A&L REFERENCE GUIDE

Manure Analysis

A&L Laboratories

The Soil Experts.

Manure Application

INTRODUCTION

Manure is a co-product of animal agriculture. Depending on the point of view, it is either a resource for crop production or it is a waste product of the livestock enterprise. No matter what the point of view, it must be removed to continue the livestock operation. Soils normally benefit from the application of organic material and animal manure is an excellent source. This organic material acts as a source of nutrients and as a soil conditioner. Therefore, it makes sense to use manure to recycle nutrients and improve the soil.

It is difficult to place a dollar value on the improvements in physical properties of the soil from the addition of manure, but the value can be considerable when evaluated on a long term basis.

The main value of manure is its supply of nitrogen, phosphorus, and potassium. Micronutrients will also be available, but the amounts will vary greatly depending on type of livestock and their diet.

About half of the nitrogen is in the inorganic or ammonium form, the form that is immediately available for plant intake. The inorganic forms of nitrogen are subject to being lost through leaching out of the root zone or volatilization into the atmosphere. Volatilization is minimized by injection or tillage into the soil.

Proper application rates and methods must be utilized to ensure environmentally sound results and cost effective application. Excessive manure application rates or improper application methods can result in surface or ground water contamination and reduced crop yields.

Much of the yield reduction is thought to be caused by germination damage and growth reductions due to high concentrations of ammonium and soluble salts including sodium, potassium, magnesium, calcium, and chloride, which can limit water uptake by the plants.

High salt level can also cause injury to plant root hairs which will result in reduced nutrient and water uptake. Also, improper balance between sodium in relation to calcium and magnesium will cause soil aggregates to break down or disperse. The dispersed clay particles will move down into the soil profile, blocking soil pores, reducing the rate of water infiltration.

NUTRIENT REQUIREMENTS

Before manure is applied, the nutrient requirement of the crop should be determined. Soil testing is a reliable method to determine nutrient levels in the soil. With this information, and knowledge of the nutrient levels of the manure, economically and environmentally sound application rates for both manure and fertilizer can be determined.

Manure application rates are usually based on crop nitrogen requirements. Manure application rates should never exceed the crop nitrogen requirement. However, after long term application, the phosphorus level in the soil will probably build up to a level that will prohibit continued manure applications. All manure application sites should be monitored with a soil testing program. To prevent the build up of soil phosphorus and potassium levels to a very high range, it would be best to calculate a manure application rate on basis of crop phosphorus or potassium removal (do not exceed crop N requirements). Table 1 provides a list of estimated nutrient removal per unit of yield for many crops. Actual removal will be site specific and may be determined by a laboratory analysis of a representative sample of the plant material removed from the field.

NUTRIENT AVAILABILITY

The nutrients contained in animal manures, composts, or other organic materials are less readily available to plants than the nutrients of most inorganic fertilizers. The nutrient content of these materials is highly variable (Table 2) and a laboratory analysis should be used to determine the actual nutrient content of manure materials.

NITROGEN: Manure would be classified as a slow release nitrogen fertilizer. Approximate manure nitrogen availability percentages are listed in Table 3. They vary according to the type of material, storage, and application method. When incorporated, most of the ammonium nitrogen is available during the first year. Nitrogen availability percentages listed in Table 3 are total N and account for ammonium nitrogen content. The figures in Table 3 are based on availability of total N during the first year following a spring application.

ORGANIC N (Total N minus ammonium N, or assume 60 to 75 percent of the Total N as organic) will supply nitrogen to the cropping system for several years. To estimate residual N use the availability factors listed in Table 4.

PHOSPHORUS AND POTASSIUM: About 70 percent of the total P applied in manure will become available in the year of application. Of the total potassium, 100 percent will be available the year of application.

DETERMINING NUTRIENT AND FERTILIZER NEEDS

Nitrogen is usually selected as the priority nutrient and total crop nutrients are determined by soil test and crop removal. When soil test results are high or very high in phosphorus or potassium it may be best to use these nutrients to determine the manure application rate. Also, if the manure tests low in nitrogen, basing the application rate on phosphorus or potassium may be best. In any situation, manure application rate should never exceed the crop's nitrogen requirement.

