ES00-049

Liquid Manure Sampling Kit Instructions

CIRCULATE LAGOON AT LEAST SIX HOURS WITH 100 HORSEPOWER AGITATOR PER ONE MILLION GALLONS OF LIQUID ANIMAL WASTE.

AFTER CIRCULATION HOLD COLLECTION TUBE OVER LAGOON AND LOWER CONE END OF TUBE SLOWLY INTO LIQUID AS FAR AS POSSIBLE. PULL RING UNTIL CONE IS SECURE INTO THE BOTTOM OF TUBE. LOCK CHAIN INTO KNOCH. REMOVE FILLED TUBE AND INSERT CONE END INTO LARGE BUCKET. RELEASE CHAIN FROM KNOCK AND LET LIQUID FLOW INTO BUCKET. POUR CONTENTS OF LARGE BUCKET INTO SMALL SAMPLE BUCKET. FOLLOW THIS PROCEDURE FOUR TO SIX TIMES TIME AROUND LAGOON. AFTER ALL SAMPLES ARE COLLECTED INTO SMALL BUCKET STIR WELL AND POUR INTO LIQUID ANIMAL WASTE SAMPLE BOTTLE PROVIDED BY THE UNIVERSITY OF KENTUCKY COLLEGE OF AGRICULTURE. LEAVE AT LEAST TWO INCHES OF SPACE IN TOP OF SAMPLE BOTTLE WHEN FILLING.

KEEP SAMPLE COOL AND SEND TO LABORATORY AS SOON AS POSSIBLE.

AFTER USE CLEAN THROUGHLY AND RETURN TO EXTENTION OFFICE. THIS IS VERY IMPORTANT SO THAT EACH SAMPLE WILL BE AS ACCURATE AS POSSIBLE.

LIQUID MANURE SAMPLING

NEED FOR MANURE TESTING:

The nutrient content of manure varies considerably. For example, the nitrogen content of broiler litter tested in the UK lab has ranged from about 25 pounds per ton to as high as 80 pounds per ton. Therefore, it is important to have samples tested when making plans to use manure as a nutrient source for crops. Annual testing of manures will be required for large concentrated animal feeding operations (CAFO's) as part of their permitting process in accordance with the new Environmental Protection Agency regulations. Also, annual manure testing is included in the best management practices for manure management in the Kentucky Agriculture Water Quality Act. This applies to all farms in Kentucky of 10 acres or more in size that use animal manures on land regardless of whether they raise animals or not.

FILLING OUT THE SAMPLE INFORMATION FORM:

Sample information forms for animal waste testing can be found at http://soils.rs.uky.edu/SAMPLE1.HTM. It is important to fill out a sample information form for every sample submitted. Make sure the county code and county sample numbers are filled in and are also marked on the sample container.

TAKING SAMPLES: Follow the instructions included with the manure sampling kit. Remember that the results can be no better than the sample submitted; so, it is very important to obtain a sample that is representative of the manure that will be applied. This will require taking several sub-samples from different areas and depths of the lagoon or holding tank. Samples should be taken as close to the time the manure will be spread as possible.

FOR LIQUID MANURES, use the one-liter plastic bottles that can be ordered on the web (www.rs.uky.edu/soils then click on County Gate. Your username is your county code number. Your password is your zip code). LIQUID MANURES SHOULD OCCUPY ONLY ONE-HALF OF THE 1 L PLASTIC BOTTLES WE PROVIDE. THE BOTTLES SHOULD THEN BE PLACED INSIDE TWO ONE-GALLON SIZE ZIPLOC BAGS. It is hazardous to open the bottles if they are more than one-half full because of the build up of gas.

GENERAL: DO NOT USE ANY OTHER CONTAINERS TO SEND IN MANURE SAMPLES, LIKE GLASS JARS, PLASTIC POP BOTTLES, ETC. Also, make sure the sample information forms are properly filled out with a county code number and county sample no. Manure samples can not be processed without this information. The sample bottle should have the same county code and county sample number placed on it so we can easily discern what sample belongs to what information sheet.

SAMPLE STORAGE AND HANDLING: Once the samples are taken, they should be sent for testing as soon as possible. Ship samples early in the week in order to avoid being held over a weekend. If samples can't be shipped immediately, they need to be refrigerated until they can be shipped.

UNIVERSITY OF KENTUCKY

College of Agriculture Cooperative Extension Service

AGRICULTURE ANIMAL WASTE SAMPLE INFORMATION SHEET

Department of Agronomy Division of Regulatory Services

Section I.

DATE SAMPLED: ___/___/___

NAME: _____

ADDRESS: _____

CITY: _____ STATE___ ZIP____

PHONE: _____

Owner's Sample ID

Section II.
Test to be made.

