Fertilizer Value of Swine Manure
Michigan State University
Cooperative Extension Service

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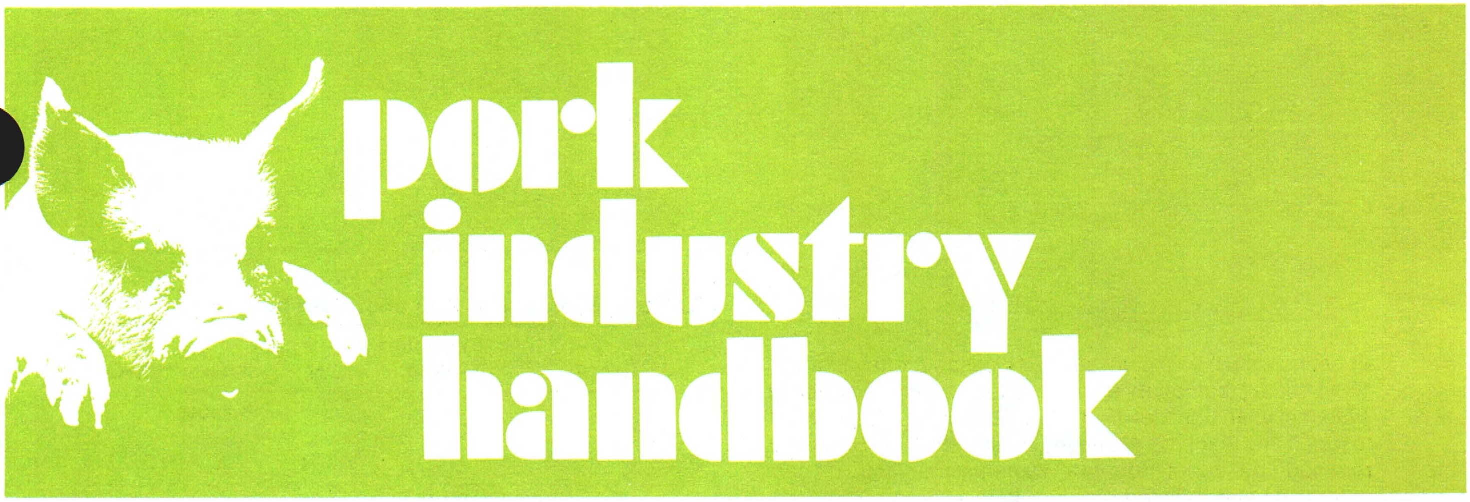

COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

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Swine manure contains fertilizer nutrients that can be utilized to support efficient crop production and enhance soil chemical and physical properties. Thus, manure can be an asset to a swine operation when managed to maximize the use of the available nutrients for fertilizer. The purpose of this fact sheet is to provide the swine producer with pertinent information on (1) the fertilizer nutrient content of swine manures available for land application, (2) how to determine manure application rates and the need for supplementary fertilizer for maximum crop production, and (3) related management techniques for maximizing the fertilizer potential of swine manure on the farm.

Factors Affecting Fertilizer Value of Manure, and Recommendations for Application

The type and amount of nutrients in swine manure and their eventual availability to plants varies considerably from farm to farm. Some factors affecting nutrient value of manure are: type of ration fed to swine; method of manure collection and storage; amount of feed, bedding and/or water added; time and method of application; soil characteristics and type of crop to which the manure is applied; and climate.

Increasing levels of additives (copper, arsenic, etc.) and inorganic salts (sodium, calcium, potassium, magnesium, phosphate, chloride, etc.) in swine rations will change concentrations of these elements in manure. There is concern about the potential toxic effects of elevated concentrations of heavy metals and salts in soil and plants as a result of high application rates of manure to the land. Routine soil tests and manure analysis on your farm are recommended to monitor the balance of nutrients in the soil, especially on land receiving heavy manure applications.

Bedding and water that get into manure dilute its nutrient concentration, thus lessening its value per ton or gallon when applied to the land. Feed spillage, on the other hand, will increase manure nutrient concentration for land application. Feed spillage and inadequate agitation may cause sludge buildup and difficult removal in liquid manure systems.

