

LAND APPLICATION OF ANIMAL MANURE

Animal manure can be an economical source of crop nutrients. There are three key steps to utilizing manure in an environmentally and economically sound manner:

- know the nutrient content of the manure,
- apply a uniform rate based on crop nutrient needs, and
- adjust the rate of supplemental fertilizer to compensate for the nutrients applied in the manure.

Use of manure and fertilizer as nutrient sources for crop production must be managed properly to ensure that they do not contaminate ground or surface water.

Nutrient Content

Nutrient content of animal manure is variable, depending on the type and age of animal, feed source, housing type, handling method, temperature, and moisture content. Because of this variability in nutrient content, individual land application decisions should be based on the nutrient content of the manure to be applied.

Average nutrient contents (Tables 1 and 2) are useful in determining overall waste management plans, but should not be used to determine actual land application rates. Application rates are usually based on nitrogen (N), phosphorus (P expressed as P_2O_5) and/or potassium (K expressed as K_2O) contents. Quantities of secondary and micronutrients applied in manure are generally sufficient to prevent deficiency.

Why Measure the Nutrient Content of Manure?

Not knowing the nutrient content of the manure to be applied can result in large errors in application rate. For instance, the plant-available N content of broiler litter can easily range from 25 to 50 lb N/ton. To supply 125 lb N/acre to a corn crop, 5 ton/acre of the low N litter is needed, but only 2.5 ton/acre of the high N litter is required. If 5 ton/acre of the high N litter were applied, an extra 125 lb N/acre would be added to the soil, wasting valuable nutrients and increasing the potential for ground and surface water contamination. Two and one-half ton/acre of the low N litter would only provide 63 lb N/acre and would be insufficient to produce the intended yield.



What Happens When I Stockpile Manure?

Stockpiling solid manure uncovered and exposed to rainfall results in a reduction in the N and K_2O content. Also, the manure becomes sticky and difficult to spread uniformly. Leaching of N and run-off of N and P from the stockpiled manure may pollute ground and surface water.

Manure Sampling

Nutrient analysis of animal manure for land application can be obtained from the Agricultural Service Laboratory, Cooperative Extension Service, Cherry Road, Clemson, SC 29634-0391. Analyses include moisture, organic-N, ammonium-N, available-N, P_2O_5 , K_2O , calcium (Ca), magnesium (Mg), sulfur (S), zinc (Zn), copper (Cu) and manganese (Mn). The fee is \$10 to \$15 per sample and depends on the analyses requested.

Obtaining a representative sample is one of the most important tasks in manure management because application rates are based on the concentration of nutrients in the manure. Samples should be taken as close as possible to the time of application. If several weeks elapse between sampling and land application, or if the manure gets altered by rainfall or manure additions, another sample should be obtained.

To take a representative sample, obtain a quart of waste from 15 to 20 locations in the pile or lagoon and place in a large clean plastic bucket. Mix this bulk sample thoroughly, then place about a quart in a clean plastic bag or bottle. Seal tightly, but leave room for the sample to expand. Keep the sample cool. If the sample is not mailed to the laboratory on the same day it is sampled, it should be refrigerated.

Nutrient Availability

Although manure application rates are usually based on N availability, managing manures for their P_2O_5 and K_2O contents can also be important. The availability of P_2O_5 and K_2O in manures in the year of application is similar to that of fertilizer sources, so basing application rates

Improper storage of manure can result in water pollution. The nutrient content of the manure, as well as the ability to spread it uniformly, are reduced with rainfall.

Table 1. Nutrient content of different sources of animal manure.

