UGA extension

Land Application of Livestock and Poultry Manure

Contents

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Livestock and poultry manures contain nutrient elements that can support crop production and enhance the chemical and physical properties of soil. Manure can be an asset to livestock and poultry operations when its nutrients are used for fertilizer. This publication provides information on (1) the nutrient content of manures available for land application, (2) how to determine manure application rates and whether supplemental fertilizer will be needed for maximum crop production and (3) how to use management techniques to maximize the fertilization potential of farm manures.

Factors Affecting Fertilizer Value of Manure and Recommendations for Application

The type and amount of nutrients in livestock and poultry manures and the nutrients' eventual availability to plants may vary considerably. Some factors affecting nutrient value of applied manure are type of ration fed, method of collection and storage, amount of feed, bedding and/or water added, time and method of application, soil characteristics, the crop to which the manure is applied, and climate.

Increasing levels of various elements (copper, arsenic, etc.) and inorganic salts (sodium, calcium, potassium, magnesium, etc.) in feed will increase their concentrations in manure. There is concern about the potential toxic effects to plants of high concentrations of heavy metals and salts in soil as a result of high application rates of manure to the land. Perform regular soil tests and manure analyses to monitor the balance of nutrients in the soil on your farm, especially on land receiving heavy manure applications. From an environmental standpoint, limit the rate of manure application to the needs of the crop grown on the land.

Bedding and water dilute the nutrient concentration of manure and reduce its value. On the other hand, feed spilled and incorporated into the manure increases the nutrient concentration. Excessive feed spillage and/or inadequate agitation may cause sludge buildup in liquid systems, making removal of the manure more difficult.

The type of housing and/or waste handling system you use greatly affects the nitrogen (N) concentration of manures (Table 1). Major N losses occur when manure is dried by sun and air movement or leached by rain, as is the case in open lot systems. In contrast, manure loses comparatively little N in a completely covered facility using a manure pack or liquid pit storage system. Loss of N is greatest in long-term treatment or storage systems such as oxidation ditches or lagoons.

Table 1. Approximate Nitrogen Losses from Manure as Affected by Handling and Storing Methods

Handling, Storing Methods	Nitrogen Loss*
Solid Systems:	
Manure Pack	35%
Poultry Litter	35%
Liquid Systems:	
Anaerobic Pit	25%
Oxidation Ditch	60%
Lagoon	80%

* Based on composition of manure applied to the land vs. composition of freshly excreted manure.

Phosphorus (P) and potassium (K) losses are minimal (5 to 15 percent) for all but open lot and lagoon manure handling systems. In an open lot, you can lose from 40 to 50 percent of the manure's P and K to runoff and leaching. However, most of the P and K can be retained for fertilizer use by runoff control systems (setting basins, detention ponds). In lagoon systems, from 50 to 80 percent of the P in manure can settle in the sludge layer and thus be unavailable if only the liquid portion is applied to the land.

You will realize maximum nutrient benefit from manure if you incorporate it into the soil immediately after land application (Table 2). Incorporation minimizes N loss into the air and/or in runoff and also allows soil microorganisms to start decomposing the organic matter in the manure, thus making nutrients available to the plant sooner. In addition, incorporation of manures into the soil minimizes odor.

Table 2. Approximate Nitrogen Losses from Manure to the Air as Affected by Application Method

Application	Type of Nitrogen Manure	Method Loss
Broadcast without cultivation	Solid Liquid	20% 25%
Broadcast with cultivation[1]	Solid Liquid	5% 5%
Knifing	Liquid	5%
Irrigation	Liquid	30%

* Percent of total nitrogen in manure applied which was lost within 4 days after application.
[1] Cultivation immediately after application.

Generally, P and K losses are negligible and are not affected by the method of application; however, incorporating manure minimizes P and K losses due to surface runoff. Apply manure as uniformly as possible to prevent local concentrations of ammonium-N or other inorganic salts that can reduce seed germination and crop yields.