☐ Routine (Total N, P2O5, K20, and moisture for solids.)

Section VI. (Lab Use)

_____

Section VII. (County)

County Code

County Sample No.

Section III. TYPE OF ANIMAL WASTE

___ Poultry ___ Solid

___ Dairy ___ Liquid

___ Swine

___ Beef

Section VIII.
(Lab Use Only)

Billing Code ___

Section IV. Animal Waste Application History

Section V. Other Information.

Paid ___

_____
Signature of Extension Agent

NOTE: See back for sampling information.

COOPERATIVE EXTENSION SERVICE
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Livestock Waste Sampling and Testing

Monroe Rasnake, Agronomy; *Doug Overhults,* Agricultural Engineering; *Vern Case,* Regulatory Services

It is estimated that about 25 million tons of animal manure are currently produced on Kentucky farms each year. Most of this is deposited by grazing animals on pastures where the nutrients are recycled. However, an increasing percentage is accumulated in feed lots, barns, poultry houses, lagoons, and other facilities until it can be spread on the land.

Nutrient Value

The nutrient content of manure depends on the animal, the ration, how it is handled and stored, moisture content, and other factors. Data from several studies show there is much variability within and between sources of animal manure. The data in Table 1 illustrate average values for different sources of poultry and dairy manure.

Data from USDA Publication No. URR6. 1979 also show average nutrient contents of fresh manure from other types of animals (calculated as lb N - P_2O_5 - K_2O per ton) as follows: beef (9.1 - 14.2 - 8.4), swine (13.4 - 16.3 - 6.6), sheep (21.9 - 26.8 - 21.8), and turkeys (29.7 - 43.1 - 13.9). Obviously, animal type and source of the manure influence nutrient content. The variability of nutrient content of manures within the same animal type is shown in Table 2. These data illustrate the need for accurate sampling and analysis to determine the nutrient content of each type of manure. Other data in the literature often show differences of two to six times or more for the same nutrient in different samples of the same animal type manure.

Table 1. Average Nutrient Content of Samples as Received in Lab*

Type Manure	Source of Data	Number Samples	Water	N	P_2O_5	K_2O
			%	------ lb/ton ------		
POULTRY						
Broiler	Kentucky	47	20.5	48.2	66.8	47.0
Broiler	Alabama	147	19.7	62.6	59.4	40.2
Broiler	USDA	—	—	29.8	44.0	13.7
Layer	Kentucky	15	38.0	36.8	80.2	39.6
Pullet	Kentucky	9	27.8	29.4	45.0	28.0
DAIRY						
Stack pad	Kentucky	14	79.0	9.0	8.2	10.0
Fresh	USDA	—	—	8.2	7.3	9.4
Liquid**	Kentucky	13	—	2.8	1.6	1.8

*Kentucky samples were analyzed by UK Regulatory Services Lab. Alabama data are calculated from AGR-146, Table 1. Fresh data from "Animal Waste Utilization on Cropland and Pastureland," USDA No. URR6. 1979.

**The nutrient content of the Dairy Liquid converts to 158 lb N, 90 lb P_2O_5, and 102 lb K_2O per acre half inch of irrigation (13,577 gallons).

Table 2. Variability of Selected Animal Manure as Received and Analyzed by UK Regulatory Services

Type Manure	Number Samples	Approximate Range in Content			
		Water	N	P_2O_5	K_2O
		%	----------lb/ton----------		
Broiler	47	<10* - 60	19 - 73	13 - 90	18 - 73
Dairy, solid	14	72 - 85	6 - 13	5 - 10	5 - 20
Dairy, liquid	13	—	0.2 - 7.6	0.2 - 5.4	0.2 - 3.4

*Moisture content was not measured on very dry samples.

When to Sample

To allow time for the analyses to be completed and a decision made on application rates, livestock waste should be sampled about a month before it is to be applied. There are some disadvantages with early sampling. The nutrient content of the manure may change during storage as additional accumulation takes place, such as in beef feeding floors, broiler houses, or stack pads. In the case of lagoons, it is very difficult to take a good sample except when it is being pumped out.

Samples can be taken just before or while spreading the manure. The disadvantage is in not having the analysis to use in determining rates of application. However, nutrient estimates can be used to determine an application rate that is not likely to provide excessive amounts of nutrients. Successive sampling of the same type of manure on one's farm each year can improve these estimates. Additional nutrients can be applied later if the test results show they are needed.

How to Sample

A good sample is one that represents the particular batch of animal waste being tested. This may be one poultry house, a stack of solid manure, a storage tank, or a lagoon. Effective sampling methods will be different for each one.

Solid Wastes:

Poultry (floor grown) — Take 10 to 12 subsamples of about one pint each from different areas of the house to the full depth of accumulation. Take samples under waterers and feeders in proportion to the area they occupy.