MANURE TYPE AND HANDLING	INFO. SOURCE	TOTAL N	AMMONIUM-N	PHOSPHORUS P ₂ O ₅	POTASSIUM K ₂ O
BROILER		----- lb/ton -----			
all types	a	51	13	64	48
fresh (no litter)	b	26	10	17	11
broiler litter	b	72	11	82	46
roaster litter	b	73	12	75	45
breeder litter	b	31	7	54	31
stockpiled litter	b	36	8	80	34
all types	d	59	15	63	40
TURKEY		----- lb/ton -----			
all types	a	61	18	57	41
fresh (no litter)	b	27	8	25	12
brooder litter	b	45	9	52	32
grower litter	b	57	16	72	40
stockpiled litter	b	36	8	72	33
LAYER		----- lb/ton -----			
all types	a	35	14	42	28
fresh (no litter)	b	26	6	22	11
under cage scraped	b	28	14	31	20
highrise stored	b	38	18	56	30
all types	d	39	15	57	30
		----- lb/1000 gallon -----			
liquid slurry	b	62	42	59	37
anaerobic lagoon sludge	b	26	8	92	13
		----- lb/acre-inch -----			
anaerobic lagoon liquid	b	179	154	46	266
SWINE		----- lb/ton -----			
fresh	c	12	7	9	9
scraped	c	13	7	12	9
		----- lb/1000 gallon -----			
liquid slurry	c	31	19	22	17
anaerobic liquid sludge	c	22	6	49	7
all types	d	40	19	37	23
		----- lb/acre-inch -----			
anaerobic lagoon liquid	c	136	111	53	133
DAIRY		----- lb/1000 gallon -----			
all types	d	28	11	19	25
HORSE		----- lb/10 ton -----			
all types	d	90	6	58	109

a - Data compiled by J. J. Camberato, Extension Agronomist, 1990-91.

b - Soil Facts-Poultry Manure as a Fertilizer Source. North Carolina Agricultural Extension Service Fact Sheet AG-439-5.
J. P. Zublena, J. C. Barker, and T. A. Carter.

c - Soil Facts-Swine Manure as a Fertilizer Source. North Carolina Agricultural Extension Service Fact Sheet AG-439-4.
J. P. Zublena, J. C. Barker, and J. W. Parker.

d - Using Manure to Cut Fertilizer Costs. University of Maryland Cooperative Extension Service Fact Sheet 512. V. Allan Bandel.

on the manure's P₂O₅ and K₂O content should be adequate. Determine how much P₂O₅ and K₂O are applied in the manure and supplement with fertilizer, if necessary. On soils testing high in P₂O₅ and K₂O (no P₂O₅ and K₂O recommended from soil test), consider using the manure on other fields requiring P₂O₅ and K₂O. Incorporation of the manure into the soil as soon as possible and controlling erosion and runoff minimizes the impact of P on

surface water quality.

Nitrogen availability from animal manure is difficult to predict. Availability of N is dependent on release of N from the waste and loss from the soil. Nitrogen is in manure in three forms—organic, ammonia/ammonium, and nitrate. The quantity of each is difficult to predict because of the dependence on the same environmental factors that affect nutrient content. The three

Table 2. Secondary and selected micronutrient content of different sources of animal manure

MANURE TYPE AND HANDLING	INFO. SOURCE	Ca	Mg	S	Mn	Zn	Cu
BROILER		— — — — — lb/ton — — — — —					
all types	a [†]	41	8	12	0.5	0.5	1.0
broiler litter	b	41	8	15	0.7	0.6	0.5
roaster litter	b	43	9	14	0.7	0.7	0.5
breeder litter	b	94	7	9	0.6	0.5	0.2
stockpiled litter	b	54	8	12	0.6	0.6	0.3
all types	d	30	13	10	0.4	0.4	0.3
TURKEY		— — — — — lb/ton — — — — —					
all types	a	32	7	10	0.7	0.6	0.6
brooder litter	b	28	6	8	0.5	0.5	0.4
grower litter	b	42	7	10	0.7	0.6	0.5
stockpiled litter	b	42	7	10	0.6	0.6	0.3
LAYER		— — — — — lb/ton — — — — —					
all types	a	85	5	6	0.4	0.3	<0.1
under cage scraped	b	43	6	7	0.3	0.3	<0.1
highrise stored	b	86	6	9	0.5	0.4	<0.1
all types	d	101	14	6	0.2	0.2	0.1
		— — — — — lb/1000 gallon — — — — —					
liquid slurry	b	35	7	8	0.4	0.4	0.1
lagoon sludge	b	71	7	12	2.3	0.8	0.1
		— — — — — lb/acre-inch — — — — —					
lagoon liquid	b	25	7	52	0.2	0.7	0.2
SWINE		lb/ton					
fresh	c	8	2	2	<0.1	0.1	<0.1
paved lot scraped	c	12	2	2	0.2	0.4	0.2
		— — — — — lb/1000 gallon — — — — —					
liquid slurry	c	9	3	5	0.2	0.4	0.1
lagoon sludge	c	16	5	8	0.3	0.7	0.2
all types	d	11	8	5	0.1	0.3	0.1
		— — — — — lb/acre-inch — — — — —					
lagoon liquid	c	26	8	10	0.3	1.5	0.3
DAIRY		— — — — — lb/1000 gallon — — — — —					
all types	d	23	7	3	0.1	<0.1	<0.1
HORSE		— — — — — lb/10 ton — — — — —					
all types	d	156	62	16	0.8	0.1	0.1

