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Fertilizing Cropland with Poultry Manure

Michael Schmitt and George Rehm
Extension Soil Fertility Specialists
Department of Soil Science
University of Minnesota

MINNESOTA EXTENSION SERVICE



UNIVERSITY OF MINNESOTA

Manure management should be a top priority on poultry farms as we approach the 21st century. Mismanagement of manure can have a substantial impact on our water, soil and air resources. When used appropriately, manure has nutritive, and thus economic value. Manure also improves biological activity, soil tilth, and soil chemical properties.

According to 1990 Minnesota Agricultural Statistic Service data, the Minnesota poultry industry generates approximately 2 million tons of manure annually. Poultry excrete almost 29,000 tons of nitrogen (N) per year that can serve as a nutrient source for crops. Manure also contains 24,000 tons of P₂O₅ (phosphorus fertilizer equivalent) and 14,000 tons of K₂O (potassium fertilizer equivalent). High concentrations of poultry in relation to cropland acres necessitates the need for proper manure management.

Manure Inventory Assessment

A comprehensive manure management plan is essential for all poultry operations. Knowing the amount of manure produced as well as the nutrient content contained in this manure will allow poultry producers to plan for the number of acres that will be manured.

The best method to determine nutrient supply from manure is to analytically test it for nutrient contents and multiply this by the storage volume. This method does not require numerous assumptions--yet it does require that representative manure samples be collected and storage volume calculations be made. Collecting a representative sample of poultry manure can be tedious but necessary for the manure nutrient analysis to have meaning. Several subsamples should be taken throughout the manure layer or piles.

An alternative method to determine nutrient quantities is to calculate storage capacities and multiplying by the average nutrient content for that particular manure, based on the species and the storage and handling methods (Table 1). While Table 1 might be a good reference to begin with in developing application rates, these tabled values will vary significantly among storage facilities and poultry operations.

Table 1. Nutrient analysis of poultry manure.
Livestock waste facilities handbook, Midwest Plan Service, March 1985.

Form	Dry Matter	Total N	P ₂ O ₅	K ₂ O
	%	-----lbs/ton-----		
No bedding	22	27	20	17
With bedding	29	20	16	13

A third alternative, one that is relatively easy to calculate, is to calculate the average amount of manure produced per day per bird, multiply by number of birds and assume standard storage and handling losses. Table 2 can be used to calculate the initial amount of manure produced by the birds.

Table 2. Daily poultry manure production.
Livestock waste facilities handbook, Midwest Plan Service, March 1985.

Type	Manure	N	P ₂ O ₅	K ₂ O
	lbs	----- lbs -----		
Turkey	0.70	0.009	0.008	0.004
Chicken				
Layer	0.20	0.003	0.003	0.001
Broiler	0.14	0.002	0.001	0.001

Table 3 lists some average N losses that will affect nutrient content from several storage and handling systems. This method may be a good method for planning cropland needs with proposed increases in poultry numbers.

Table 3. Storage losses of nitrogen.
Livestock waste facilities handbook, Midwest Plan Service, March 1985.

System	N Lost
	--%--
Daily scrape and haul	15-35
Manure pack	20-40
Open lot	40-60

Determining Application Rates

Next, manure application rates must be calculated. This requires knowing the nutrient content of the manure, nutrients required by the crop, and availability of nutrients in the applied manure.

The majority (70-90%) of the phosphorus and potassium applied in manure will be available to the crop the first year after application. The availability of N varies considerably. This variation is primarily a function of the method of application. Table 4 provides an estimate of the amount of the total N that will be available in the application year and in the year after application.

Table 4. Nitrogen availability and loss as affected by method of application.

	Broadcast-Incorp.^{1/}		
	None	<12 hrs	<4 day
	-----% Total N -----		
Avail. Year 1	30	75	55
Avail. Yrs. 2-3	25	25	25
Lost	35	5	20

^{1/}The categories refer to the length of time between manure application and incorporation.

Often there is a sense of futility in trying to use manure analysis, application loss coefficients, and crop nutrient requirements to determine manure application rates. Here is a five-step process to get started:

- 1) Determine nutrient needs of each field's crop based on soil tests, previous crops, yield expectations, etc.
- 2) Make an initial manure rate selection. Use the crop needs and a tabled nutrient composition of the manure, or a previous year's test.
- 3) While applying the manure at the predetermined rate, collect a representative manure sample--either when loading the spreader in the yard or unloading the spreader in the field. Send it to a laboratory for analysis.
- 4) After receiving the laboratory analysis (presumably the manure will have been applied), calculate the actual amount of nutrients applied based on data and the application rate.
- 5) In a record keeping system, record any possible overapplications or underapplications.

