production and Characteristics with exception of those "*".

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 can be estimated by one of the following:

1. Using one of the calibration methods detailed in *Nebraska CNMP Application Workbook* (EC720), pp. 87-88, available online at *http://cnmp.unl.edu/landapplication workbook.html.*
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," 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 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.

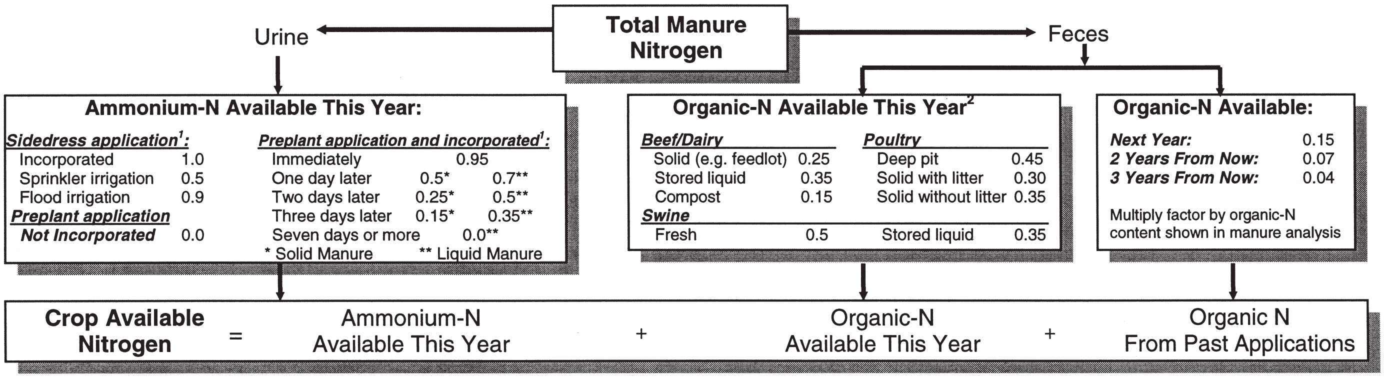
Determining nitrogen availability, however, is more complex. The availability of ammonium and organic-nitrogen for specific livestock species, application methods and other factors can be found in *Figure 2*. Ammonium and organic-nitrogen originate from the urine and feces respectively. The ammonium 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 environmental conditions. 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, 15 percent, 7 percent and 4 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 determining 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.



[1]Incorporation can be accomplished by tillage or by a 0.50 inch or greater rainfall.

[2]Organic-N availability assumes spring seeded crops such as corn and soybeans. For winter or spring manure application prior to planting small grains, multiply organic-N availability factor by 0.7.

Figure 2. Availability factors for manure nitrogen.

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 future 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. 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. NebGuide G174, *Fertilizer Suggestions for Corn*, details how to determine the total nutrients needs based on soil tests and yield expectation. The *Nebraska CNMP Application Workbook* (EC720) provides reference tables for nutrient recommendations for many common crops.

Additional Resources

All University of Nebraska–Lincoln resources for nutrient management planning can be found online at *http://cnmp.unl.edu.* The Web site contains software tools, sample records, regulatory information, and other tools associated with nutrient management planning. Of particular value are two software tools, UNL's Manure Use Planner and Purdue's Manure Management Plan. These tools can be downloaded at no cost from the CNMP Web site.

NOTE: Use your Adobe Reader® to fill in the blanks in the following form and print out the results. Use the Tab key on the computer keyboard to move through the form. The form will automatically calculate equation solutions. The file cannot be saved to your computer, but can be completed and printed to create a record.

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

Print Blank Form

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**.)

Check one.

Step 2. Calculate total manure nitrogen applied.

Total Ammonium-N

Manure Rate (?/acre) (lb/acre)	X	NH_4 From Analysis (lb./?)	=	Total (lb/acre)
28 t/ac	X	5 lb/t	=	140
				0

From Manure Analysis: 5 lb. NH^4 / ton

Total Organic-N from Present Application

Manure Rate (?/acre)	X	Organic-N From Analysis (lb./?)	=	Total (lb/acre)
28 t/ac	X	13 lb/t	=	364
				0

From Manure Analysis:
13 lb. organic N/ton (this year)
11 lb. organic N/ton (2 years ago)

Total Organic-N from Past Applications

	Manure Rate (?/acre)	X	Organic-N From Analysis (lb./?)	=	Total
1 year ago:	0	X		=	0
					0
2 years ago:	28 t/ac	X	11 lb/t	=	308
					0
3 years ago:	0	X		=	0
					0

Step 3. Calculate crop available nitrogen applied.

Part 2. Crop Available Ammonium-N

Total (lb/acre)	X	Fraction Available[a]	=	Available (lb/acre)
140	X	0.5	=	70
0				0

[a]Left box of *Figure 2*

Incorporated within 24 hours of application

Part 2. Crop Available Organic-N From Present Application

Total (lb/acre)	X	Fraction Available[b]	=	Available (lb/acre)
364	X	0.25	=	91
0				0

[b]Middle box of *Figure 2*

Beef feedlot manure

Part 2. Crop Available Organic-N From Past Applications

	Total (lb/acre)	X	Fraction Available[c]	=	Available (lb/acre)
1 year ago:	0	X	0.15	=	0
	0		0.15		0
2 years ago:	308	X	0.07	=	22
	0		0.07		0
3 years ago:	0	X	0.04	=	0
	0		0.04		0

[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
70	+	91	+	22	=	183 lbs. N/acre
0		0		0		0 lbs. N/acre

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

P_2O_5 concentration in manure: 12 lb/t ____ lb/? K_20 concentration in manure: 21 lb/t ____ lb/?

lb P_2O_5/?	X	?/acre	X	% available	=	lb P_2O_5/acre
12 lb/t	X	28 t/ac	X	0.7	=	235
				0.7		0

lb K_20/?	X	?/acre	X	% available	=	lb K_20/acre
21 lb/t	X	28 t/ac	X	0.8	=	470
				0.8		0

Step 6. Summarize crop available manure nutrients for selected application rate: 28 t/ac ____ **?/ac.**

Available Manure Nitrogen	Available Manure P_2O_5	Available Manure K_20
183 lb/acre	235 lb/acre	470 lb/acre
0 lb/acre	0 lb/acre	0 lb/acre

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