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Managing Crop Nutrients Through Soil, Manure and Effluent Testing

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Benefits of Manure and Effluent

Livestock manures are often rich in plant nutrients. Studies have shown that up to 75 percent of the nitrogen (N), 60 percent of the phosphorus (P_2O_5) and 80 percent of the potassium (K_20) fed to dairy cattle are excreted in manure. Poultry litters and swine manures may have even higher values for phosphorus and potassium. These elements are essential plant nutrients required by all plants for normal growth and production. In addition, litter and manures contain smaller amounts of other plant nutrients including calcium, magnesium, sulfur, manganese, copper, iron, zinc, boron, molybdenum, and chloride.

Along with these nutrients, manures and litters supply valuable organic matter to help improve soil structure, soil tilth and workability, and water and nutrient holding capacities. In addition, manures and litters increase the activity of beneficial soil microbes. However, nutrient concentrations in manure can be highly variable, depending on feeding rations and methods of collection, storage and handling. Table 1 shows the average and range in concentrations of nutrients in various types of livestock manure.

For operations using runoff and effluent containment systems, the benefits of supplemental irrigation water during periods of low rainfall are obvious. In addition, these waters will contain significant quantities of plant nutrients. However, depending on rainfall runoff amounts, effluent production and seasonal evaporational losses, nutrient concentrations vary significantly. Table 2 shows the average and range of nutrient concentrations in effluents at various stages of collection and management.

Soil Testing

Soil testing is the foundation of a sound fertility management program. A soil test is a series of chemical analyses on soil which estimates whether levels of essential plant nutrients are sufficient to produce a desired crop and yield. When not taken up by a crop, some nutrients, particularly nitrogen, can be lost from the soil by leaching or volatilization. Others, like phosphorus, react with soil minerals over time to form compounds which are not available for uptake by plants. Soil testing can be used to estimate how much loss has occurred and predict which nutrient(s) and how much of that nutrient(s) should be added to produce a particular crop and yield.

Collecting a good soil sample is the most critical step in soil testing. It is generally recommended that one "composite"soil sample be collected from each uniform area (field or part of a field) of 10 to 40 acres. Care should be taken to prevent sampling across areas with historically different land uses, soil types, fertilization practices, or crop yields. For fields used for routine land application of manure and wastewater, one sample per field is commonly submitted. A composite

Table 1. Average and Range ( ) in Nutrient Value for Manure at the Time of Land Application.[1]

Source	Dry Matter	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
	%	(lbs/ton)		
Cow (fresh)	25	15	8	10
Beef (feedlot)	65 (45-79)	27 (23-39)	24 (15-39)	36 (18-56)
Dairy (corrals)	65 (2-80)	28 (4-44)	11 (1-78)	26 (1-48)
Dairy (stockpile)	80	28	12	23
Broiler (litter)	65 (25-85)	58 (34-89)	51 (32-67)	40 (16-48)
Layer	35 (4-78)	30 (13-70)	40 (2-85)	20 (8-52)
Swine	18 (15-20)	10 (9-11)	9 (7-13)	7 (6-9)

[1]Adapted from Mathers, et al., 1973, Harty et al., 1992, and Bandel, 1990.

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Table 2. Average and Range ( ) in Nutrient Value of Effluents at the Time of Land Application.[1]

Source	Dry Matter	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
Dairy	%	(lbs/acre-inch)		
Primary Lagoon	<10	49 (39-64)	11 (8-13)	62 (48-150
Second Stage Lagoon	<10	21 (16-27)	5 (1-9)	55 (46-66)
Beef	<10	38	25	32
Swine	<10	113	34	79
Poultry	<10	271	90	497
Dairy		(lbs/acre-inch)		
Primary Lagoon	<10	1.8 (1.4-2.4)	0.4 (0.3-0.5)	2.6 (1.8-5.5)
Second Stage Lagoon	<10	0.8 (0.6-1.0)	0.2 (0.04-0.3)	2.0 (1.7-2.4)
Beef	<10	1.4	0.9	12
Swine	<10	4.1	1.2	2.9
Poultry	<10	9.9	3.3	18.3

[1]Adapted from Sweeten and Wolfe, 1993.

sample is obtained by combining 10 to 15 individual soil cores taken randomly across each field. The 10 cores are placed in a clean plastic bucket, thoroughly mixed and then about 1 pint is sent to the laboratory for testing.

Individual soil cores can be taken using a regular spade, soil auger or soil sampling tube (Figure 1). First, scrape any plant residue from the surface and then make the core or boring 6 inches deep. Be careful not to remove dark colored, partially decomposed organic matter when removing plant residue. When using a spade, dig a 6-inch deep, 45 degree V-shaped hole and take a 1-inch slice from the smooth side of the hole. Then remove a 1 by 1-inch core from the center of the shovel slice. By collecting 10 to 15 individual cores across the area, one can better ensure that the soil test results will be representative of the site and fertilizer recommendations will be appropriate. Complete sampling instructions and sample bags can be obtained from your local county Extension office.

