Manure Analysis And Interpretations

FACT SHEET

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 the type of livestock and their diet.

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. When plant residue or manure is added to soil, there is an immediate and marked drop in oxygen and an increase in carbon dioxide in the soil air, which can inhibit plant growth. Germination damage occurs from high concentrations of ammonium and soluble salts (including sodium, potassium, magnesium, calcium, and chloride), which can limit water uptake by the plants. High salt levels can also cause injury to plant root hairs, which will result in reduced nutrient and water uptake. 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.

The carbon-nitrogen (C:N) ratio of applied manure affects both microbial and plant growth. If a waste having a high C:N ratio, such as manure with excess bedding, is added to a soil, organisms decomposing the organic matter grow until the available mineralized nitrogen becomes limiting. All of the immediately available nitrogen is bound by the microorganisms. For a short period of time, nitrogen is unavailable for plant use, resulting in nitrogen deficiencies for the crop. **Table 1** lists the C:N ratios of various materials.

Nutrient Requirements

Before manure is applied, the nutrient requirements 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 may 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 is best to also calculate a manure application rate on the basis of crop phosphorus or potassium removal (do not exceed crop N requirements). **Table 2** 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 the plant material removed from the field.

Nitrogen requirements should be made after taking account of credits from the last year's crop. An average soybean crop can supply around 30 pounds of nitrogen per acre. Alfalfa can add around 50 pounds per acre of nitrogen. Nitrogen will also be available from the mineralization of the existing organic matter in the soil. Every one percent of organic matter can supply around 20 pounds of nitrogen per acre.

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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 3**). A laboratory analysis should be used to determine the actual nutrient content of manure materials.

Nitrogen

Manure generally contains very little nitrate nitrogen, and only a portion of the nitrogen is in the inorganic ammonium form. Inorganic N is readily available for plant uptake, but is also subject to loss through volatilization into the atmosphere or leaching through the root zone following nitrification. Volatilization is minimized by injection or tillage into the soil.

Manure would be classified as a slow release nitrogen fertilizer. Manure nitrogen availability factors are listed in **Table 3**. They vary according to the type of material and storage conditions of the manure. Nitrogen availability factors listed in **Table 3** do not account for the ammonium nitrogen content, but are used to estimate the nitrogen mineralized from the organic nitrogen. When incorporated, most of the ammonium nitrogen is available during the first year. The figures in **Table 3** are based on availability of total N during the first year following a spring application.

Organic Nitrogen

Organic N (Total N minus ammonium N) will supply nitrogen to the cropping system for several years. Organic N released during the second, third, and fourth cropping years after initial application is usually about 50%, 25%, and 12.5%, respectively, of that mineralized during the first cropping season.

Phosphorus and Potassium

Almost all of the phosphorus and potassium applied in manure will become available during the year of application.

Lime

Some manure, such as dairy, beef, and poultry, may contain substantial amounts of carbonates from calcium supplements used in feed rations. This neutralizing value can have an effect on soil pH in fields where manure is applied.

Secondary and Micronutrients

Availability of these nutrients will vary greatly with livestock type and storage conditions. Because of the variation in estimated availability, it is best to monitor micronutrient levels with soil and plant tissue tests. Micronutrients from manure sources will behave similarly to inorganic sources, and may become tied up in the soil following application.

Determining Crop Nutrient Requirements

Nitrogen has traditionally been selected as the priority nutrient for a crop, with the remaining essential nutrients 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, the manure application rate should never exceed the crop's nitrogen requirement. **Worksheet 1** can be used to calculate the pounds per acre of N, P_2O_5, and K_2O needed by a crop.

Amounts of nutrients that can be added from manure without greatly increasing soil test levels can be estimated on the basis of expected crop removal. Values in **Table 2** 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 a solid manure. 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 when collecting a manure sample is to obtain it in a way similar to the method used in developing the standard nutrient values.

Collecting Manure Samples

Although sampling at this time will not provide manure recommendations that can be used to adjust the amount of manure applied, the results can be used to adjust future manure applications and to adjust the amount of inorganic fertilizer applied.

If you apply manure throughout the growing season, you may want to take samples each time to determine if the manure nutrient content varies. Once a baseline of nutrient information has been established, the number of samples collected can be decreased, unless significant changes are made in livestock feeding, watering, or housing. Ideally, manure sampling should be done as manure is applied. This ensures that losses that occur during handling, storage, and application are taken into account.