If fewer nutrients were applied than planned and a fall application was made, starter or sidedressed programs can supply the deficiency. If spring manure applications were made and less N was applied than planned, a sidedressed application of N can be made. Overapplications should be credited for the next year.

Field Spreading Priority

Each livestock producer should determine the amount of manure generated and the nutrient requirements of the crops where the manure is to be used. If there is an excess of manure produced in relation to the farm's crops' needs, manure rates should be based on the crops' N requirements. At no time should rates in excess of agronomic needs be used--this is both illegal (state rules, chapter 7020) and environmentally unsound. Rates will have to be based on P requirements if there is a potential phosphorus/surface water problem because of soil erosion, a very high soil test for phosphorus, and/or there is close proximity to water.

Additional strategies such as hauling the manure off-farm, composting the manure, refeeding and/or acquiring more cropland must also be considered in situations where excess manure is produced. If the manure produced on a farm cannot supply all of the farm's crop nutrient needs, it is best to base the manure application rates on the phosphorus requirements, resulting in a lower manure application rate and the need for supplemental fertilizer.

A field priority system should be developed to maximize the nutrient value of the manure. Priority should be given, in order, to those fields that: 1) require the greatest amount of N to grow the crop, 2) have the lowest phosphorus and potassium soil tests, and 3) will benefit most from adding the organic material to the soil.

Making a multi-year plan

Thus far we have discussed annual manure management plans. For most planning processes, a three- to five-year forecast is often desirable. This may also be true with manure. In developing a multi-year plan, cropland nutrient needs often change due to crop rotations. The supply of nutrients should not change from year to year unless animal numbers change.

For each year in a rotation, the crop's needs must be determined and appropriate application rates determined. In an operation where cropland needs always exceed the manure's nutrient supply, shifting

application rates and fields will occur. If there is a near balance in nutrient supply and needs, strategies that can correct for those “excess” and “deficient” years are needed. The primary strategies would be to apply/allow for multiple year needs.

Also, due to manure’s residual properties, second and third year credits need to be accounted for in determining crop needs. Approximately 35-50% of the N in the organic fraction is available each year. Thus, second and third year N credits should be given for manure (Table 4). After applying poultry manure, approximately 20% of the total N is available to the crop in the second year; approximately 5-10% is available in the third year.

Calibrating Application Equipment

Correct application of manure to cropland is critical to maximize the value of manure to crop producers. For manure to replace commercial fertilizer and not create environmental problems, farmers must be confident about the application rate. All calculations involving calibration of manure must be done using manure on an “as is” basis. All analysis should be interpreted on an “as is” basis and the application rate should be as well. Do not worry about the moisture content or change to a dry matter basis.

Three conditions must be addressed to achieve this confidence. First, the **analysis of the manure loaded into the application equipment must be known** and should not change. Loading procedures that do not separate the solids and the semi-solids can assure this for solid manure systems. Second, the **rate of manure being applied to the field must be known** and kept constant. Calibration must be conducted for all manure applications. And finally, the **application or spread pattern of the manure must be throughout the field** so that all plants will have equal access to the nutrients. Having a predetermined travel plan for applying manure to a field and noting where loads stop and start will help ensure uniform applications.

The weight of manure applied can be determined by any one of several ways. Weigh your manure spreader before and after going to the field and determine the weight of manure spread. Then determine the width the manure is being spread and the distance it took to unload the manure. Using the ratio of weight per portion of an acre, a per-acre application rate can be calculated. It is best not to unload the entire spreader because the spread pattern at the end of a load is not representative. *Example:*

Operator A weighs a loaded spreader; it is 9800 lb. After spreading a 12-ft width of manure a distance of 300 ft, the spreader is reweighed and it now measures 6200 lb. The rate calculation is:

$$[(9800 \text{ lb} - 6200 \text{ lb}) \div 2000 \text{ lb/ton}] \div [(12 \text{ ft} \times 300 \text{ ft}) \div 43560 \text{ ft}^2/\text{acre}] = 21.8 \text{ tons/acre}$$

A practical method is using a scale to determine a weight per load, then counting the number of loads it takes to spread manure on a given field. Calculate the total tons per field and divide by the number of acres in the field to determine rate of application. *For example, if Operator B has previously calculated their spreader to hold 8.5 tons of manure when fully loaded, and uniformly applied 16 loads in a 13-acre field. The solution for rate is:*

$$(16 \text{ loads} \times 8.5 \text{ tons/load}) \div 13 \text{ acres} = 10.5 \text{ tons/acre}$$

Another method is to lay a tarp or piece of heavy-duty plastic in a field. After the spreader has passed over, collect and weigh the manure from the tarp or plastic. Then determine the area of the plastic, and convert the weight measurement to a per-acre basis. This method generally has a large amount of variability unless several samples are collected and weighed. *In an example, Operator C places five 4 ft by 4 ft plastic sheets in their field and spreads manure across these sheets. The combined weight of the sheets is 38.5 lb. The solution for the rate is:*

$$(38.5 \text{ lb} \div 2000 \text{ lb/ton}) \div [(5 \times (4 \text{ ft} \times 4 \text{ ft})) \div 43560 \text{ ft}^2/\text{acre}] = 10.5 \text{ tons/acre}$$

After determining the manure application rate, it is often necessary to adjust the rate to better match the recommended rate that you need. The most common method to change application rate is by changing the speed you drive across the field. Manure equipment may also have an adjustment that changes the chain speed in the box, thereby changing the manure rate.