Soil samples taken for the purpose of regulatory reporting may require more than one soil depth. For example, current regulations for most concentrated animal feed operations require composite samples from each land application field for two depths: 0 to 6 and 6 to 24 inches. Both depths should be collected at each of the 10 to 15 coring sites in a field, placed into separate buckets and submitted as separate samples to the laboratory. Care should be taken during sampling not to mix soil from the two sampling depths, to avoid obtaining incorrect results. In addition, both the sample bags and soil test information sheets should be clearly marked to distinguish between different samples and among different fields. Facilities subject to state regulations should review their permits to determine which samples and tests may be required.

To ensure good samples, a producer also should follow these recommendations:

1. Never use heat to dry a sample. You can air dry the sample by laying it on clean paper (do not use newsprint of any kind).
2. Keep accurate records of the area represented by each sample.
3. Avoid sampling areas such as small gullies and other eroded areas, depressions, terraced waterways and unusual spots.
4. When sampling fertilized fields, do not sample in the fertilized band.
5. Do not use metal buckets or containers with any residue in them since it might affect test results.
6. To avoid contamination, be sure to clean your sampling tool and bucket(s) before sampling the next field.

Soil tests can be obtained from the Texas AgriLife Extension Service Soil, Water and Forage Testing Laboratory in College Station, Texas, or from various private laboratories across the state. Costs range from about $10 and up, depending on the laboratory and type of tests requested. Contact your local county Extension agent for more information. The lab can be reached at (979) 845-4816. For further information, visit our website at *soiltesting.tamu.edu*.

Table 3 illustrates the results from a typical soil test analysis. The numerical values are given in parts per million (ppm), which can be multiplied by 2 to obtain estimated pounds of nutrient per acre. Depending on the crop and yield goal (as requested on the soil test information sheet), a fertilizer recommendation for all major and most minor crops in Texas will be provided by the Texas AgriLife Extension Service Soil, Water and Forage Testing Laboratory. You may need to request recommendations from many commercial laboratories. The fertilizer recommendation can be used to determine commercial fertilizer needs, or used in conjunction with manure/wastewater analyses to determine proper land application rates.

Figure 1. Soil sampling is the most important step in soil testing. Above is an example of a 1 x 1 x 6-inch core taken with a spade.

Table 3. Example of a Soil Test Report.

SOIL TEST REPORT

TEXAS AGRILIFE EXTENSION SERVICE–THE TEXAS A&M UNIVERSITY SYSTEM

SOIL TESTING LABORATORY, COLLEGE STATION, TX 77843

LAB DIRECTOR (979) 845-4816

DATE RECEIVED: ______________________

DATE PROCESSED: ______________________

COUNTY: ______________________

LAB#: ______________________

SOIL ANALYSIS

| SOIL TEST RATINGS – PPM ELEMENT (AVAILABLE FORM) |

PH ACIDITY	NITROGEN	PHOSPHORUS	POTASSIUM	CALCIUM	MAGNESIUM	SALINITY	ZINC	IRON	MANGANESE	COPPER	SODIUM	SULPHUR
6.6 MILDLY ACIDIC	3. VERY LOW	3. VERY LOW	40. VERY LOW	820 HIGH	41. LOW	260. NONE	.22 MOD	5.2 MOD	1.2 MOD	.12 MOD	16. VERY LOW	3 LOW

(PPM X 2 – LBS/ACRE 6 INCHES DEEP)

CROP AND YIELD RANGE: Improved and Hybrid Bermuda Grass (1 Hay Cutting Plus Grazing)

Suggested Fertilizer Rate LBS/A: 95 – 50 – 110

N P_2O_5 K_2O

Broadcast at spring growth.

Topdress with additional 60 lbs/a of nitrogen after each 4 to 6 week graze down.

Magnesium levels are becoming low. Consider using 150 lbs/a of potassium magnesium sulfate annually.

Broadcast 15 lbs of sulphur per acre. In some cases, deep rooted perennial crops may not respond to sulphur applications due to its preseence in the deeper profile.

Further information and assistance can be obtained from your county Extension agent:

Agent name: Address:

Manure and Effluent Testing

Nutrient concentrations in manures and effluents can vary substantially due to differences in feeding rations and methods of collection, handling, storage and moisture content. This will affect the fertilizer value of the material and determine proper land application rates. As a result, regular laboratory analyses of manures and effluents are strongly recommended. In addition, annual soil testing is recommended to evaluate soil nutrient levels and adjust loading rates.