Poultry (caged layers) — Take 10 to 12 subsamples of about one pint each from random areas under the cages to the full depth of accumulation.

Stacked manures — Take 10 to 12 subsamples of about one pint each from random areas over the entire stack. Sampling should extend as deep as possible into the stack. Do not limit your testing just to samples from the surface.

Livestock feeding areas (covered or uncovered) — Take 10 to 12 subsamples of about one pint each from random locations over the whole area. Sampling should extend to the full depth of manure accumulation.

Liquid Wastes:

Holding tanks — These need to be agitated, or stirred, to thoroughly mix the solids with the liquid to get a good sample. The sample can be taken by dipping from the tank or collecting wastes as they are pumped out. *Be careful* to avoid exposure to *toxic gases* while sampling holding tanks. Take special precautions with covered tanks or areas where ventilation is limited.

Holding ponds or lagoons — It is difficult to take representative samples from ponds or lagoons until they have been agitated and thoroughly mixed. Good samples can be taken if special sampling devices are available. These allow subsamples to be taken from different depths and various locations to collect a sample that is representative of the whole pond.

Handling Samples

Solids:

Place subsamples in a clean plastic bucket and mix thoroughly. Take a one-pint sample and put it in a clean, one-quart, self-sealing plastic bag. *Do not* fill the bag. Compress the air from the bag, seal it, and tape over the seal. Using a permanent ink marker, label the outside of the bag with the owner's name, sample identification number, type of manure, and county.

Liquids:

Place subsamples in a clean plastic bucket and mix thoroughly. Fill a clean, wide-mouth plastic bottle one-half full of the mixture. Tighten the lid and check to see that it does not leak. Using a permanent ink marker, label the bottle with the owner's name, sample identification number, type of waste, and county. Plastic bottles can be obtained from the laboratory in Regulatory Services for shipping test samples to the University of Kentucky. *Do not use glass containers for any livestock waste samples.*

Where to Send Samples and Cost of Analyses

Manure samples for analysis can be sent to commercial laboratories or to 103 Regulatory Services Building, Alumni and Shawneetown Roads, University of Kentucky, Lexington, Kentucky 40546-0275, (Attention: Soil Lab). Send samples by UPS or hand carry or mail them early in the week (Monday through Wednesday) to avoid weekends. Also, avoid holidays, which could delay delivery. The accuracy of the test depends on taking a good sample and getting it to the laboratory quickly. Include an information sheet that lists the sample identification number shown on the sample bag or bottle and the owner's address and phone number.

A test for moisture, nitrogen (N), phosphorus (P), and potassium (K) will cost $20 per sample at UK Regulatory Services. Reports are sent electronically to the County Extension Office from which the manure sample is received. The P and K will be reported as P_2O_5 and K_2O, which is the common terminology for fertilizer materials. Extension agriculture agents can advise farmers on taking samples and interpreting results.

Related Publications

AGR-146	Using Poultry Litter on Agricultural Land
AGR-146A	Calculating Rates of Poultry Litter for Crop Production
ASC-80	Fertilizer Value of Swine Manure
ID-19	Farm Manure: Production-Value-Use
AGR-165	The Agronomics of Manure Use for Crop Production

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, C. Oran Little, Director of Cooperative Extension Service, University of Kentucky College of Agriculture, Lexington, and Kentucky State University, Frankfort.
Issued: 1-97, 3000 copies.

AGR-146

COOPERATIVE EXTENSION SERVICE
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Using Animal Manures as Nutrient Sources

Monroe Rasnake, Bill Thom, and Frank Sikora

Animal manures can be an economical and effective source of crop nutrients. Land application of animal manures is also a Best Management Practice for protecting water quality when it is carried out properly. Correct land application of animal manures depends on the producer knowing:

- the manures' nutrient content.
- best application times and methods.
- availability of manure nutrients to crops.
- how to balance crop nutrient needs using manures, fertilizers, and other nutrient sources.

This publication provides information on proper use of animal manures as nutrient sources for crops.

Nutrient Content

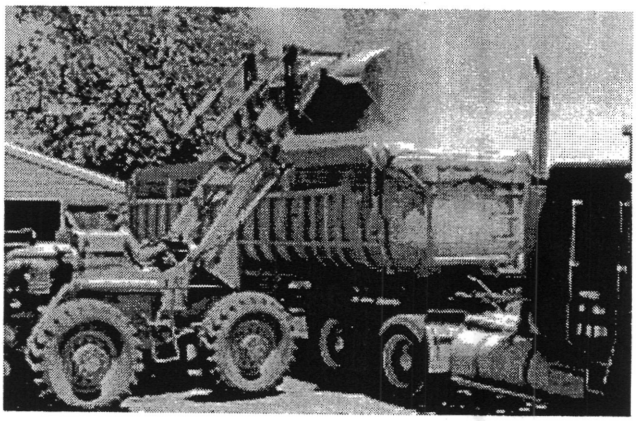
Nutrient content of manures varies, depending on the:

- type of animal.
- type and amount of bedding used.
- manure's moisture content.
- time and method of storage.