[†]See footnotes following Table 1.

forms of N have different plant availabilities and are lost from the soil in different ways.

Often, organic-N is the predominant form of N in animal manure. Organic-N is not available to crops until it has been decomposed to ammonium. The speed and extent of degradation are dependent on the type of manure, soil type, soil moisture and temperature and how well the manure is mixed with the soil. Estimates of organic-N availability range from 30 to 80 percent of the organic-N available in the first cropping season. We are currently assuming an average of 60 percent availability of organic-N from animal manure in the first cropping season after incorporation. Since many factors influence the decomposition rate of organic-N, its actual decomposition can be more or less than this estimate. Organic-N is lost from the soil only by erosion.

Do we Get Any Benefit From The Manure After The First Cropping Season?

The organic-N that is not decomposed to ammonium in the first cropping season may be released in subsequent seasons. Unfortunately, there is not enough research to make recommendations on how much becomes available. There is probably little N released after the first season from one-time applications at rates to provide the crop N requirement in the first season. However, for fields with a long-term manure history—annual applications for five years or more—the amount of N released from previous seasons' applications may be significant.

Considerable quantities of ammonia/ammonium N occur in most manures.

Ammonia (NH_3) is a gas, and ammonium (NH_4^+) is a charged molecule dissolved in the soil water. Ammonia and NH_4^+ are rapidly interchangeable, dependent on the pH of the solution. Increasing pH increases the amount of NH_3 and decreases NH_4^+ . Most crops will take up NH_4^+ as well as any other form of N but do not accumulate NH_3 to any extent. Ammonia is readily lost to the atmosphere from the soil. As much as 15 percent of the NH_3 from surface applied manure can be lost each day with breezy, warm, moist conditions on sandy soils with a high pH. Considerable losses of NH_3 can occur when manure is applied to pasture. Leaching losses of NH_4^+ from soil are small.

How Fast Is NH_4 Converted To The Leachable Form Of Nitrogen--Nitrate?

Ammonium does not persist in soils in South Carolina if soil temperatures exceed 40°F , because it is rapidly converted to nitrate (NO_3^-). For example: Dairy wastewater high in NH_4^+ was applied to the soil in February. Within twelve days after application, most of the NH_4^+ had been converted to NO_3^- . (Fig. 1)

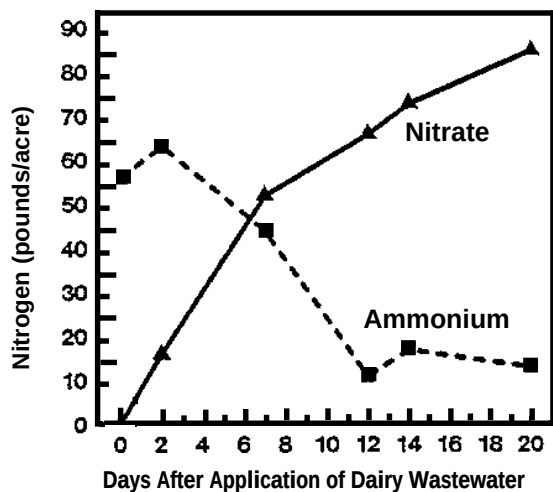


Figure 1. Changes in soil nitrate and ammonium after an application of dairy wastewater in February containing 56 lb/acre of organic-N and 56 lb/acre of ammonium-N.

