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Part XI.

Fertilizing With Manures

Authored by:

Rory Maguire, Extension Nutrient Management Specialist, Virginia Tech

Steven E. Heckendorn, Manager, Soil Testing Laboratory, Virginia Tech

Animal manures contain valuable crop nutrients and can have liming value too. 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 saving. 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 a set N, P, and K concentration. Because the N to P ratio in manures normally does not reflect crop requirements, you need to decide whether to apply manures on an N or a P basis. Applying manures on an N basis means supplying sufficient N to meet crop needs, but this method generally overapplies P relative to crop requirement. This may be of benefit in P-deficient soils, but it is not needed and could cause environmental problems in higher P soils. Applying manures to meet crop P requirements generally leads to underapplying N, so additional N must be applied from other sources, normally from inorganic fertilizer.

There are also practical considerations to using animal manures, such as having the appropriate machinery to handle it because volumes and textures are substantially different from inorganic fertilizers. Dairy manure contains about 95% water, so it must be pumped, and transporting it long distances is expensive. Poultry manure is only about 25% 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 animal farms produce more manure nutrients than the farms' crops need. Concerns about the impact of these excess nutrients have driven nutrient management regulations, which currently affect mainly large producers but are subject to change. Therefore, if you wish to use manure as a nutrient source, check current regulations with your local Virginia Cooperative Extension or Department of Conservation and Recreation office.

Factors To Consider in Applying Manures

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 by farm in forage and concentrates and also storage and handling. During storage, manure can also lose substantial amounts of N.

Therefore, the basis of accurate manure nutrient management is having an accurate sample analysis. The first step is to get a representative sample of the manure you will be using. 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. If you are receiving manure from a regulated farm, you should receive a manure analysis from the supplier. The importance of manure sampling and analysis cannot be overstated. For example, manure testing in Virginia by the DCR (2014) shows that concentrations of phosphate phosphorus (P_2O_5) 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 P_2O_5 and the use of the enzyme phytase that helps broilers digest dietary P.

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

Manure Type	TKN*	NH_4	P_2O_5	K_2O	% Moisture
Liquid dairy slurry, lbs/1000gal	19.2	8.9	9.1	17.4	94.6
Semi-solid dairy, lbs/ton	15.3	3.5	7.6	14.3	67.4
Semi-solid beef, lbs/ton	18.0	2.4	9.9	19.0	63.1
Dry chicken broiler litter, lbs/ton	64.9	11.5	52.2	53.4	27.8
Dry chicken layer/breeder, lbs/ton	47.9	8.5	60.8	43.7	29.5
Dry turkey litter, lbs/ton	62.0	13.1	50.2	38.3	28.6
Dry turkey breeder, lbs/ton	58.8	12.6	61.2	36.2	25.5
Liquid swine lagoon, lbs/1000gal	7.2	5.7	2.8	12.2	99.4
Liquid swine pit, lbs/1000gal	23.6	15.3	16.7	15.7	97.5

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

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 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 nitrogen in manures is transformed into plant-available forms through microbial breakdown and will only be partially plant-available, and this plant-available portion varies by manure type (**table 3, page 148**). Therefore, when you submit a manure for testing or are interpreting a manure analysis, you must consider the method of manure application before you can know how much N will be plant-available. Labs that analyze manure will generally calculate the plant-available N (PAN) in manure.

Table 2. Plant availability of ammonium nitrogen in manures.

Method of application	Semisolid manure	Liquid manure slurry	Lagoon liquid	Dry litter
Injection	-	0.95	0.95	-
Broadcast with immediate incorporation	0.75	0.75	0.90	0.90
Incorporated after 2 days	0.65	0.65	0.80	0.80
Incorporated after 4 days	0.40	0.40	0.60	0.65
Incorporated after 7 days or no incorporation	0.25	0.25	0.45	0.50
Irrigated without incorporation	-	0.20	0.50	-

Table 3. Plant availability of organic nitrogen in manures.			
Manure type	Single crop	Winter topdress/Spring residual	Perennial grass
Dairy manure	0.35	0.20/0.15	0.35
Poultry litter	0.60	0.30/0.30	0.60
Swine manure	0.50	0.25/0.25	0.50

Sample calculation: Consider surface-applying dairy manure with no incorporation in the spring for corn, and the manure has total nitrogen (TKN) of 20 lb/1,000 gal and NH_4 of 9 lb/1,000 gal.

1. Calculate organic N = 20 – 9 = 11 lb organic N/1,000 gal.
2. Calculate NH_4 availability = 9 × 0.25 (table 2) = 2.25 lb/1,000 gal.
3. Calculate organic N availability = 11 × 0.35 (table 3) = 3.85 lb/1,000 gal.
4. Total plant-available N = 2.25 + 3.85 = 6.1 lb/1,000 gal.

Balancing and Calculating Manure and Fertilizer Application Rates

Although manures contain N, P, K, lime, and micronutrients, they are generally applied to meet crop N or P requirements. Manures usually 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 soil test P levels may rise to levels where losses of P in runoff and 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 strategy you use, you must add organic (manure) and inorganic (fertilizer) nutrients together to calculate the total nutrients applied for each year along with soil testing in succeeding years to determine the residual effects of applications.

Sample calculation: Consider applying poultry litter to a corn crop that requires 150 lb of N/acre (known from yield expectation) and 50 lb of P_2O_5/acre (known from soil test). The litter contains 45 lb PAN/ton for a surface application and 55 lb P_2O_5/ton (known from manure analysis).

1. Applying on a nitrogen basis: 150 lb N/acre ÷ 45 lb PAN/ton = 3.3 ton/acre.
2. Applying on a phosphorus basis: 50 lb P_2O_5/acre ÷ 55 lb P_2O_5/ton = 0.9 ton/acre.

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

Timing of Manure Applications

As for inorganic fertilizers, it is best to apply manures close to the time of nutrient uptake by crops because this 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 cold-season grasses and summer for warm-season grasses.

References

DCR (Virginia Department of Conservation and Recreation). 2014. *Virginia Nutrient Management Standards and Criteria*. Rev. July 2014. Richmond, VA: DCR. www.dcr.virginia.gov/document/standardsandcriteria.pdf.