The best way to determine manure's nutrient content is to have manure samples tested as near the time of use as possible. In many cases, however, this is not practical or is nearly impossible to do. However, tabular values for the nutrient concentration of manure or the results of previous testing of similar manures can be used to determine application rates for good crop production and water quality protection.

Table 1 provides a good estimate of nutrient values of some manures available for use in Kentucky. These values should be used unless manure test results are available for the materials actually being used. Manure test data for a particular farm, either current or historical, will allow a more accurate calculation of available nutrients being applied, but Table 1 still should be used as a base reference.

It is often hard to obtain a representative sample of manures, so results that vary significantly from the values in Table 1 should be questioned. For guidelines on taking manure samples, see UK Cooperative Extension Service publication *Livestock Waste Sampling and Testing* (ID-123).



Dry manures can be transported and used economically some distance from where they are produced, but liquid manures cannot.

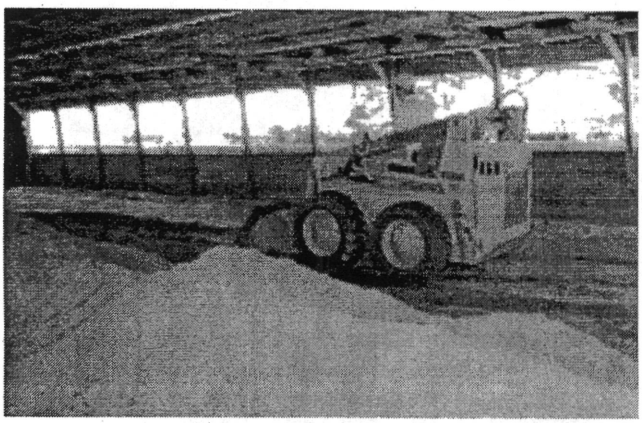
Table 1. Nutrient content of manures commonly used in Kentucky. (All values on an "as-is" moisture basis.)

		N	P_2O_5	K_2O	Moisture (%)
Solid Manures (lb/ton)					
Beef		11	7	10	80
Dairy		11	9	12	80
Swine		9	9	8	82
Broiler	(fresh)	55	55	45	20
	(stockpiled)	40	80	35	20
	(cake)	60	70	40	30
	(pullet)	40	68	40	25
	(breeder)	35	55	30	40
Layer		30	40	30	40
Liquid Manures (lb/1,000 gal)					
Holding Pit	Swine	36	27	22	96
	Dairy	31	15	19	94
Lagoon	Swine	4	2	4	99
	Dairy	4	2	3	98

Availability to Crops

Some manure nutrients are not as readily available to crops as those in commercial fertilizers, especially nitrogen. Its availability to a crop depends on:

- the crop being grown.
- the type of manure used.
- when and how the manure is applied.



Dry manures accumulating inside grower houses are protected from rain, but they need to be stored properly once removed to prevent surface and ground water contamination.

Table 2 lists nutrient availability situations most likely to occur on Kentucky farms.

Nitrogen tends to be more readily available from poultry or liquid manures than other manures, primarily because these manures have a higher nitrogen-to-carbon ratio, which increases microbial activity. However, time of application and whether or not the manure is mixed with the soil are the most important factors in nitrogen availability. Growing crops have the greatest ability to take up nitrogen, so manure applied close to the time of maximum crop growth will have the least risk of nitrogen loss.

The most extreme example of low nitrogen availability shown in Table 2 is that of manure applied in the fall with no cover crop. In that case, only 15 to 20 percent of the nitrogen remains available for the next year's corn crop. Most of the nitrogen loss from applying manure in the fall could be prevented by growing a cover crop. A cover crop would take up nitrogen as it becomes available and release it as the cover crop decomposes and the corn crop grows. Manure applied to pastures of cool-season grass in fall or early spring has a high nitrogen availability because volatilization losses are less at these times of year. Nitrogen can be taken up by the grass all year as the nitrogen is released from the decomposing manure.

Mixing of manure with the soil—especially during warm weather—increases nitrogen availability to crops, which is reflected in the coefficients in Table 2 for spring-applied manure for corn. If the manure is not incorporated within seven days of application, the nitrogen availability coefficient decreases by 15 points. As little as ½ inch of rainfall after manure is applied also helps move nitrogen into the soil and prevent its loss. Excess rainfall, on the other hand, can cause nitrogen loss through runoff or leaching. The risk of nitrogen loss is small, however, unless manure is applied on soil that is already wet or frozen.

