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The Agronomics of Manure Use for Crop Production

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Land application of manures for crop production has in-creased in recent years primarily due to the expansion of the poultry industry in Kentucky. However, regulatory concerns related to water quality are causing some farmers to reconsider their use. This publication will discuss the value of manure in providing nutrients for crop production while minimizing the risk to water quality. Proper agronomic use of animal manures is compatible with most best management practices (BMPs) connected with water quality regulations.

The Agronomic Value of Manures

Animal manures are the digestive by-products of the feed ingested by animals and any associated bedding materials or water used in the animal production operation. Therefore, the nutrient content of manure is closely related to the chemical content of feeds consumed by the animals. During digestion, some of the energy, nutrients, vitamins, and minerals in feed are retained by the animal. However, most of the nutrients pass through the animal in urine or feces. For example, about 75% of nitrogen (N), 80% of phosphorus (P), and 85% of the potassium (K) consumed by cattle is excreted. Undigestible and partially digested organic residues are also excreted. Because of this, animal manure provides:

- nutrients for crop growth, and
- organic material that can increase soil structure, porosity, and water-holding capacity.

Thus, the agronomic value of manure depends on its nutrient and organic matter content.

Ability of Manure to Supply Plant Nutrients

How well animal manure performs as a plant nutrient source is determined by the chemical form in which nutrients occur, how the manure is applied, when it is applied, and how much is used. The effects of each of these factors on nutrient availability are discussed below.

The nutrients in liquid manures are highly available to crops, especially when applied in early spring.

Nitrogen Availability

Soluble N (primarily in the form of ammonium) in animal manures ranges from about one-third of the total N in poultry manure to about two-thirds or more in lagoon liquids. This portion has the same availability to plants as N contained in commercial fertilizer. The remaining N is contained in insoluble organic compounds. This N will become available to crops over a period of weeks, months, or even years after the manure is applied to a field. How much of the total N that is actually utilized by the crop depends on the application rate and the length of the growing season. Corn is less efficient in utilizing N than cool-season grass pastures. Corn can utilize N only during three or four months, while the pasture will be growing and taking up N for eight to 10 months.

Substantial amounts of the ammonium and urea-N in manures can be lost through volatilization to the air if left on the soil surface. How much is lost depends on the type of manure and weather conditions at the time of application. High temperatures increase losses, while as little as 1/3 inch of rain can move the inorganic N into the soil and prevent its loss. The organic N is less subject to loss but requires time to become available. Soil incorporation or injection of manure increases availability of both organic and inorganic N.

Table 1. Percent of nutrients from manure available to a crop for one year from the time of application as compared to commercial fertilizer.

Nutrient	Crop	Management	Poultry or liquids (%)	Other manures (%)
Nitrogen				
	Corn, tobacco, or annual grasses	*Spring applied*		
		2 days*	60	50
		3-4 days	55	45
		5-6 days	50	40
		7 days or more	45	35
	Corn, tobacco, or annual grasses	*Fall applied*		
		No cover crop	15	20
		Cover crop	50	40
	Small grains	*Applied preplant*	50	40
	Pasture or hay (cool-season)	*Applied spring or fall*	80	60
	Bermudagrass	*Applied spring or summer*	50	40
Phosphate (P_2O_5)			80	80
Potash (K_2O)			100	100

* How soon manure is mixed into the soil, or 1/3+ inch of rain is received after application.

Table 2. Estimated available N from manure as a percentage of the total manure N applied in the previous year.

Years in which manure was applied in last 10 years	Poultry or liquid manures	Other manures
< 4	3	5
4-8	7	15
> 8	12	25

The effect of various factors on availability of N in manure is illustrated in Table 1. Soil incorporation of manure for summer annual crops can increase N availability by one-third or more. The use of a winter cover crop can double or triple the N availability of fall-applied manure to next year's corn crop. When manure is applied to cool-season grass pasture or hay fields, N availability can be as high as 80% of that of commercial N fertilizer. Nitrogen losses are less if manure is applied in cool weather or where there is a longer growing period for the crop to use the N.

Some of the organic N in manures can be released a year or more after application. This needs to be taken into consideration when planning N fertilizer rates for crops grown the year after manure is applied. The amount of N available to a crop from manures applied the previous year can be estimated using Table 2. Poultry or liquid manures have higher percentages of N as inorganic N, which increases availability during the year of application. Other manures have more organic N that is released slowly and can carry over to the next year. If manure is applied to the same field year after year, the slowly decomposable organic N accumulates and increases N carryover.