Solid Manure

For solid manure, take at least five grab samples from several spreader loads and combine these into one composite sample. Thoroughly mix the composite sample and transfer approximately one pound of the mixture to a one gallon plastic bag.

If you prefer to collect a sample of solid manure prior to application, use a hollow pipe or similar device to probe from the outer surface of the pile into the center. Collect at least ten grab samples throughout the pile in this manner. Combine these to form one composite sample. Transfer approximately one pound of this composite to a gallon plastic bag.

Semi-Solid and Liquid Manure

Liquid pits or lagoons should be thoroughly mixed or agitated for at least 2-4 hours prior to collecting a sample. Solids that settle to the bottom will contain a higher percentage of phosphorus. Nitrogen and potassium tend to stratify towards the top of the liquid. Collect samples as the manure is being transferred to the spreader truck. Take samples from several spreader loads and mix them to form one composite sample.

If you prefer to collect a liquid manure sample prior to application, assure the sample collected is representative of the entire profile of the pit or lagoon. This is best done by agitating the liquid for at least 2-4 hours. Another means is to collect a profile sample using a length of pipe that will extend to the bottom of the pit. Collect several of these around the pit and combine them for one composite sample.

Once a composite is collected, transfer a well mixed portion to a sixteen ounce flexible plastic bottle, leaving about 1/4 of the bottle empty. Squeeze out the air in the upper fourth of the container (to allow for gas expansion), and seal tightly for shipping. Seal the container in a plastic bag. Do not place manure samples in glass containers since gas expansion during storage can cause the container to explode.

Collecting Solid or Liquid Manure Samples in the Field

Samples of both types of manure can be collected during field application by placing several catch pans or plastic buckets randomly throughout the field and combining the manure collected in each into a composite sample. This helps to account for ammonia loss during the actual application process, especially when liquids are applied through irrigation equipment. Thoroughly mix all of the sub-samples into one composite and transfer one pound of solid to a gallon plastic bag or twelve ounces of liquid to a sixteen ounce plastic bottle. Squeeze out the air in the upper fourth of the container and seal tightly.

Submitting Manure Samples to The Laboratory

Samples should be promptly sent to the laboratory after collection. If shipment is delayed, refrigerate or freeze the sample to preserve the nutrient content. Be sure to remove as much air from sealed plastic bottles as possible to allow for gas expansion.

Identify each sample with a unique number or code using a permanent marker. Fill out a sample submittal form listing the same sample numbers or codes, and identifying the type of manure and how it is stored before field application. This information is necessary in order for the laboratory to calculate the first year availability of nutrients.

As a minimum, manure should be tested for percent solids, total nitrogen, ammonium nitrogen, phosphorus, and potassium. Additional testing may be useful depending on the livestock and feeding practices of the operation.

Interpretation of Manure

Laboratory data is reported on an as-received basis. These values are used to calculate the actual pounds of nutrients being applied per unit of manure. If the manure is classified as a solid, the unit is in tons. If the manure is classified as a liquid, the unit is 1000 gallons. Unless actually determined, the density of liquid manure is assumed to be 8.33 lbs/gallon. This factor is used in the calculations to report pounds of nutrient per thousand gallon on the analysis report.

Availability of Organic Nitrogen

As previously mentioned, not all of the nitrogen in a manure application is available for crop uptake in the first year. The report of analysis lists a result for Total Nitrogen, which represents the Organic Nitrogen plus the Ammonium Nitrogen. The First Year Available Nitrogen is also reported. This value is calculated by multiplying the Organic-N by the corresponding organic nitrogen availability factor **(Table 3)** and adding the NH_4-N to that result. The NH_4-N value is obtained from a reference source when the analysis is not requested. When NH_4-N is requested, values for Total N, Organic N, and NH_4-N are reported, as well as the First Year Available Nitrogen.

Nitrogen Losses

Interpretation of the available nitrogen should also take into account the amount of nitrogen lost in the application process. The test results indicate the amount of nitrogen available at the time of sample collection but do not reflect any losses occurring due to the incorporation process or the time between application and incorporation. Soil temperature also has an effect on losses of nitrogen. **Table 4** lists estimates of nitrogen available for a spring planted crop following these losses.