Amounts of nutrients that can be added from manure without greatly increasing soil test levels are estimated on the basis of expected crop removal. Values in Table 1 may be used to estimate crop removal expected per unit of yield for various crops.

Manure sampling, manure analysis, and spreader calibration are part of a comprehensive nutrient management plan. Manure with greater than 20 percent solids is classified as dry manure and is handled as a solid. Manure with 4 to 20 percent solids is classified as semi-solid and can be handled as a liquid. Semi-solid manure usually requires thorough agitation before pumping and sampling. Manure with less than 4 percent solids is classified a liquid manure and is handled with pumps, tank wagons, and irrigation equipment.

A representative sample is needed to provide an accurate manure analysis. One of the many factors affecting the nutrient content of manure is how the manure is handled and stored. Each handling system results in different types of nutrient losses. The most important thing in collecting a manure sample is to obtain it in a similar way to the methods used in developing the standard nutrient values.

WHEN TO SAMPLE MANURE

Sample manure at the time of land application or as close to the time of application as possible. Sampling at the time of application will not provide manure recommendations that can be used to adjust the amount of manure applied. However, the results can be used to adjust future manure applications and to adjust the amount of inorganic fertilizer applied. If you apply manure several times a year, sample when you apply the bulk of the manure.

Ideally, manure sampling should be done in the field as manure is applied. This ensures that losses that occur during handling, storage, and application are taken into account.

MANURE SAMPLING IN THE FIELD

Dry or Solid Field Sampling

To sample manure from barns, holding areas, dry stacks, or feed lots, collect a sample as follows:

Use the "hand and bag" method to collect all solid manure samples. Place a one-gallon resealable freezer bag turned inside out over one hand. Grab a handful of manure with the covered hand and turn the freezer bag right side out over the sample with the free hand. Seal the bag and place it in another freezer bag to prevent leaks. Label the bag and send to the lab or freeze it immediately to prevent nutrient losses. Take three samples for dry or solid manure. Combine the samples and mix. Place in a zip-lock bag.

Liquid Manure Sampling

When sampling liquid manure agitate the manure in the storage facility to obtain a representative sample for laboratory analysis.

Liquid Manure Applied with Spreaders

1. Immediately after filling the tank spreader, use a clean plastic bucket to collect manure from the unloading port or the opening near the bottom of the tank. Be sure the opening does not have solids accumulated that can contaminate the samples.

2. Stir the manure in the pail and immediately fill a one-quart flexible plastic bottle about 25 percent full. **Do not use a glass bottle as it might explode from pressure build up.** Squeeze as much air out of the bottle as possible before capping.

3. Put your name, date and sample number on the bottle and the information sheet.

4. If the sample cannot be sent to the laboratory within a few hours, it should be refrigerated. Place the sample in a plastic bag, seal the bag, and keep cool until it is sent to the laboratory. Ship so that the sample arrives promptly at the laboratory.

Liquid Manure Applied by Irrigation Systems

1. Place catch pans or buckets randomly in the field to collect the liquid manure that is applied by an irrigation system.

2. Immediately after the manure has been applied, collect the manure from each pan or bucket and combine in one bucket to make a composite sample.

Mix the manure and fill a one-quart flexible plastic bottle about 25 percent full. Seal and label the bottle and seal in a plastic bag. If the sample cannot be shipped to the laboratory right away, keep refrigerated. Ship to arrive promptly in the laboratory.

Dry or Solid Manure

Paved Lots

1. Collect manure by scraping a shovel across 25 feet of the paved feedlot. Repeat this process six to eight times. Avoid samples from areas that are very wet or contain large amounts of feed and hay.
2. Use the shovel to thoroughly mix manure by scooping the outside of the pile to the center of the pile.
3. Collect a sample using the "hand and bag" method that was described in the section on dry or solid field sampling.