By applying manure just before the planting date of crops, you maximize plant nutrient availability, especially in high rainfall areas and on porous soils having rapid percolation. However, don't plant immediately after heavy manure application. Salt accumulation near the soil surface and/or a temporary excess of ammonia resulting from the breakdown of organic nitrogen lower germination and reduce seedling growth. As an alternative, late fall applications may be desirable because of labor availability, field conditions, etc. Even though fall applications may result in 5 to 10 percent total N loss, the extra time allows soil microorganisms to more fully decompose the manure and release its nutrients for use during the following cropping season. This is especially advantageous for solid manure that contains much organic matter.

For sandy or coarse-textured soils, manures can best be applied frequently and at low rates throughout the growing season to provide environmental protection and maximum plant growth. Soils with more than 10 percent slope should not have manure applied or if applied, use injection of liquid manure into sod.

Not all manure nutrients are readily available to a crop in the year of application. To be used by plants, nutrients in manure must be released from the organic matter in a water-soluble form. Manure nitrogen is in ammonium (inorganic) and organic forms. Potentially, plants could use all of the ammonium-N in the year of application. Nitrogen in the organic form, however, must be "released" before plants can use it. In other words, the organic nitrogen must be converted to ammonium $(NH_4)+$ or nitrate (NO_3) — before it can be used by plants. Ap-proximately 75 percent of the total N will be available to crops during the year of application with the remainder carried over and available the next cropping season.

However, the rate of availability of N is largely influenced by soil, climate, etc. In contrast, nearly all the P and K in manures are available for plant use during the year of application.

Table 3 shows the pounds of nutrients excreted annually by various livestock per 1,000 pounds liveweight. The nutrient content of manure from your farm might differ considerably from the values presented here. These figures can, however, serve as a guideline for planning purposes. Nutrient analysis of the manure is highly desirable.

Table 3. Annual Pounds of Nutrients in Manure as Excreted per 1,000 Pounds Liveweight

	Dairy Cow	Beef Feeder	Swine Feeder	Laying Hen	Broiler
Nitrogen, N	150	124	164	263	423
Phosphate, P_2O_5*	60	91	124	232	216
Potash, K_2O	118	106	132	136	158

* Elemental P and K conversion can be made as follows: to convert P_2O_5 to elemental P, multiply by 0.44; and to convert K_2O to elemental K, multiply by 0.83.

Determine How Much Manure Can Be Applied

You can only determine the exact amount of nutrients available for land application from your operation by laboratory analysis. But you can use Tables 1, 2, and 3 to calculate the approximate nutrient value of your manure from Table 3, then subtract storage and handling losses (Table 1) and application losses (Table 2) to get the nutrients available at time of application. With these figures you can estimate the amount of manure to apply to a given crop area and whether your crop will require additional commercial fertilizer. If you know the quantity of nutrients available from your operation per year, you can determine how much land is needed for manure disposal. Table 4 gives nutrient needs for various crops. Apply to the land at such a rate that the amount of available nutrients does not greatly exceed the amount removed by the growing crop.

Example

A swine producer has a 1,000-head finishing operation (averaging 125 pounds weight per animal) in an enclosed confinement building. Liquid manure is collected in a lagoon. If the manure is spread by irrigation annually on land producing 150 bushels of corn per acre, how many acres are required for maximum fertilizer utilization?

Step 1. Determine the nutrient needs of the crop. From Table 4, for 150 bushels of corn: N = 225 pounds/acre, P_2O_5 = 80 pounds/acre, K_2O = 215 pounds/acre.

Step 2. Determine the nutrient value of manure from Table 3. Pounds nutrient/year/animal unit in manure as excreted: N = 164, P_2O_5 = 124, K_2O = 132. Reduce nitrogen value 80 percent for storage losses (Table 1) and 30 percent for application loss (Table 2). This means only 23 pounds of N/1,000 pound animal unit are available for crop utilization. At 125 pounds/ head the number of 1,000 pound animal units = 1,000 head x 125 lbs/head divided by 1,000 lbs/animal unit =125 animal units.