Phosphorus and Potassium

Phosphorus and potassium levels are converted to P_2O_5 and K_2O equivalents on the report in order to easily calculate the pounds of fertilizer material the manure contains on either a per ton or 1000 gallon basis. No adjustment is made for the First Year Available estimates for these two nutrients since they are almost completely available during the year of application.

Secondary and Micronutrients

These nutrients are reported as they exist in the manure, as well as what is estimated to be available the first year of application. Availability of secondary and micronutrients for crop uptake varies: fifty-five percent of the sulfur, calcium, and magnesium in manure is available the first year, while sixty-five percent of the boron, copper, iron, manganese, and zinc is available for crop uptake the first year of application.

Carbon to Nitrogen Ratio

As a general rule, when organic materials with a C:N ratio of greater than 30 are added to soils, there is immobilization of soil nitrogen during the initial decomposition process. During this time, a rapid increase in the number of heterotrophic organisms causes an increase in carbon dioxide levels until the carbon supply decreases and mineralization of nitrogen begins. Organic materials with a C:N ratio below 20 that are added to soils generally show an early release of nitrogen in the decomposition process. For ratios between 20 and 30 there may be neither immobilization nor release of mineral nitrogen.

Table 1. Carbon to Nitrogen (C:N) Ratios of Various Materials

Material	C:N Ratio
Manure	5-30:1
Vegetable Waste	10-20:1
Hay	15-30:1
Grass Clippings	15-25:1
Corn Stalks	60-70:1
Straw	40-150:1
Newspaper	400-800:1

Table 2. Nutrient Removal By Crops

Crop	Unit	Approximate pound per acre of nutrients removed by the portion of crop shown			Crop	Unit	Approximate pound per acre of nutrients removed by the portion of crop shown		
Crop	Unit	N	P_2O_5	K_2O	Crop	Unit	N	P_2O_5	K_2O
Corn	bu				**Silage**	ton			
Grain		1.0	0.37	0.26	Alfalfa		15	4	17
Stover		0.75	0.15	1.06	Barley		12	4	14
Soybeans	bu				Corn		8	3	8
Beans		4.00	0.8	1.40	Grass-legume		16	5	16
Stover		1.15	0.27	0.96	Oat		11	4	15
Wheat	bu				Grain Sorghum		8	2	9
Grain		1.25	0.62	0.37	Forage Sorghum		7	2	7
Straw		0.57	0.15	0.90	Sudangrass		10	3	14
Hay	ton				Soybean		17	7	7
Alfalfa (early bloom)		52	9	43	Timothy		11	3	14
Alfalfa (full bloom)		41	9	37	Wheat		10	3	10
Ryegrass		28	10	30	Rye		12	3	14
Ladino Clover		67	16	47	**Barley**	bu			
Red Clover		42	10	35	Grain		1	0.4	0.3
Fescue		28	10	34	Straw		0.4	0.1	1.1
Lespedeza		40	10	23	**Dry Beans**	bu			
Oat		26	8	30	Beans		2.5	0.8	0.9
Orchardgrass		31	11	44	**Sugar Beets**	ton	4.1	0.6	7
Sudangrass		31	8	32	**Tomatoes**	ton	3.8	1.45	7
Soybean		39	9	20	**Grain Sorghum**	bu			
Timothy		27	7	34	Grain		0.83	0.41	0.21
Vetch		54	10	44	Stover		0.94	0.18	1.06
Wheat		25	7	31	**Canola**	bu	3.00	1.31	2.37
Oats	bu				**Rye**	bu	1.2	0.35	0.35
Grain		0.7	0.25	0.2	**Tobacco**	lb			
Straw		0.3	0.15	1.25	Leaf		0.03	0.01	0.05
Potatoes	cwt	0.33	0.15	0.53	Stalk		0.01	0.01	0.03