Barn Gutter

1. Shovel a manure sample to the depth of the gutter from the gutter.
2. Remove the manure from the gutter and place it on the barn floor. Mix the sample by hand (wearing freezer bags) with a kneading motion. When collecting samples from a gutter, be sure to include the liquid that is in the bottom of the gutter.
3. Collect a sample using the "hand and bag" method.
4. Repeat steps one through three from other locations in the gutter to collect three subsamples. Combine the subsamples and mix. Place in zip-lock bag and squeeze out all of the air before closing.

Dry Stack

This is manure stored outside in a stacking shed or above ground solid waste storage facility.

1. Using a pitchfork or shovel, take manure from several locations throughout the dry stack and place it in a pile. Collect samples from the outside and center of the stack.
2. Mix the manure with a shovel by scooping the outside of the pile to the center of the pile.
3. Collect a manure sample by the "hand and bag" method.
4. Repeat steps one through three to collect the three subsamples. Combine the subsamples and mix. Place in a zip-lock bag and squeeze out all of the air before closing.

Table 1. Nutrient Removal by Crops

		Approximate Pounds per Acre of Nutrients Removed by the Portion of Crop Shown		
Crop	**Unit**	**N**	**P_2O_5**	**K_2O**
CORN				
Grain	bu.	1.0	0.37	0.26
Stover		0.75	0.15	1.06
Total Removed		1.75	0.52	1.32
COTTON				
Lint and seeds	lb.	0.08	0.04	0.03
Stalk, etc.		0.06	0.02	0.05
Total Removed		0.14	0.06	0.08
BARLEY				
Grain	bu.	1.0	0.4	0.3
Straw		0.4	0.1	1.1
Total Removed		1.4	0.5	1.4
OATS				
Grain	bu.	0.7	0.25	0.2
Straw		0.3	0.15	1.25
Total Removed		1.0	0.40	1.45
PEANUTS				
Nuts	lb.	0.03	0.01	0.01
Vines		0.02	0.01	0.03
Total Removed		0.05	0.02	0.04
RICE				
Grain	bu.	0.5	0.24	0.14
Straw		0.3	0.11	0.85
Total Removed		0.8	0.35	0.99
GRAIN SORGHUM				
Grain	bu.	0.83	0.41	0.21
Stover		0.94	0.18	1.06
Total Removed		1.77	0.59	1.27
SOYBEANS				
Beans	bu.	4.00	0.80	1.40
Stover		1.15	0.27	0.96
Total Removed		5.15	1.07	2.36
TOBACCO				
Leaf	lb.	0.03	0.01	0.05
Stalk		0.01	0.01	0.03
Total Removed		0.04	0.02	0.08
WHEAT				
Grain	bu.	1.25	0.62	0.37
Straw		0.57	0.15	0.90
Total Removed		1.82	0.77	1.27

Table 1. Nutrient Removal by Crops

Crop	Unit	Dry Matter%	Approximate Pounds per Acre of Nutrients Removed by the Portion of Crop Shown		
			N	P_2O_5	K_2O
HAY	Ton				
Alfalfa (early bloom)		89.2	52	9	43
Alfalfa (full bloom)		89.2	41	9	37
Coastal Bermuda		89.0	40	9	23
Ryegrass		89.0	26	10	30
Ladino Clover		91.2	67	16	47
Red Clover		87.7	42	10	35
Fescue		88.5	26	10	34
Lespedeza		93.2	40	10	23
Oats		88.2	26	8	30
Orchardgrass		88.3	31	11	44
Sudangrass		88.9	31	8	32
Soybeans		87.6	39	9	20
Timothy		88.4	27	7	34
Vetch		88.2	54	10	44
Wheat		85.9	25	7	31
Peanut		90.6	32	7	30
SILAGE	Ton				
Alfalfa		28.0	15	4	17
Barley		35.0	12	4	14
Corn		35.0	8	3	8
Grass-Legume		45.0	16	5	16
Oats		35.0	11	4	15
Grain Sorghum		30.0	8	2	9
Forage Sorghum		30.0	7	2	7
Sudangrass		35.0	10	3	14
Soybeans		30.0	17	7	7
Timothy		37.5	11	3	14
Wheat		35.0	10	3	10
Rye		33.0	12	3	14