Some NO_3^- is found in manure but usually not much. However, the fate of NO_3^- is important, because organic-N and NH_4^+ are converted to NO_3^- . Although NO_3^- is readily accumulated by crops, it can be lost from the soil by two ways. Excess rainfall or irrigation that results in water movement through the crop rooting zone will result in loss of NO_3^- by leaching. When soils are saturated, but leaching does not occur, NO_3^- can be converted to several gaseous N forms and lost to the atmosphere.



Incorporate as soon after application as possible to conserve nitrogen and phosphorus and reduce odors and flies.

These processes can occur readily; therefore, it is best to apply manure or fertilizer to provide N at the time the crop's requirement for N is greatest.

Application Rates

The rate of manure applied is usually based on the plant-available N content of the manure and the recommended N rate for the crop to be grown. Available-N is calculated as 60 percent of the organic-N and 80 percent of the NH_4^+ for the first year after application, if the manure is incorporated into the soil immediately. Plant-available NH_4^+ should be reduced 15 percent per day for every day the manure remains unincorporated. Recommended N rates for crops are as low as 70 lb N/acre for cotton and tobacco to as much as 400 lb N/acre for bermudagrass hay. A portion or all of the crop's N need can be provided with manure. If manure rates provide more available-N than is required by the crop, excess NO_3^- in the soil may contaminate groundwater, if rainfall or irrigation leach it from the rooting zone.

Use the worksheet at the end of this circular to assist you in determining the proper application rate.

Application rates of solid manures are determined in one of two ways. The most common method is to weigh a truck load of manure, spread it until the truck is empty, determine the acres spread, and then calculate the rate of application. An alternative method is to spread several plastic sheets on the soil surface, weigh the manure that lands on each sheet, and then calculate the rate. Although both methods give an average rate of application, the second method measures the variability of the application and allows one to spread the first truck load of manure at the intended rate.

Are Applications Of Manure Variable?

The rate of poultry manure applied by several South Carolina farmers was measured by the sheet method (Table 3). The actual application rate was significantly less than the farmers intended, and the range in application rates from place to place in the field was generally two-fold. Determining the application rate, as well as the nutrient content, of manure enables one to add known amounts of plant nutrients.

Table 3. Rates of Manure Application Fall 1990

LOCATION	TARGET RATE	ACTUAL RATE	RANGE IN RATE	NO. TIMES MEASURED
————TON/ACRE————				
LAYER MANURE				
McCormick	3.0	1.8	1.3 - 2.6	4
Greenwood 1	2.5	1.4	0.9 - 2.0	4
Greenwood 2	3.0	4	2.0 - 6.4	10
Darlington	3.0	3.2	1.5 - 4.6	4
Lee	4.0	1.3	0.7 - 1.6	6
BROILER/TURKEY MANURE				
Newberry 1	2.5	2.7	1.4 - 3.9	6
Newberry 2	5.0	3.8	3.4 - 4.1	2
Clarendon	4.5	3.4	2.6 - 5.0	10
Lee 1	2.5	0.5	0.2 - 2.0	5
Lee 2	2.5	0.9	0.5 - 1.0	6

Liquid manure application rates can be determined by knowing the quantity of liquid applied to a known acreage or measuring the inches of liquid applied with a rain gauge. One acre-inch of liquid is equivalent to 27,154 gallons. Variability of liquid manure application rate can be high and is dependent on the type of application equipment.

Uniform application of manure is important, because managing the crop will become more difficult as variability increases. Variability in application often leads to over-fertilization of the majority of the field to compensate for small areas receiving inadequate nutrient supplies.

Determining the Dollar Value of Manure Nutrients

The value of manure nutrients is dependent on the nutrient status of the field to which it is applied, the nutrient needs of the crop to be grown, the nutrient content of the manure, and the cost of purchased nutrients. For example: A farmer has three fields of different fertility status—testing low, medium and high for P and K. The farmer wishes to grow 120 bu/acre corn and follows Clemson's nutrient recommendations. The farmer has poultry manure with a nutrient content of 40 lb available-N/ton, 60 lb P_2O_5 /ton, and 40 lb K_2O /acre. The farmer applies 3 ton manure/acre to provide all of the N needed to grow the crop. Purchased N, P_2O_5 , and K_2O cost 24, 24, and 18 cent/pound, respectively. The value of the manure per ton for each field can be calculated using the formulas on page 6.