To determine total pounds of each nutrient available, multiply unit values by number of animal units:

N = 23 x 125 = 2,875 pounds
P_2O_5 = 62 x 125 = 7,750 pounds*
K_2O = 66 x 125 = 8,250 pounds*

* Assumes 50 percent recovery with little or no agitation of the lagoon.

Step 3. Determine number of acres required for maxi-mum nutrient utilization. Divide total pounds of each nutrient (from Step 2) by pounds of that nutrient required per acre (from Step 1).

Acres Required for N = 2,875 225 = 12.8
Acres Required for P_2O_5 = 7,750 80 = 96.8
Acres Required for K_2O = 8,250 215 = 38.4

Table 4. Approximate N, P_2O_5 and K_2O Utilization by Various Crops

		Nutrient Uptake, lb/A*		
Crop	**Yield/Acre**	**N**	**P_2O_5**	**K_2O**
Corn (grain)	150 bu	170	80	215
	180 bu	225	100	240
Corn silage	32 tons	480	80	245
Wheat	40 bu	80	27	81
	70 bu	140	47	142
	100 bu	200	68	203
Bermudagrass	6 tons	258	60	288
(Hybrid)	8 tons	368	96	400
Clover/grass	6 tons	270	90	360
Sorghum/Sudan Hybrid	8 tons	360	122	466
Grain Sorghum	6,000 lb	225	63	180
Barley	100 bu	150	55	150

* Figures given are total amounts taken up by the crop in both the harvested and the above-ground unharvested portions. These numbers are estimates for indicated yield levels taken from research studies, and should be used only as general guidelines.

Thus P_2O_5 is the acreage-determining nutrient if nutrients are fully used. Manure should be applied over 96.8 acres to assure maximum utilization of the manure (in actual practice, P and K are often over applied to allow more nitrogen application). Make up the remaining N and K_2O required for production with commercial fertilizer.

Step 4. Determine supplemental fertilizer needed (total needs - supplied). Since manure will be applied over 96.8 acres, the following total amounts of N, P_2O_5, and K_2O will be required:

N = 96.8 x 225 (from Table 4) = 21,780 pounds
P_2O_5 = 96.8 x 80 (from Table 4) = 7,744 pounds
K_2O = 96.8 x 215 (from Table 4) = 20,812 pounds

Supplemental nutrient requirements may be determined by subtracting nutrients available in manure (from Step 2) from total nutrients required as follows:

Supplemental N required = 21,780-2,875 = 18,905
Supplemental P_2O_5 required = 7,744-7,744 = 0
Supplemental K_2O required = 20,812-8,250 = 12,562

Solids in Liquid Manure

Flushing gutters with recycled water from lagoons can be a major obstacle when solids content is higher than pumping equipment can handle. A major handicap can occur when dairy freestall bedding, for example, gets in the flush gutters and ultimately into lagoons. Table 5 shows typical solids content of some liquid waste handling systems.

Table 5. Typical Solids Content of Some Liquid Waste Handling Systems

	VS/TS* (%)	Solid Content (%)
Manure Pit		
Swine	80	4-8
Cattle	82-85	10-15
Poultry Layers	69.8	25
Holding Pond		
Pit Overflow		1-3
Feedlot Runoff		Less than 1
Dairy Barn Wash Water		Less than 1
Lagoon		
Single or First Stage Swine		½-1
Cattle (no bedding)		1-2
Second Stage		Less than ½

* Volatile Solids/Total Solids. Volatile solids will dissipate and volatilize into the air over time. Values do not include any bedding.

The chart in Figure 1 shows the relationship of the liquid manure solids content to viscosity or consistency and type pump required.