Unlike nitrogen, phosphate is not readily lost from manure and the soil, but the availability of manure phosphate to the first year's crop is somewhat less than that of fertilizer phosphate. For this reason, the phosphate availability coefficient of manure in Table 2 is set at 80. Potash in manure is comparable in availability to fertilizer potash and is given an availability coefficient of 100.

Table 2. Percent nutrients from manure available to a crop for one year from the time of application. *Percentages are availability coeffcients as compared to commercial fertilizers.*

Nutrient	Crop	Management	Poultry or Liquid (%)	Other Manures (%)
Nitrogen	Corn or Annual Grasses, Spring Applied	2 days or less[a]	60	50
		3-4 days[a]	55	45
		5-6 days[a]	50	40
		7 or more days[a]	45	35
	Corn or Annual Grasses, Fall Applied	No cover crop	15	20
		Cover crop	50	40
	Small Grains	Applied preplant	50	40
	Pasture or Hay, Cool Season	Applied in spring or fall	80	60
	Bermudagrass	Applied spring or summer	50	40
Phosphate (P_2O_5)			80	80
Potash (K_2O)			100	100

[a] *Incorporation shown, referring to how long after application manure is mixed into the soil.*

Calculating Manure Application Rates

The rates of manure application for a particular crop depend on:

- nutrient needs of the crop based on soil test results.
- nutrients available from the manure.
- the amount of a priority nutrient to be supplied by the manure (nitrogen, phosphorus, or potassium).

The worksheet on the facing page can be used to calculate how much manure should be applied to provide the nutrient most needed by a crop. A balance sheet (Nos. 8 and 9 in the worksheet) also calculates nutrients that may need to be added from other sources.

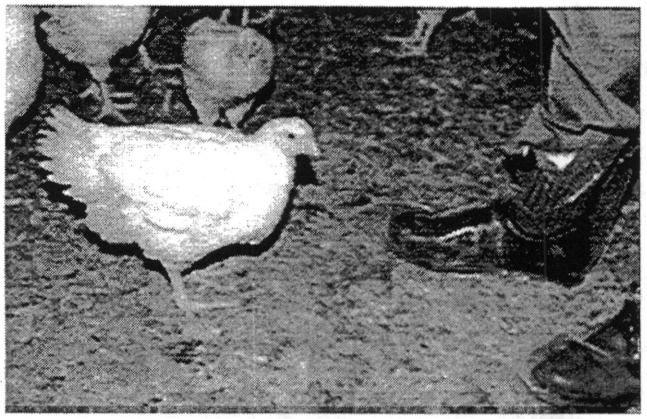
An example calculation in the first column shows fresh broiler litter being used to provide the nitrogen needs of a corn crop. Fertilizer recommendations from soil test results call for 180 pounds of nitrogen, 70 pounds of phosphate, and 125 pounds of potash. No preplant fertilizer is used in the example, but 2 tons per acre of broiler litter would have been applied the previous year and in four out of the last 10 years. The litter is to be broadcast on the surface, and corn is planted no-till. The amount of manure required to supply the priority nutrient needed by the crop—in this example, nitrogen—is calculated.

Worksheet

Calculations	Example	Your Field
1. Crop to Be Grown	Corn	
2. Fertilizer Recommendation		
a. Nitrogen (lb N/A)	180	
b. Phosphorus (lb P_2O_5/A)	70	
c. Potassium (lb K_2O/A)	125	
3. Preplant Fertilizer		
a. N	0	
b. P_2O_5	0	
c. K_2O	0	
4. Residual N from Manure (Units[a] of manure applied previous year x lb N/unit x availability coefficient—see Table 3)	2T x 55 lb/T x .07 = 8 lb	
5. Net Nutrient Needs		
a. N (2a - 3a - 4)	172 lb	
b. P_2O_5 (2b - 3b)	70	
c. K_2O (2c - 3c)	125	
6. Available Nutrients with As-Is Moisture in Manure (lb/unit)		
a. N (lb N/unit) (Table 1 or test results) x available coefficient (Table 2)	55 x .45 = 25	
b. P_2O_5 (lb P_2O_5/unit [Table 1] x .8)	55 x .8 = 44	
c. K_2O (lb K_2O/unit [Table 1])	45	
7. Application Rate to Supply Priority Nutrient		
a. Priority nutrient	N	
b. Amount needed (5a, b, or c)	172	
c. Manure needed (7b ÷ 6a, b, or c)	172 ÷ 25 = 6.9 T	
8. Nutrients Supplied by 7c		
a. N (7c x 6a)	6.9 x 25 = 172	
b. P_2O_5 (7c x 6b)	6.9 x 44 = 304	
c. K_2O (7c x 6c)	6.9 x 45 = 310	
9. Additional Nutrients Needed[b] (-) = need; (+) = excess		
a. N (8a - 5a)	172 - 172 = 0	
b. P_2O_5 (8b - 5b)	304 - 70 = 234	
c. K_2O (8c - 5c)	310 - 125 = 185	

[a]Units = tons, 1,000 gal, or acre inches, depending on the type of manure used (1 acre inch equals approximately 27,000 gal).