To obtain samples for manure analysis, take 5 to 7 random core samples from various locations in the manure stockpile using a spade or shovel. Be certain to dig into the stockpile to collect the samples since weathering of the outside layer can change nutrient levels. Mix the core samples in a clean plastic bucket or paper bag. Place about 1 pint of the mixed sample into a sampling bag or a sealable plastic storage bag to submit for testing. Samples should be submitted as soon as possible after collection since chemical changes in the nutrients within the bag can occur during storage.

Effluent samples can be obtained by collecting 5 to 10 samples from various locations around the lagoon. These samples can be taken using a plastic bottle attached to a long pole (Figure 2). Mix the samples in a clean container and submit a minimum of eight ounces of the mixture in a tightly sealed plastic bottle (new plastic baby bottles work well). Fill the container to within one to two inches of the top to allow for expansion. Do not use glass containers, as they may explode due to pressure buildup or break during shipment.

Figure 2. Lagoon effluent samples being collected with a bottle attached to a pole extension.

Clearly label each sample with an identification number. This number should correspond to the one listed on the sample identification sheet submitted with the sample to the laboratory. Place all samples, information sheets and payment into a sturdy paper box for shipment to the laboratory. Keep a record of the dates and locations from which the samples were collected. Submit all samples as soon as possible after collection.

Table 4 presents results from a typical laboratory analysis of manure for three samples from different sources. Values for nitrogen, phosphorus, potassium, calcium and magnesium are given in percent (%). Multiplying these numbers by 20 will give the total pounds of nutrient per ton. For example, 1.09% nitrogen would be equivalent to 21.8 lbs N/ton. Phosphorus (P) values should then be multiplied by 2.29 to give pounds of P_2O_5/ton. Potassium (K) values should be multiplied by 1.2 to give pounds of K_2O/ton. Other nutrients expressed in parts per million (ppm) can be multiplied by 0.002 to obtain pounds per ton.

Table 5 presents the results from a typical laboratory analysis of effluent for two samples from different sources. Values for nitrogen, phosphorus and potassium are given in percent (%). Multiply these percentages by 2264 to obtain the total pounds of nutrient per acre-inch.

Here again, phosphorus and potassium must then be multiplied by 2.29 or 1.2, respectively, to give pounds of P_2O_5 or K_2O per acre-inch. For nutrients expressed in ppm,multiply values by 0.2264 to determine pounds per acre-inch.

Manure and effluent tests can be obtained from the Texas AgriLife Extension Service Soil,Water and Forage Testing Laboratory in College Station, Texas, or from various private laboratories across the state. Costs range from about $20 and up, depending on the laboratory and type of tests requested. Contact your local county Extension agent for more information.

Determining Land Application Rates

Land application rates should be beneficial to crops while protecting the environment. However, nutrient ratios ($N:P_2O_5 : K_2O$) in manures usually do not match the nutrient requirements of crops. As a result, the most efficient and economical fertilizer management strategy generally involves using a combination of manure and/or effluent, and commercial fertilizer to meet crop nutrient needs. In this way, the proper balance of nutrients for optimum crop production can be provided.

Phosphorus-based application rates can help prevent the buildup of phosphorus in soils. Excessive levels of phosphorus in soils can lead to nutrient imbalances which reduce crop yields, and can potentially contribute to water pollution. Once the proper application rate is determined based on soil and manure/

Table 4. Typical Laboratory Analysis Report for Solid Dairy Manure Obtained from Three Sources.

PLANT ANALYSIS REPORT
TEXAS AGRILIFE EXTENSION SERVICE, THE TEXAS A&M UNIVERSITY SYSTEM
SOIL, WATER AND FORAGE TESTING LABORATORY
COLLEGE STATION, TX 77843-2474
LAB COORDINATOR (979) 845-4816:__________
DATE RECEIVED:__________
DATE REPORTED:__________
COUNTY:__________

Plant Analysis*
Plant Analysis Ratings

Lab Number	Sample ID Sample Type	Nitrogen %	Phosphorus %	Potassium %	Calcium %	Magnesium %	Sodium PPM	Zinc PPM	Iron PPM	Copper PPM	Manganese PPM	Sulfur PPM	Boron PPM
xxx	MAN	1.09	.58	2.25	1.40	.82	2,000	130	6,116	36	202	3,956	42
xxx	MAN	2.00	1.03	1.93	4.73	1.81	5,751	263	9,611	88	427	6,390	56
xxx	MAN	1.24	.77	1.20	4.15	.81	2,456	164	12,392	65	291	3,911	37

*Results Reported on 100% Dry Matter Basis

Table 5. Typical Laboratory Analysis Report for Dairy Lagoon Effluent Obtained from Two Sources.

