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Soil Test Note 5:

Fertilizing With Manures

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Introduction

Animal manures contain valuable crop nutrients and may also have liming value. With high costs for fertilizers, using animal manures to supply the major crop nutrients – nitrogen (N), phosphorus (P), and potassium (K) – may represent an economic savings. However, animal manures present some challenges compared to inorganic nutrient sources.

The Soil Testing Laboratory at Virginia Tech analyzes soil samples and provides crop N, P, and K recommendations based on sample analysis and crop yield expectations. Inorganic fertilizers can be blended to give the required N, P, and K required by crops, while manures have variable N, P, and K concentrations that can't be changed. Because the N:P ratio in manures normally does not match crop requirements, the decision must be made to apply manures on an N or P basis. Applying manures on an N basis means supplying sufficient N to meet crop needs, which generally overapplies P relative to crop requirement. This may be of benefit in P-deficient soils, but it is unnecessary in soils with high P levels and may cause environmental problems. Applying manures to meet crop P requirements generally leads to underapplying N, so additional N must be applied from other sources – normally inorganic fertilizer.

There are also practical considerations to using animal manures, such as having the appropriate machinery, because volumes and textures are substantially different from inorganic fertilizers. Dairy manure contains about 95 percent water, so it must be pumped, and long-distance transportation is expensive. Poultry manure is only about 25 percent water and there are transportation subsidies in some areas, making transportation much more economically attractive. Intensification of animal production over the past decades has led to a situation where some livestock and poultry farms produce more manure nutrients than the farm's crops need. Concerns about the impact of these excess nutrients have driven nutrient-management regulations, which primarily affect large producers but are subject to change. Therefore, those who use manure as a nutrient source should check current regulations with the local Virginia Cooperative Extension or Department of Conservation and Recreation office.

Factors to Consider in Applying Manures

1. Nutrient concentration in manures

Average concentrations of nutrients in manures are given in table 1. However, nutrient concentrations in manures can vary substantially for many reasons, such as source, animal diet, and moisture content. For example, when poultry litter is taken out of poultry houses, sometimes just the surface crust that is predominantly manure is taken, and sometimes all the litter is taken that contains a higher proportion of bedding material. For dairy cattle, diets vary greatly among farms due to different forage and feed concentrate sources, as well as storage and handling. During storage, manure can also lose substantial amounts of N. Therefore, the basis

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of accurate manure nutrient management is an accurate sample analysis.

The first step is to get a representative sample of the manure. For lagoons this involves agitating the tank, while dry manures should be sampled from several representative places, avoiding the surface of piles. Taking samples during spreading is best but not always possible due to time constraints between sampling and obtaining results. The importance of manure sampling and analysis cannot be overstated. For example, manure testing by the Department of Conservation and Recreation in Virginia shows that concentrations of phosphate in broiler litter have dropped from around 62 pounds per ton in the early 1990s to 52 pounds per ton now, due to a combination of reduced insurance feeding of phosphate (P_2O_5) and the use of the enzyme phytase, which helps broilers digest dietary P.

2. Plant availability of nutrients in manures

Application rates of P and K are based on the total P and K analysis of the manures; however, N is much more complicated. When a manure is surface-applied, it can rapidly lose N through ammonia (NH_3) volatilization, mostly in the first two days following application (table 2). Incorporation of manure by tillage immediately after surface application or direct injection of manures into the soil can greatly decrease these losses. Organic N in manures is transformed into plant-available forms through microbial breakdown and will only be partially plant-available; this plant-available portion varies by manure type (table 3). Therefore, when submitting a manure for testing or interpreting a manure analysis, the method of manure application must be considered before the amount of plant-available N can be determined. Labs that analyze manure will generally calculate and report the plant-available N in manure.

Sample calculation for plant-available nitrogen in manure

Consider surface-applying dairy manure with no incorporation in the spring for corn. The manure has Total Kjeldahl Nitrogen (TKN) of 20 pounds per 1,000 gallons and ammonium (NH_4-N) of 9 pounds per 1,000 gallons.