[b]The example calculation shows that 6.9 tons of broiler litter per acre can supply all the nitrogen needed by the crop. However, an excess of 234 pounds of phosphate and 185 pounds of potash per acre is supplied by this much manure. These amounts will result in higher soil test levels of phosphate and potash. Repeated overapplication of phosphate could restrict the amount of manure that can be applied to a field in future years.



Growing animals in large numbers leads to accumulation of manure that must be stored and used carefully to provide the maximum benefit to the farmer and minimum risk to the environment.

Carry-Over

Some of the nitrogen contained in manure is released slowly and becomes available in subsequent years. Significant amounts of this carry-over nitrogen can accumulate with frequent manure applications. Estimates of availability of carry-over nitrogen are shown in Table 3. This residual nitrogen should be taken into account by subtracting it from crop nitrogen recommendations when calculating a crop's nitrogen needs.

Phosphate and potash from manure also can be held in the soil and carried over. They are not likely to be lost through runoff or leaching if good conservation practices are used. Instead, they stay in the soil and help build fertility for future crops. Phosphate and potash carried over from manure applied in previous years will be reflected in soil test results.

Table 3. Estimated available nitrogen from manure as percentage of manure nitrogen applied previous year.

Frequency of Annual Application over 10-Year Period	Poultry or Liquid Manure	Other Manures
< 4	3	5
4-8	7	15
8 >	12	25

Source: D.B. Beegle, Penn State University.

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AGR-165

UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

The Agronomics of Manure Use for Crop Production

Monroe Rasnake, Extension Specialist—Animal Waste Management

Land application of manures for crop production has in-creased in recent years primarily due to the expansion of the poultry industry in Kentucky. However, regulatory concerns related to water quality are causing some farmers to reconsider their use. This publication will discuss the value of manure in providing nutrients for crop production while minimizing the risk to water quality. Proper agronomic use of animal manures is compatible with most best management practices (BMPs) connected with water quality regulations.

The Agronomic Value of Manures

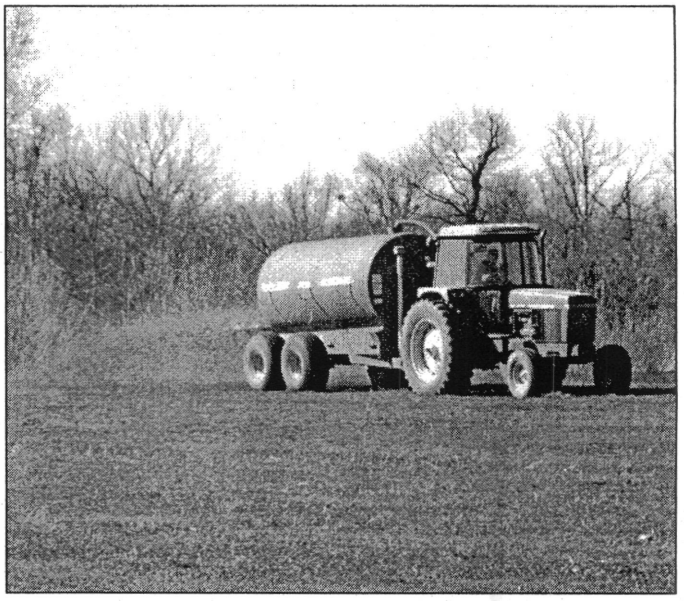
Animal manures are the digestive by-products of the feed ingested by animals and any associated bedding materials or water used in the animal production operation. Therefore, the nutrient content of manure is closely related to the chemical content of feeds consumed by the animals. During digestion, some of the energy, nutrients, vitamins, and minerals in feed are retained by the animal. However, most of the nutrients pass through the animal in urine or feces. For example, about 75% of nitrogen (N), 80% of phosphorus (P), and 85% of the potassium (K) consumed by cattle is excreted. Undigestible and partially digested organic residues are also excreted. Because of this, animal manure provides:

- nutrients for crop growth, and
- organic material that can increase soil structure, porosity, and water-holding capacity.

Thus, the agronomic value of manure depends on its nutrient and organic matter content.

Ability of Manure to Supply Plant Nutrients

How well animal manure performs as a plant nutrient source is determined by the chemical form in which nutrients occur, how the manure is applied, when it is applied, and how much is used. The effects of each of these factors on nutrient availability are discussed below.