When applying manure at a rate to satisfy the N needs of a crop, P_2O_5 and K_2O are usually applied in excess of need. The value of manure as a nutrient source is greatest when applied to a soil of low fertility status. Excess nutrients are not given any value. Hauling and application costs were not considered in this analysis but should be determined on an individual basis.

Plant and Soil Analysis

Because of the uncertainty in decomposition of organic-N in manure, as well as unquantifiable losses of NH_3 and NO_3^- , it is recommended that the N status of the crop be monitored with plant and soil analysis. Sampling representative plant tissues on a regular basis—every two weeks, for instance—gives one the ability to track the nutrient status of the plant and take corrective measures, if necessary. Repeated sampling is most often used to follow the N status of the plant, because soil tests for N are not currently available. For small grains and corn, the part to be sampled and sufficiency ranges for several nutrients, including N, are published in Clemson University Extension Information Leaflets 34 and 42, available from your County Extension Office.

To determine



Use some method to calibrate your spreader so you can add the proper amount of nutrients to each field. This is the plastic sheet method.

Soil Testing Low in P + K

NUTRIENT	RECOMMENDED APPLICATION	AMOUNT APPLIED WITH MANURE	VALUE	EXCESS NUTRIENTS
	—————lb/acre—————		\$/3 ton	lb/acre
N	120	120	$120 \times .24 = 28.80$	0
P ₂ O ₅	80	180	$80 \times .24 = 19.20$	100
K ₂ O	80	120	$80 \times .18 = 14.40$	40

The nutrient value of this manure on a soil testing low in P and K is \$20.80/ton. When the manure is added to a low fertility soil, 80 lb/acre of P₂O₅ and K₂O are recommended from soil analysis and credited with value.

Soil Testing Medium in P + K

NUTRIENT	RECOMMENDED APPLICATION	AMOUNT APPLIED WITH MANURE	VALUE	EXCESS NUTRIENTS
	—————lb/acre—————		\$/3 ton	lb/acre
N	120	120	$120 \times .24 = 28.80$	0
P ₂ O ₅	50	180	$50 \times .24 = 12.00$	130
K ₂ O	50	120	$50 \times .18 = 9.00$	70

The nutrient value of the manure on a soil testing medium in P and K is \$16.60/ton. Partial credit is given to the P and K content of the manure, because only 50 lb P₂O₅ and K₂O/acre were recommended from soil analysis.

Soil Testing High in P + K

NUTRIENT	RECOMMENDED APPLICATION	AMOUNT APPLIED WITH MANURE	VALUE	EXCESS NUTRIENTS
	—————lb/acre—————		\$/3 ton	lb/acre
N	120	120	$120 \times .24 = 28.80$	0
P ₂ O ₅	0	180	$0 \times .24 = 0$	180
K ₂ O	0	120	$0 \times .18 = 0$	120

The nutrient value of the manure on a soil testing high in P and K is \$9.60/ton. In this situation, no credit is given to the P and K content of the manure, because no P and K were recommended from soil analysis.

the sufficiency of nutrients other than N, it is acceptable to take diagnostic tissue samples. These samples should be taken once a season at easily identified crop growth stages, such as heading for small grains and silking for corn. The sufficiency range for the plant tissue sampled will be included with the plant analysis. Yearly sampling can be used not only to assess the level of several nutrients in that year, but to follow changes in soil fertility over several seasons.

Currently, there are no guidelines for determining if soil supplies of N are adequate for crop growth. However, soil sampling of the root zone and determination of NO₃⁻ can be useful. Several of the requirements for taking a representative soil sample for NO₃⁻ analysis are the same as those for taking traditional soil samples. Fields should be separated into different

soil types. Areas that were cropped, fertilized, or manured differently should be sampled separately. Soil samples should represent no more than 10 acres, and each sample should be comprised of fifteen or more cores.