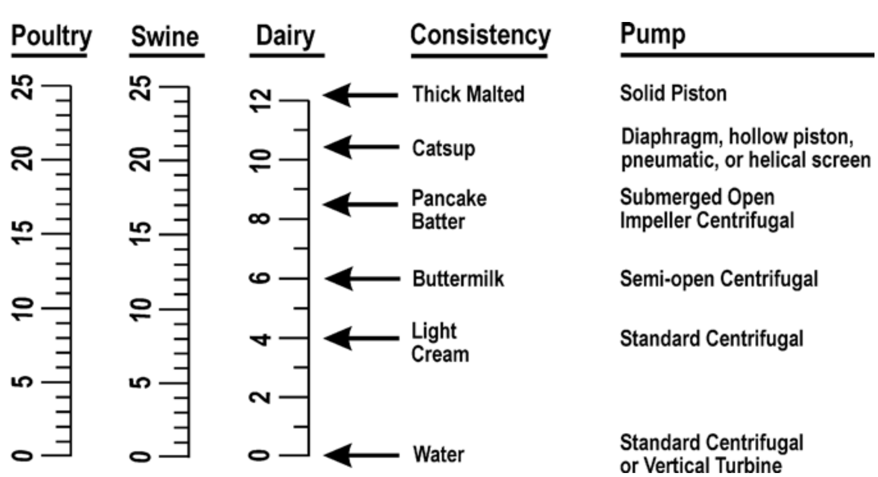

Figure 1. Solids Content and Pump Type Required

Management Factors

Some additional management techniques that will help ensure safe and effective application of manure to cropland follow:

- Incorporate manure into the soil immediately. Otherwise, apply manure to surface at reasonable distances from streams, ponds, open ditches, neighboring residences and public buildings to minimize runoff and odor problems.
- Minimize odor problems by using common sense, especially during the summer. Spread early in the day when the air is warming up and rising rather than later when the air is cool and settling, and do not spread on days when the wind is blowing toward populated areas or when the air is still. Good management helps avoid neighbor complaints. Analysis from liquid manure varies considerably depending on the amount of dilution. Laboratory analysis is recommended for all animal waste and soil samples are recommended as well. Table 6 shows average nutrients in liquid manure.
- Apply manure to relatively level land — if slope exceeds 10 percent, knife liquid manure into sod.
- Agitate or mix liquid manure thoroughly in pits to facilitate removal of settled solids and thus insure uniform application of the nutrients.
- Consider irrigating with dilute manures (lagoon or runoff liquids) during dry weather to apply needed water and nutrients to growing crops.
- Wash the plants with clean water to avoid leaf burn when irrigating manure on growing crop.
- Avoid spreading liquid manure on water-saturated or frozen soils where runoff is apt to occur.
- Apply sufficient water sometime during the year to avoid accumulation of salts in the root zone of soils in arid regions.
- Use good safety measures when moving manure from tanks or pits. Because of oxygen deficiency or toxic gas accumulation, avoid entering storage structures when agitating the liquid manure.

The chemical and physical properties of soil, such as water infiltration rate, water-holding capacity, texture and total exchange (nutrient-holding) capacity also affect how much manure can be safely applied to land. Fine-textured soils have low water infiltration rates; therefore, the rate at which liquid manure, especially lagoon effluent, can be applied without runoff may be restricted to the intake rate of the soil. Coarse-textured soils, on the other hand, are quite permeable and can accept higher rates of liquid manure applications without runoff. But because most coarse soils have a very low exchange (nutrient-holding) capacity, you may have to apply smaller amounts of manure during the growing season to minimize the chance of soluble nutrients entering ground water. Organic matter in the manure is decomposed more rapidly in coarse-textured than fine-textured soil and during warm, moist conditions rather than cold, dry conditions. However, fine-textured soils will retain the nutrients longer in the upper profile, where plants can get them.

Table 6. Nutrients in Liquid Manure — Approximate Fertilizer Value of Manure — Liquid Handling Systems

Animal	Waste Handling	Dry Matter	Available N	Total N	P_2O_5	K_2O
		%	lbs/1,000 gal of waste			
Dairy cattle	Liquid pit	8	12	24	18	29
	Lagoon*	1	2.4	4	4	5
Swine	Liquid pit	4	20	36	27	34
	Lagoon*	1	3.2	4	2	4
Beef	Liquid pit	11	24	40	27	34
	Lagoon*	1	2	4	9	5
Poultry	Liquid pit	13	64	80	36	96

* Lagoon — including lot runoff water

Note: There will be little odor if manure is immediately incorporated.

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