The nutrients in liquid manures are highly available to crops, especially when applied in early spring.

Nitrogen Availability

Soluble N (primarily in the form of ammonium) in animal manures ranges from about one-third of the total N in poultry manure to about two-thirds or more in lagoon liquids. This portion has the same availability to plants as N contained in commercial fertilizer. The remaining N is contained in insoluble organic compounds. This N will become available to crops over a period of weeks, months, or even years after the manure is applied to a field. How much of the total N that is actually utilized by the crop depends on the application rate and the length of the growing season. Corn is less efficient in utilizing N than cool-season grass pastures. Corn can utilize N only during three or four months, while the pasture will be growing and taking up N for eight to 10 months.

Substantial amounts of the ammonium and urea-N in manures can be lost through volatilization to the air if left on the soil surface. How much is lost depends on the type of manure and weather conditions at the time of application. High temperatures increase losses, while as little as 1/3 inch of rain can move the inorganic N into the soil and prevent its loss. The organic N is less subject to loss but requires time to become available. Soil incorporation or injection of manure increases availability of both organic and inorganic N.

Table 1. Percent of nutrients from manure available to a crop for one year from the time of application as compared to commercial fertilizer.

Nutrient	Crop	Management	Poultry or liquids (%)	Other manures (%)
Nitrogen				
	Corn, tobacco, or annual grasses	*Spring applied*		
		2 days*	60	50
		3-4 days	55	45
		5-6 days	50	40
		7 days or more	45	35
	Corn, tobacco, or annual grasses	*Fall applied*		
		No cover crop	15	20
		Cover crop	50	40
	Small grains	*Applied preplant*	50	40
	Pasture or hay (cool-season)	*Applied spring or fall*	80	60
	Bermudagrass	*Applied spring or summer*	50	40
Phosphate (P_2O_5)			80	80
Potash (K_2O)			100	100

* How soon manure is mixed into the soil, or 1/3+ inch of rain is received after application.

Table 2. Estimated available N from manure as a percentage of the total manure N applied in the previous year.

Years in which manure was applied in last 10 years	Poultry or liquid manures	Other manures
< 4	3	5
4-8	7	15
> 8	12	25

The effect of various factors on availability of N in manure is illustrated in Table 1. Soil incorporation of manure for summer annual crops can increase N availability by one-third or more. The use of a winter cover crop can double or triple the N availability of fall-applied manure to next year's corn crop. When manure is applied to cool-season grass pasture or hay fields, N availability can be as high as 80% of that of commercial N fertilizer. Nitrogen losses are less if manure is applied in cool weather or where there is a longer growing period for the crop to use the N.

Some of the organic N in manures can be released a year or more after application. This needs to be taken into consideration when planning N fertilizer rates for crops grown the year after manure is applied. The amount of N available to a crop from manures applied the previous year can be estimated using Table 2. Poultry or liquid manures have higher percentages of N as inorganic N, which increases availability during the year of application. Other manures have more organic N that is released slowly and can carry over to the next year. If manure is applied to the same field year after year, the slowly decomposable organic N accumulates and increases N carryover.

Phosphorus Availability

Whether phosphorus exists in manure as predominantly organic P or inorganic P depends on the species and animal production intensity. Animals and poultry under intense production are likely to have higher amounts of dicalcium phosphate added to the ration which passes through as inorganic P (50% to 60% of the total P). This form of P, which acts similar to fertilizer forms of P in the soil, may be readily available during the first year when soil pH is at recommended levels. Beef cattle and broiler manure will have more than 50% of their total P as organic P, which is released more slowly as the manure is decomposed. In general, this means that P in manures is slightly less available to crops during the first year of application.

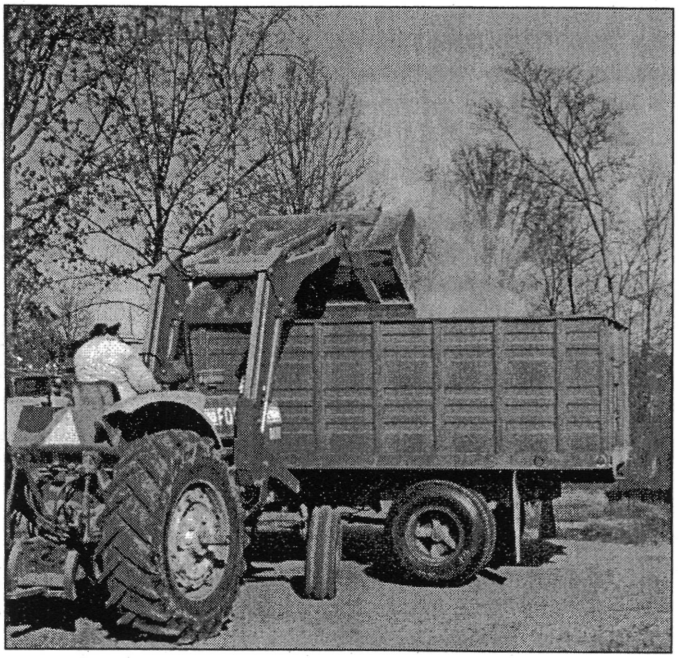
When properly applied and managed, P remains in the soil to maintain or increase soil test P levels. When P is applied repeatedly in excess of that removed from harvested crops, soil test P can increase to a level that becomes a concern for water quality. Application rates of manure P should be planned and soil test P levels monitored regularly to be sure this does not happen. This should be a part of the Agricultural Water Quality Plan that is required by the Kentucky Agricultural Water Quality Act that became effective in October 2001.