Lab#	Sample ID	N	P	K	Ca	Mg	Na	Zn	Fe	Cu	Mn	NO_3	pH	Conductivity
		<------		%		------>	<------		PPM		------>	%		µmhos/cm
xxx	Lagoon 1	.027	.005	.065	.015	.009	145	0	3	0	0	< 1	7.3	5,170
xxx	Lagoon 2	.014	.004	.056	.010	.006	114	0	3	0	0	< 1	7.3	3,440

effluent testing, supplemental commercial fertilizer can be used to supply the balance of crop needs for other essential nutrients (particularly nitrogen).

Management Considerations

Using manures and wastewaters effectively can greatly reduce crop fertilizer needs, and thus improve the economics of production. At the same time, application of too much manure,wastewater or commercial fertilizer, or a combination of these materials, can reduce crop yields, hurt animal performance and limit profits. When nutrients are applied at excessive rates and are not balanced with crop requirements, plant nutrient deficiencies or toxicities can occur. For example, excessive phosphorus levels in soil can cause a zinc and/or iron deficiency in crops. In addition,over application and/or improper spreading of manure and effluent can pollute surface and ground water with nitrates, phosphates and/or fecal bacteria. This accidental contamination of the ground and surface water can pose a health risk to you, your family and livestock,and may require years to correct.

Other best management practices (BMPs),which should be followed when using any fertilizer material, include:

1. Time applications of manures and fertilizers as close as possible to periods of crop nutrient need.
2. Avoid applications when the ground is frozen, saturated, or when the potential for heavy rainfall is great.
3. Inject or incorporate wastes into the soil if possible to conserve nutrients.
4. Avoid surface applications on steep (>8%) slopes.
5. Use management practices to control sediment losses.
6. Provide a filter or buffer strip (25 to 100 feet) between the application area and any nearby water resources including wells, ponds, streams, etc. (increase strip width in areas prone to erosion, slow infiltration, or limited plant growth).

Calibrating Solid Manure Spreaders

No fertilizer material can be properly applied if the rate of application is not known. A properly calibrated manure spreader will help ensure the correct amount of manure is applied. The following procedure can be used to calibrate typical solid manure spreaders.

Materials needed:

- Bucket
- Plastic sheet, tarp or old bed sheet. Even sizes, such as 8 feet x 8 feet, 10 feet x 10 feet or 10 feet x 12 feet will make the calculation easier.
- Scales (accurate to ½ pound).

To calibrate:

1. Locate a large and reasonably smooth, at area where manure can be applied.
2. Spread the plastic sheet, tarp or bed sheet evenly on the surface of the test held.
3. Start driving the spreader at the normal application speed toward the sheet, and begin spreading at an even rate.
4. Drive over the sheet at the normal application speed while continuing to apply manure.
5. Collect all manure spread on the sheet and pour it into the bucket.
6. Weigh the bucket with manure, then subtract the weight of the empty bucket to determine pounds of manure applied to the sheet.
7. Repeat the procedure at least three times to get a reliable average.
8. Determine the average weight of the manure applications.

Table 6. Calibration of Solid Manure Spreaders.

Pounds of Manure Applied to Sheet	Tons of Manure Applied/Acre Size of Sheet (feet)		
	8’x8’	10’x10’	10’x12’
1	0.34	0.22	0.18
2	0.68	0.44	0.36
3	1.02	0.65	0.54
4	1.36	0.87	0.73
5	1.70	1.09	0.91
6	2.04	1.31	1.09
7	2.38	1.52	1.27
8	2.72	1.74	1.45
9	3.06	1.96	1.63
10	3.40	2.18	1.82
11	3.74	2.40	2.00
12	4.08	2.61	2.18
13	4.42	2.83	2.36
14	4.76	3.05	2.54
15	5.10	3.27	2.72
16	5.45	3.48	2.90
17	5.79	3.70	3.09
18	6.13	3.92	3.27
19	6.47	4.14	3.45
20	6.81	4.36	3.63
21	7.15	4.57	3.81
22	7.49	4.79	3.99

If the size of the sheet being used is not listed, the following equation may be used to determine litter application per acre. Remember to account for the moisture content of the material if application rates are to be made on a dry weight basis. This can be done by dividing tons/acre (wet weight basis) by the percent moisture content (decimal fraction).

$$\frac{\text{Pounds of manure collected over sheet x 21.78}}{\text{Area of sheet, ft.}^2} = \text{tons/acre (wet weight basis)}$$

9. Refer to the chart in Table 6 under the appropriate sheet size to read Tons of Manure Applied Per Acre.

10. Remember to account for moisture content when determining actual land application rates on a dry weight basis.

Optional Method for Easy Calculations

1. Use a square sheet measuring 4 feet 8 inches on all sides, which is equal to 1/2000th of an acre.

2. Follow steps 1 through 8 above.

3. Pounds of manure collected on this size of sheet is equal to the Tons of Manure Applied Per Acre.

Literature Cited

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