Phosphorus Availability

Whether phosphorus exists in manure as predominantly organic P or inorganic P depends on the species and animal production intensity. Animals and poultry under intense production are likely to have higher amounts of dicalcium phosphate added to the ration which passes through as inorganic P (50% to 60% of the total P). This form of P, which acts similar to fertilizer forms of P in the soil, may be readily available during the first year when soil pH is at recommended levels. Beef cattle and broiler manure will have more than 50% of their total P as organic P, which is released more slowly as the manure is decomposed. In general, this means that P in manures is slightly less available to crops during the first year of application.

When properly applied and managed, P remains in the soil to maintain or increase soil test P levels. When P is applied repeatedly in excess of that removed from harvested crops, soil test P can increase to a level that becomes a concern for water quality. Application rates of manure P should be planned and soil test P levels monitored regularly to be sure this does not happen. This should be a part of the Agricultural Water Quality Plan that is required by the Kentucky Agricultural Water Quality Act that became effective in October 2001.

Potassium Availability

The K content of manure is mostly soluble and consequently is readily available to crops. It is given an availability factor of 100% in Table 1, which means that it acts the same as K in commercial fertilizer when applied to the soil. Like P, it can accumulate in the soil and increase soil test K or move down into the soil profile if more is applied than the crops remove. This is not currently a water quality concern but may be an economic loss to the farmer.

Amounts of Manure to Apply

Manure application rates should be no greater than the nutrient needs of the crop(s) to be grown. This is difficult to determine, however, due to the variability of nutrient content of manures and the fact that the ratio of nutrients in manure is not the same as the ratio taken up by plants. For example, N in manure is low in comparison to P in terms of what crops need. In many cases, it may be best to apply manure to supply the P needs and add fertilizer N to get the correct ratio of N to P. In some cases, it is possible to apply manure at rates to provide

Poultry manure is portable and can be an economical source of nutrients 50 miles or more from where it is produced.

the N and P needs of one crop (e.g., corn) and the P needs of the next crop in the rotation (e.g., soybeans). Extension publication AGR-146, *Using Animal Manures as Nutrient Sources*, discusses nutrient values of manures and shows how to calculate application rates to supply crop nutrient needs. A computer spreadsheet ("Manure Use 1.2-x1s") that calculates application rates is also available through the College of Agriculture .

In addition to environmental risks associated with overapplying manure, there may be agronomic problems as well. Manure rates on tobacco should be limited to 4 T/A of poultry manure or 10 T/A of other manures in order to avoid excess chloride. Poultry manure, for example, contains about 12 lb chloride per ton, and a 4 T/A rate would apply 48 lb/A of chloride, which is about the maximum rate that can safely be used on tobacco.

Another possible problem related to high rates of manure application, particularly if the high rates are repeated for several years, is a "salt" build-up. In this situation, high concentrations of ammonium and soluble salts of potassium, sodium, calcium, and magnesium can accumulate. This can cause poor seed germination, reduced soil water availability, and deterioration of soil structure. This problem with excess salts commonly occurs in soil where manure has been stockpiled. Soil pH in these areas will likely be 7 or above, and nothing will grow there for a year or more.

Uniformity of Manure Application

It is difficult to apply manures uniformly on fields. Spread patterns and application rates of manure spreaders should be checked at least once a year. This can be done by placing sheets of plastic film of uniform size at equal intervals across the path of application and then measuring how much manure is on each. Uniformity of spread can be improved by using lower application rates and going over the field twice with the spreader. The second pass can "split the middle" of the first pass, or run perpendicular to it. For nutrients other than N, this should give adequate uniformity. Uniformity of N from manure is less critical if a portion of the N need of the crop is supplied by fertilizer.

Placement of Manure

The primary concern of manure placement should be the efficiency of N use. Incorporating, or mixing, the manure with the soil, especially during hot weather, will reduce the risk of N loss. This benefit must be weighed against disadvantages such as exposing the soil to erosion or loss of soil moisture. For example, it is seldom worthwhile to sacrifice conservation tillage in order to reduce the risk of N loss from manure.

If liquid manure is injected into the soil in concentrated subsurface bands, especially in poor soil drainage conditions, there will likely be anaerobic decomposition that produces organic compounds toxic enough to stunt or kill plants. This risk can be minimized on soils with restricted water movement by broadcasting the manure and discing it in.

Summary

Animal manures can be used to supply nutrients needed to grow crops. If manures are managed properly, they can save farmers money and be an environmentally safe means of disposal. Application rates should be planned in combination with commercial fertilizer to provide the nutrients recommended for growing a crop. Apply manure close to the time the crop will need the nutrients. Mixing or injecting manure into the soil helps reduce nutrient losses and odor problems. Farmers can visit their local Cooperative Extension Service or Natural Resources Conservation Service office for help in planning for manure use.

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