Table 1. Average analysis for manure tested from October 2001 through October 2004 in Virginia

Manure type	TKN*	Ammonium nitrogen (NH_4-N)	Phosphate (P_2O_5)	Potash (K_2O)	% moisture
Liquid dairy slurry, lb/1,000 gal	19.2	8.9	9.1	17.4	94.6
Semisolid dairy, lb/ton	15.3	3.5	7.6	14.3	67.4
Semisolid beef, lb/ton	18.0	2.4	9.9	19.0	63.1
Dry chicken broiler litter, lb/ton	64.9	11.5	52.2	53.4	27.8
Dry chicken layer/breeder, lb/ton	47.9	8.5	60.8	43.7	29.5
Dry turkey litter, lb/ton	62.0	13.1	50.2	38.3	28.6
Dry turkey breeder, lb/ton	58.8	12.6	61.2	36.2	25.5
Liquid swine lagoon, lb/1,000 gal	7.2	5.7	2.8	12.2	99.4
Liquid swine pit, lb/1,000 gal	23.6	15.3	16.7	15.7	97.5

*TKN is Total Kjeldahl Nitrogen, a measure of total N in a manure.

Table 2. Plant availability of ammonium nitrogen in manures for Virginia

Method of application	Semisolid manure	Liquid manure slurry	Lagoon liquid	Dry litter
	% plant availability			
Injection	-	95	95	-
Broadcast with immediate incorporation	75	75	90	90
Incorporated after 2 days	65	65	80	80
Incorporated after 4 days	40	40	60	65
Incorporated after 7 days or no incorporation	25	25	45	50
Irrigated without incorporation	-	20	50	-

Table 3. Plant availability of organic nitrogen in manures

Manure type	Single crop	Winter topdress/ spring residual	Perennial grass
	% plant availability		
Dairy manure	35	20/15	35
Poultry litter	60	30/30	60
Swine manure	50	25/25	50

a) Calculate organic N = 20 − 9 = 11 lb organic N/1,000 gal.

b) Calculate ammonium nitrogen (NH4-N) availability = 9 x 0.25 (table 2) = 2.25 lb/1,000 gal.

c) Calculate organic N availability = 11 x 0.35 (table 3) = 3.85 lb/1,000 gal.

Total plant-available N (PAN) = 2.25 + 3.85 = 6.1 lb/1,000 gal.

3. Balancing and calculating manure and fertilizer application rates

Although manures contain N, P, K, and micronutrients, they are generally applied to meet crop N or P requirements. Manures generally have an imbalance of N and P relative to crop requirements, so applying manures to meet crop N needs results in overapplying P relative to crop uptake. Therefore, applying manure to meet crop N requirements every year will build up P in the soil above concentrations necessary for optimum yields over a period of several years, and it may rise to levels where losses of P in surface runoff and soil erosion are of environmental concern. This can be avoided by monitoring soil-test P and not applying manure every year or by applying lower rates based on crop P requirements, with either strategy generally requiring inorganic N fertilizer.

As a rule of thumb, applying manure to meet crop N needs applies about the same amount of P taken up by crops in three years. So applying manure on an N basis one year in three, with inorganic fertilizer containing no P for the other two years, would be close to balance for P. This obviously varies slightly with crops grown, yields, and manure type and analysis. Whatever the strategy used, organic (manure) and inorganic (fertilizer) nutrients are added together to calculate the total nutrients applied for each year along with soil testing in succeeding years to determine the residual effects of applications. An example of calculating N-based or P-based manure rates is shown below.

Sample calculation

Consider applying poultry litter to a corn crop that requires 150 pounds of N per acre (known from yield expectation) and 50 pounds of P_2O_5 per acre (known from soil test). The litter contains 45 pounds of plant-available N (PAN) per ton for a surface application, and 55 pounds of P_2O_5 per ton (known from manure analysis).

a) Applying on a nitrogen basis: 150 lb N/acre ÷ 45 lb PAN/ton = 3.3 tons/acre

b) Applying on a phosphorus basis: 50 lb P_2O_5/acre ÷ 55 lb P_2O_5/ton = 0.9 tons/acre

Note that applying to meet crop N requirements is a much greater rate. It is also difficult to accurately apply 0.9 tons per acre, another reason for the suggestion of applying one year in three, as discussed above.

4. Timing of manure applications

As for inorganic fertilizers, it is best to apply manures close to the time of rapid nutrient uptake by crops because it minimizes unwanted nutrient losses. This particularly applies to N, which can be lost through leaching, denitrification in waterlogged soils, or ammonia volatilization. For spring crops, manure is therefore normally applied in the spring prior to planting. For forages, manure should be applied at the start of the periods of maximum growth: spring and late summer/fall for cool-season grasses and summer for warm-season grasses.

References

Commonwealth of Virginia, Department of Conservation and Recreation, Division of Soil and Water Conservation. Revised 2005. Virginia nutrient management standards and criteria. Richmond, Va.: DCR. Also available online at: https://www.dcr.virginia.gov/document/standardsandcriteria.pdf (accessed August 2019).