Table 2. Approximate Manure Nutrients Remaining at time of application

Species	System	Solids %	Lb/Ton			Lb/1000 gal		
			N	P_2O_5	K_2O	N	P_2O_5	K_2O
Dairy Cattle	Daily Spread	15	8	5	10	—	—	—
	Anaerobic Pit	8	—	—	—	24	18	29
	Earthen Storage	10	—	—	—	32	14	28
	Anaerobic Lagoon	1	—	—	—	4	5	5
	Above Ground Storage	12	—	—	—	46	18	40
	Covered Stack	18	10	9	12	—	—	—
Swine	Anaerobic Pit	4	—	—	—	36	27	19
	Anaerobic Lagoon	1	—	—	—	4	2	4
Beef	Open Feedlot	15	10	7	10	—	—	—
Poultry	Liquid Pit	13	—	—	—	80	37	96
	Dry Pit (dry)	85	100	70	40	—	—	—
	Dry Pit (Crumbly)	70	60	55	30	—	—	—
	Dry Pit (moist)	50	40	40	20	—	—	—
	Dry Pit (fresh)	25	30	20	10	—	—	—
	Compost	54	44	66	48	—	—	—
Sheep	Dry Pit	25	23	8	20	—	—	—
Horse	Dry Pit	20	12	5	9	—	—	—
Composted Poultry Materials	Dry Pit	54	44	66	48	—	—	—

Worksheet 1.
Determining Fertilizer Needs

	Example	Your Field
1. Crop to be Grown	corn for grain	
2. Date crop to be established	Spring 19__	
3. Field	W1	
4. Total Fertilizer Needs (From soil test report). If P_2O_5 or K_2O is the priority nutrient then estimate maintenance from Table 1		
A. Nitrogen (lb N/acre)	120	
B. Phosphorus (lb P_2O_5/acre)	100	
C. Potassium (lb K_2O/acre)	100	
5. Fertilizer Applied/Starters to be applied (lb nutrient/acre)		
A. N	0/0	
B. P_2O_5	0/0	
C. K_2O	0/0	
6. Residual Nitrogen from Materials applied in previous years. (lb Organic N x factor from table 3)		
A. N from last year's application (lb Organic N per acre x 0.13)	27	
B. N from application 2 years ago (lb Organic N per acre x 0.05)	0	
C. N from application 3 years ago (lb Organic N per acre x 0.02)	5	
D. Total Residual N (add 6A,B,C)	32	
7. Residual N credits for legumes		
A. Crimson Clover or Hairy Vetch green manure (50 to 70 lb N/acre)	0	
B. Good Alfalfa stand, 70 to 100 % more than 4 plants/sq ft (160 lb N/acre first year credit or 50 lb N/acre second year credit)	0	
C. Fair to Poor Alfalfa stand, 30 to 70 % or 1.5 to 4 plants/sq. ft. (130 lb N/acre first year credit or 50 lb N/acre second year credit).	0	
D. Soybeans (1 lb N/acre/bu Beans harvested up to max of 30).	0	
E. Other	0	
8. Net Nutrient Needs		
A. Nitrogen (4A minus 5A minus 6D minus 7A or B or C or D or E)	120- 0-32 = 88	
B. Phosphorus (4B minus 5B)	100 - 0 = 100	
C. Potassium (4C minus 5C)	100 - 0 = 100	
D. Lime (From soil test report) Tons/acre	0	
E. Micronutrient (From soil test) lb/acre	0	
F. Other	0	

Worksheet 2.