Potassium Availability

The K content of manure is mostly soluble and consequently is readily available to crops. It is given an availability factor of 100% in Table 1, which means that it acts the same as K in commercial fertilizer when applied to the soil. Like P, it can accumulate in the soil and increase soil test K or move down into the soil profile if more is applied than the crops remove. This is not currently a water quality concern but may be an economic loss to the farmer.

Amounts of Manure to Apply

Manure application rates should be no greater than the nutrient needs of the crop(s) to be grown. This is difficult to determine, however, due to the variability of nutrient content of manures and the fact that the ratio of nutrients in manure is not the same as the ratio taken up by plants. For example, N in manure is low in comparison to P in terms of what crops need. In many cases, it may be best to apply manure to supply the P needs and add fertilizer N to get the correct ratio of N to P. In some cases, it is possible to apply manure at rates to provide



Poultry manure is portable and can be an economical source of nutrients 50 miles or more from where it is produced.

the N and P needs of one crop (e.g., corn) and the P needs of the next crop in the rotation (e.g., soybeans). Extension publication AGR-146, *Using Animal Manures as Nutrient Sources*, discusses nutrient values of manures and shows how to calculate application rates to supply crop nutrient needs. A computer spreadsheet ("Manure Use 1.2-x1s") that calculates application rates is also available through the College of Agriculture .

In addition to environmental risks associated with overapplying manure, there may be agronomic problems as well. Manure rates on tobacco should be limited to 4 T/A of poultry manure or 10 T/A of other manures in order to avoid excess chloride. Poultry manure, for example, contains about 12 lb chloride per ton, and a 4 T/A rate would apply 48 lb/A of chloride, which is about the maximum rate that can safely be used on tobacco.

Another possible problem related to high rates of manure application, particularly if the high rates are repeated for several years, is a "salt" build-up. In this situation, high concentrations of ammonium and soluble salts of potassium, sodium, calcium, and magnesium can accumulate. This can cause poor seed germination, reduced soil water availability, and deterioration of soil structure. This problem with excess salts commonly occurs in soil where manure has been stockpiled. Soil pH in these areas will likely be 7 or above, and nothing will grow there for a year or more.

Uniformity of Manure Application

It is difficult to apply manures uniformly on fields. Spread patterns and application rates of manure spreaders should be checked at least once a year. This can be done by placing sheets of plastic film of uniform size at equal intervals across the path of application and then measuring how much manure is on each. Uniformity of spread can be improved by using lower application rates and going over the field twice with the spreader. The second pass can "split the middle" of the first pass, or run perpendicular to it. For nutrients other than N, this should give adequate uniformity. Uniformity of N from manure is less critical if a portion of the N need of the crop is supplied by fertilizer.

Placement of Manure

The primary concern of manure placement should be the efficiency of N use. Incorporating, or mixing, the manure with the soil, especially during hot weather, will reduce the risk of N loss. This benefit must be weighed against disadvantages such as exposing the soil to erosion or loss of soil moisture. For example, it is seldom worthwhile to sacrifice conservation tillage in order to reduce the risk of N loss from manure.

If liquid manure is injected into the soil in concentrated subsurface bands, especially in poor soil drainage conditions, there will likely be anaerobic decomposition that produces organic compounds toxic enough to stunt or kill plants. This risk can be minimized on soils with restricted water movement by broadcasting the manure and discing it in.

Summary

Animal manures can be used to supply nutrients needed to grow crops. If manures are managed properly, they can save farmers money and be an environmentally safe means of disposal. Application rates should be planned in combination with commercial fertilizer to provide the nutrients recommended for growing a crop. Apply manure close to the time the crop will need the nutrients. Mixing or injecting manure into the soil helps reduce nutrient losses and odor problems. Farmers can visit their local Cooperative Extension Service or Natural Resources Conservation Service office for help in planning for manure use.

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