Table 3. Approximate Manure Nutrients Remaining at Time of Application

Livestock	Description	Percent Solids	Organic-N Availability Factor	NH4-N Fraction (%)	Lb/Ton				Lb/1000 gallon			
					N	NH4	P_2O_5	K_2O	N	NH4	P_2O_5	K_2O
Beef	Solid with bedding	50	0.25	38	21	8	18	26				
	Solid w/o bedding	52	0.35	33	21	7	14	23				
	Lagoon	1	0.25	50					4	2	3	4
	Liquid Pit	9	0.30	34					29	10	18	26
Dairy	Solid with bedding	21	0.25	44	9	4	3	6				
	Solid w/o bedding	18	0.35	33	9	3	3	6				
	Lagoon	1	0.25	50					4	2	3	4
	Liquid Pit	8	0.30	23					31	7	15	19
Horse	Solid with bedding	46	0.20	29	14	4	4	14				
Poultry	Solid with litter	75	0.60	21	47	10	48	30				
	Solid w/o litter	45	0.60	24	33	8	48	34				
	Solid (deep pit)	75	0.60	32	38	12	45	25				
	Liquid pit	10	0.60	22					60	13	45	30
Sheep	Solid with bedding	28	0.25	36	14	5	9	25				
	Solid w/o bedding	28	0.25	28	18	5	11	26				
Swine	Solid with bedding	18	0.50	44	9	4	7	7				
	Solid w/o bedding	18	0.50	45	11	5	8	5				
	Lagoon	1	0.30	80					5	4	3	4
	Liquid pit	4	0.35	67					36	24	25	22
Turkey	Solid with litter	25	0.60	36	22	8	45	18				
	Solid w/o litter	20	0.60	40	20	8	40	17				
Veal Calf	Liquid pit	3	0.30	78					27	21	22	40

Table 4. Influence of Incorporation and Soil Temperature on N Availability

Time of Application	**Days Until Incorporations**	**Percent Available Nitrogen**	
Date	**Days**	**NH4-N**	**Organic-N**
Nov-Feb	5 or less	50	33
Nov-Feb	Greater than 5	25	33
Mar-Apr	3 or less	50	33
Mar-Apr	Greater than 3	25	33
Apr-Jun	1 or less	75	33
Apr-Jun	Greater than 1	25	33
Jul-Aug	1 or less	75	15
Jul-Aug	Greater than 1	25	15
Sept-Oct	1 or less	25	33
Sept-Oct	Greater than 1	15	33

Worksheet 1. Determining Crop Nutrient Requirements

Prepare a separate worksheet for each field where manure will be applied. Nutrient requirements of a crop can be established either by using fertilizer recommendations based on a recent soil test, or using crop removal factors. Recommendations will vary depending on whether the soil nutrient values are deficient, adequate, or need to be drawn down. Record N, P_2O_5, and K_2O requirements in **(1A)**, **(1B)**, and **(1C)**.

The amount of starter fertilizer that will be applied needs to be deducted from the initial nutrient requirements for nitrogen, phosphorus, and potassium. Record these amounts in **(2A)**, **(2B)**, and **(2C)**.

Nitrogen credits need to be deducted if manure has been applied to the field in the past 3 years. Base this credit on the total tons or 1000 gallons of manure applied per acre. Use the First Year Available Organic-N value from the past manure analysis report (s) or calculate an approximate amount using **Table 3**. Reduce this amount accordingly by the numbers of years since the manure was applied (50% for last year, 25% for 2 years ago, and 12.5% for 3 years ago). Record the sum of these in **(3A)**.

Other nitrogen credits need to be deducted if last year's crop was a legume. Record this amount in **(4A)**. Any other nitrogen credits, such as mineralized nitrogen released from organic matter can also be deducted. Record this amount in **(5A)**.

The resulting nitrogen requirements for a crop are obtained by deducting all of the nitrogen credits, as well as what will be used in the starter fertilizer, from the initial fertilizer nitrogen recommendation. This result is identified as **(WS16A)**.

The phosphate and potassium requirements are obtained by deducting the amount of these nutrients to be applied in the starter fertilizer from the initial recommendation. The result for phosphate is identified as **(WS16B)** and the result for potassium is identified as **(WS16C).**