Determining Manure Application Rate and Supplemental Fertilization Based on Net Nutrient Need from Worksheet 1

	Example	Your Field
1. Field # from worksheet 1	Field W1	
2. Calculate Available Nutrients in Manure lb of nutrient per ton or per 1000 gal to be applied this spring. Use lab analysis.	Spring 19___	
A. Nitrogen (lb Total N/Ton or 1000 gal) x Avail. Coefficient (Table 3). When ammonium N analysis is available,assume coef. of 1.0 for ammonium N and use avail. coef. in column 1 of Table 3 for organic N (Total N minus Ammonium N)	60 lb N/T dry pit poultry x 0.50 = 30 lb available N/Ton	
B. Phosphorus (lb P_2O_5/ton or 1000 gal x 0.80) lb P x 2.29 = lb P_2O_5	55 lb P_2O_5/T x 0.80 = 44 lb P_2O_5/Ton	
C. Potassium (lb K_2O/ton or 1000 gal x 0.80) lb K x 1.2 = lb K_2O	30 lb K_2O/T x 0.80 = 24 lb K_2O/Ton	
D. Other		
E. Other		
3. Determine Manure Application Rate (Tons or 1000 Gal./Acre)		
A. Priority Nutrient	Nitrogen	
B. Amount Needed (from 8A,B or C of worksheet 1, lb nutrient/acre)	88	
C. Rate of Manure or (3B/2A,2B or 2C) (Tons or 1000 gal/acre)	88/30 = 2.93	
4. Total Manure Nutrient Credits Calculated (lb/Acre)		
A. N (3C x 2A)	88	
B. P_2O_5 (3C x 2B)	129	
C. K_2O (3C x 2C)	70	
D. Other		
E. Other		
5. Nutrient Balance and Supplemental Fertilizer Needs lb/acre (-) indicates need (+) indicates excess	Field W1	
A. N (4A minus 8A from worksheet 1)	88 - 88 = 0	
B. P_2O_5 (4B minus 8B from worksheet 1)	129 -100 = +29	
C. K_2O (4C minus 8C from worksheet 1)	70 -100 = -30	
D. Lime (8D from worksheet 1)	0	
E. Micronutrients (8E from worksheet 1)	0	
F. Other (8F from worksheet 1)	0	

Table 3. Nitrogen Availability Coefficients for Manure Total Nitrogen Content

Type of Manure	Method of Incorporation			
	Broadcast, No Incorporation	Broadcast, Incorporated within 12 hours	Injected	Irrigated, No Incorporation
Dairy (semi-solid)	0.40	0.60	—	—
Dairy (slurry)	0.45	0.60	0.70	0.45
Beef	0.40	0.60	—	—
Swine (slurry)	0.40	0.60	0.70	0.40
Swine Lagoon	0.50	0.80	0.85	0.50
Poultry	0.50	0.50	0.50	—
Municipal sludge	0.50	0.50	0.50	—
Composted Materials	0.20	0.20	—	—

Table 4. Residual Availability of Organic N in Manure and Compost

Material Applied	Organic N Availability Coefficients
Last Year	0.13
2 Years Ago	0.05
3 Years Ago	0.02

References

1. Our Land and Its Care, 1966, p. 24-25, National Plant Food Institute, Washington, D.C.
2. DART Ration, 1990, Dairy Information Sheet N. 30, University of Tennessee Agricultural Extension Service.
3. The Value and Use of Poultry Waste as Fertilizer. 1989, Alabama Cooperative Extension Service Circular ANR-244.
4. Chicken Manure - its Production Composition and Use as a Fertilizer, 1964, Georgia Agricultural Experiment Station Research Bulletin 90.
5. Utilization of Organic Wastes on Agricultural Soils of Tennessee, 1985, University of Tennessee Agricultural Experiment Station Bulletin 638.
6. Animal Waste Utilization on Cropland and Pastureland, 1979, U.S. Department of Agriculture, Hyattsville, Maryland.
7. Agri-Waste Management: Livestock Waste Sampling, Analysis and Calculation of Land Application Rates, J.C. Barker, North Carolina State University, EBAE 111-84, Revised 1990.
8. Manure Application Management, University of Tennessee Agricultural Extension Service Bulletin PB 1510.
9. How to Sample Manure for Nutrient Analysis, 1994, Iowa State University.
10. Managing Manure Nutrients for Crop Production, Randy Killorn, Iowa State University, 1995.