Special Concerns and Issues

Solid versus liquid manure

A common concern for management decision with other livestock waste is whether to handle the waste as a solid or a liquid. With poultry manure, this is seldom an issue because of the inherent nature of poultry manure. While fresh dairy, beef,

or swine manure is approximately 90% moisture, poultry manure is about 75%. This is too dry to be handled as a liquid or slurry and is right on the break point between handling as a solid or a semi-solid. Thus, the bedding management and other handling decisions will dictate how the manure is to be handled. In most operations, the manure is handled as a solid, keeping in mind that there is still plenty of moisture in the manure.

Spring/winter/fall application times

Time of manure application can be extremely important if site-specific conditions create an environmental hazard. Fall applications allow for maximum time for the manure to break down before the crop uses the nutrients. While this is generally beneficial, it can also lead to environmental hazards if N loss from the soil is a concern. Fall applications of N are generally not recommended on coarse-textured soils.

With spring applications, there is less opportunity for N losses from a field. However, spring applications result in less time for organic decomposition of the manure, including the release of some nutrients. Spring applications might also delay fieldwork and planting and could increase soil compaction.

Many producers use winter and summer applications. While there will be significant losses of available N, the organic N fraction will still contribute to the plant-available N pool. The potential for nutrient runoff is an environmental concern for applications that cannot be incorporated, especially winter applications on frozen, sloping soil. If manure is applied and there is runoff from snow melt or rain, all nutrients in the manure can be lost with the runoff. This situation is not recommended.

Methods of application

Broadcasting is the most common way to apply poultry manure, generally followed by incorporation with a tillage operation. Broadcast applications allow for a good distribution of the manure across the field. Since the applied manure is visible, most producers can do a better job of uniform spreading. The drawback of broadcast applications is that until the manure is incorporated, volatilization of some inorganic N is occurring. The amount of loss depends mainly on the time between application and incorporation. Incorporation within 12 hours is ideal for maximum N efficiency (See Table 4).

Local ordinances and neighbors should be considered in determining where and when manure is broadcast due to odor issues.

Special uses

Off-farm marketing of excess poultry manure should be considered by poultry producers and by nearby farmers that need to purchase nutrients. Due to the low moisture content and high N analysis of this manure, the hauling costs of this manure moderate distances can be recovered at prices that could still provide the buyer an advantage compared to purchasing commercial fertilizer. Good application equipment can also apply this manure uniformly onto fields. When applied at agronomic rates and incorporated into the soil, poultry manure can be an excellent purchased nutrient source.

Poultry manure is quite different in its chemical make-up than other livestock manures. This is because poultry manure contains relatively high amounts of uric acid and other ureides. As there name implies, these are forms of urea and can be quite toxic to crops--both in the soil and on above-ground plant tissue. With preplant applications, thorough mixing of the manure and the plow layer of the soil is recommended to avoid planting seeds into concentrated zones of manure. The seeds will either not germinate or the plant will germinate and die due to ammonia toxicity. When topdressing poultry manure onto forage fields, low rates should be used to minimize the enhanced burning effect this manure possesses.

Composting poultry manure and its bedding or litter is often considered due to the nature of poultry manure (high C:N ratio and lower moisture content); and the need to export poultry manure because of limited crop acres. Due to the labor intensity and mechanization required for composting, it is generally more cost efficient to apply the manure to nearby cropland "as is." Composting the manure makes a product that is more convenient to handle and apply. The composting process results in carbon dioxide and volatile N compounds being lost to the atmosphere. So although the nutrient percentages of compost is higher than the raw manure, there are less nutrients in the final product than the initial product.

Refeeding of poultry manure is also an option for producers. Poultry manure is most efficiently used by ruminants (beef) and has a relatively high nutritional value--equivalent to good quality hay in terms of energy. Appropriate processing and

refeeding at reasonable levels should assure no negative effects on the quality of animal products or a hazard to human health.

Conclusion

As the demand for poultry meat increases, so will the amount of manure produced. Recycling the manure to the soil through a predetermined manure management plan is efficient and practical. This will optimize the nutrient value of the manure while minimizing potential environmental hazards. Manure is a valuable resource on a farm and should be treated as an asset.



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