WORKSHEET 1. Determining Crop Nutrient Requirements		
Field Identification	**Last Years Crop**	**Crop to be Grown and Yield Goal**
Fertilizer requirements from soil test or crop removal factor (lbs/acre)		
(1A) N	**(1B)** P_2O_5	**(1C)** K_2O
Starter fertilizer to be used (lbs/acre)		
(2A) N	**(2B)** P_2O_5	**(2C)** K_2O
Nitrogen credit (lbs/acre) from past years manure applications		
	Last year (50% of First Year Available Organic-N)	
	Two years ago (25% of First Year Available Organic-N)	
+________________________	Three years ago (12.5% of First Year Available Organic-N)	
(3A)	Total of last three years	
Residual Nitrogen credit (lbs/acre) for last year's legume crop (30 pounds for soybeans, 50 pounds for alfalfa)		
(4A)		
Other nitrogen credits (lbs/acre), such as organic matter (20 pounds for each 1% OM)		
(5A)		
Net Nutrient Requirements (lbs/acre)		
N: Deduct the total of **(2A + 3A + 4A +5A)** from **(1A)**	P_2O_5: Deduct **(2B)** from **(1B)**	K_2O: Deduct **(2C)** from **(1C)**
(WS16A)	**(WS16B)**	**(WS16C)**

Worksheet 2. Determining Manure Application Rate

and the amount of supplemental fertilizer needed to meet additional nutrient needs. Prepare a separate worksheet for each type of manure analyzed.

1. Fill in the First Year Available Nutrients for NH_4-N and Organic-N from the manure analysis report or use **Table 4** to estimate the NH_4-N and Organic-N from the Total N value. Also fill in the P_2O_5 and K_2O values.
2. Using **Table 4**, calculate the total amount of nitrogen available the first year from the NH_4-N and then Organic-N, taking into account the amount lost before incorporation.
3. Transfer the amount of nitrogen needed by the crop as determined in **Worksheet 1**, result **(WS16A)** to **(3A)**.
4. Calculate the amount of manure needed to meet the nitrogen requirements of the crop by dividing **(3A)** by the Total N amount in **(2A)**. Write the result in **(4)**. If this amount is unrealistic, enter the appropriate amount that can be applied.
5. Calculate the amount of N, P_2O_5, and K_2O that will be supplied from this quantity of manure by multiplying **(4)** by the Total N amount in (**2A**), the P_2O_5 in **(1B)**, and the K_2O in **(1C)**, respectively.
6. Determine the amount of supplemental fertilizer needed to meet the P_2O_5 requirements of the crop by deducting **(WS16B)** of **Worksheet 1** from (**5B**) . Determine the amount of supplemental fertilizer needed to meet the K_2O requirements of the crop by deducting **(WS16C)** of **Worksheet 1** from **(5C)** . If the amount of manure to be applied was reduced in Step **(4)**, determine the amount of supplemental fertilizer needed to meet the N requirements of the crop by deducting **(WS16A)** of **Worksheet 1** from **(5A)** .

If the resulting figures are negative, apply supplemental fertilizer to compensate for crop needs. Positive figures indicate an excess of nutrient applied. Phosphorus and potassium will

WORKSHEET 2. Determining Manure Application Rate		
Field Identification		
First Year Available nutrients per ton or 1000 gallons		
(1A) NH^4-N: Organic-N:	**(1B)** P_2O_5	**(1C)** K_2O
Nitrogen available due to loss from incorporation (values in **(1A)** multiplied by the % Available N in Table 4		
(2A) NH_4-N: + Organic-N: = Total N:		
Amount of nitrogen needed (from **(WS16A)** of the Nutrient Requirements Worksheet)		
(3A)		
Amount of manure needed to meet nitrogen requirements (**(3A)** divided by Total N in **(2A)**)		
(4) Tons or 1000 gal/acre units		
Pounds of nutrients per acre that will be applied		
N: **(4)** multiplied by Total N in **(2A)**	P_2O_5: **(4)** multiplied by **(1B)**	K_2O: **(4)** multiplied by **(1C)**
(5A)	**(5B)**	**(5C)**
Supplemental Fertilizer Requirements (lbs/acre)		
Negative numbers indicate fertilizer needed, positive numbers indicate excess nutrient applied. **(WS16A)**, **(WS16B)**, and **(WS16C)** are from the Net Nutrient Requirements Worksheet on page 7 of this fact sheet.		
N: **(WS16A)** from **(5A)**	P_2O_5: Deduct **(WS16B)** from **(5B)**	K_2O: Deduct **(WS16C)** from **(5C)**
(WS26A)	**(WS26B)**	**(WS26C)**

tend to build up in the soil under these conditions if applied at consistent rates over the years.