The major differences between soil sampling for NO₃⁻ analysis and traditional soil sampling are the depth and time of sampling and sample handling. Nitrate is easily leached from the sandy surface soil but can accumulate in the clay subsoil. Because of this, NO₃⁻ samples need to be taken deeper than the traditional 6-inch soil sample and as close to fertilization time as possible.

Soil samples for NO₃⁻ analysis should represent a major portion of the crop rooting zone, which is at least 3 feet for most crops. The samples should be taken in one-foot increments to a

depth of 3 feet. Each one-foot sample should be sent to the laboratory as a separate sample. Soil samples for NO_3^- analysis should be spread thinly to air dry within one hour of sampling. This minimizes changes in NO_3^- content that will occur in moist soil. After the samples have dried, send them to a soil testing laboratory and request a NO_3^- analysis or use a portable NO_3^- test kit. The results will be reported in ppm (parts per million) of NO_3^- -N. Multiply the ppm value for each one-foot increment by 4 to convert the results into lb N/acre. Add the lb N/acre in each increment to determine the total NO_3^- -N content of the entire sampling depth. This will serve as an indicator of whether excess N is being applied.

How Do I Calculate The Amount Of NO_3^- -N Available To My Crops From Soil NO_3^- Analysis Results?

Soil Increment	NO_3^- -N ppm	NO_3^- -N lb/acre
0-1'	2	8
1-2'	3	12
2-3'	6	24
TOTAL		44

Multiply NO_3^- -N in ppm times 4 to convert to NO_3^- -N in lb/acre when the sampling increment is 1 foot.

WORKSHEET: DETERMINING THE NUTRIENT NEEDS OF YOUR CROP*

Use this worksheet to determine how much manure to apply to your field.

	EXAMPLE	YOUR FARM
1. Crop to be grown.	corn	_____
2. Clemson nutrient recommendation based on soil test.		
a. N (lb/acre)	120	_____
b. P_2O_5 (lb/acre)	50	_____
c. K_2O (lb/acre)	50	_____
3. Nutrients applied preplant or at planting.		
a. N (lb/acre)	20	_____
b. P_2O_5 (lb/acre)	0	_____
c. K_2O (lb/acre)	0	_____
4. Net nutrient needs of crop (lb/acre).		
Nitrogen, phosphorus, and potassium: total need (item 2a,2b,2c) minus additional nutrients from preplant or at planting (item 3a,3b,3c)		
a. N: 120-20 (lb/acre)	100	_____
b. P_2O_5 : 50-0 (lb/acre)	50	_____
c. K_2O : 50-0 (lb/acre)	50	_____
5. Available nutrients in manure based on laboratory analysis.		
a. Available-N (lb/ton)	40	_____
b. P_2O_5 (lb/ton)	60	_____
c. K_2O (lb/ton)	40	_____
6. Application rate to supply priority nutrient.		
a. Priority nutrient	N	_____
b. Amount of priority nutrient needed (lb/acre from 4a)	100	_____
c. Rate of manure needed to supply priority nutrient (6b) divided by (5a): 100/40(ton/acre)	2.5	_____

RATE OF MANURE TO APPLY	EXAMPLE	YOUR FARM
7. Pounds per acre of all nutrients supplied at the application rate required to meet the needs for the priority nutrient: for each nutrient enter the available nutrients (5a,5b,5c) times manure rate (6c). a. N supplied: 40 X 2.5 (lb/acre) b. P₂O₅ supplied: 60 X 2.5 (lb/acre) c. K₂O supplied: 40 X 2.5 (lb/acre)	100 150 100	_____ _____ _____
8. Nutrient balance: net nutrient need (-) or excess (+): amount of nutrient applied by manure (7a,7b,7c) minus net amount needed by crop (4a,4b,4c). a. N balance: 100-100 (lb/acre) b. P₂O₅ balance: 150-50 (lb/acre) c. K₂O balance: 100-50 (lb/acre)	0 +100 +50	_____ _____ _____

*Calculation format adapted from SoilFacts - Poultry Manure as a Fertilizer Source. North Carolina Agricultural Extension Service Fact Sheet AG-439-5. July 1990.

Prepared by James J. Camberato, Extension Agronomist.
Funded in part by USDA Water Quality funds.

Printed on recycled paper with soy ink