The type of housing and/or waste handling system greatly affects the nitrogen (N) concentration of swine manures (Table 1). Major N loss occurs when manure is dried by sun and air movement or is leached by rain as would be the case in an open lot system. In contrast, comparatively little N is lost from manure in a completely covered feedlot when a manure pack or liquid pit storage system is used. Loss of N is greatest in long-term treatment or storage systems such as oxidation ditches or lagoons.

Table 1. Approximate nitrogen losses from swine manure as affected by handling and storing methods.

Handling, storing methods	Nitrogen loss*
	%
Solid systems	
Manure pack	35
Open lot	55
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 (5-15%) for all but open lot and lagoon manure handling systems. In an open lot, from 40 to 50% of the P can be lost to runoff and leaching. However, most of the P and K can be retained by runoff control systems (settling basins, detention ponds) for fertilizer use. With a lagoon, from 50 to 80% of the P in manure can settle out in the sludge layer and, thus, be unavailable if only liquid is applied to the land.

Maximum nutrient benefit is realized when manure is incorporated into the soil immediately after land application (Table 2). Soil incorporation of manure not only minimizes N loss to the air and/or runoff but also allows the soil microorganisms to start decomposing organic matter in manure, thus making nutrients available to the plant sooner. In addition, incorporation of manures beneath the soil surface minimizes potential odor problems. Generally, P and K losses are negligible and are not affected by method of application; however, incorporation of manure would minimize P and K losses in the event of surface runoff from manured land. Manure should be applied as uniformly as possible to prevent local concentrations of ammonium-N or other inorganic salts that can reduce germination and yields.

Table 2. Approximate nitrogen losses from swine manure to the air as affected by application method.

Application method	Type of manure	Nitrogen loss*
		%
Broadcast *without* cultivation	Solid	20
	Liquid	25
Broadcast *with* cultivation†	Solid	5
	Liquid	5
Knifing	Liquid	5
Irrigation	Liquid	30

*%of total nitrogen in manure applied which was lost within 4 days after application.

†Cultivation immediately after application.

Application of liquid manure near the planting date will maximize nutrients available for plant growth, especially in high rainfall, porous soil-type, rapid percolation areas. Lowered germination and reduced seedling growth could occur, however, if planting takes place immediately after heavy manure applications. This would come about from salt accumulation near the soil surface. As an alternative, late fall or winter applications may be desirable because of labor availability, field conditions, etc. Even though fall-winter applications may result in 5-10% total N loss, more time in the field allows soil microorganisms time to more fully decompose manure and release nutrients for the following cropping season use. This is especially advantageous for solid manure which contains much organic matter.

Table 3. N, P_2O_5 and K_2O utilization by various crops.

Crop	Expected yield	N	P_2O_5	K_2O
			lb./acre	
Corn	80 bu.	121	42	77
	100 bu.	160	60	120
	150 bu.	185	80	215
	180 bu.	240	100	240
Corn silage	16 tons	130	45	102
	32 tons	200	80	245
Soybeans	30 bu.	123	32	52
	40 bu.	180	45	80
	50 bu.	257	48	120
	60 bu.	336	65	145
Grain sorghum	4 tons	250	90	200
Wheat	40 bu.	70	30	50
	60 bu.	125	50	110
	80 bu.	186	54	162
Oats	80 bu.	75	35	95
	100 bu.	150	55	150
Barley	65 bu.	74	32	63
	100 bu.	150	55	150
Alfalfa	4 tons	180	40	180
	8 tons	450	80	480
Orchardgrass	6 tons	300	100	375
Bromegrass	5 tons	166	66	254
Tall fescue	3.5 tons	135	65	185
Bluegrass	3 tons	200	55	180
Coastal Bermuda grass	4 tons	225	40	160
	10 tons	535	145	410
Clover-grass	4.5 tons	185	60	175
	6 tons	300	90	360
Sugar beets	30 tons	275	85	550
Rice	2.25 tons	110	45	110
	3.5 tons	112	60	168
Timothy	4 tons	150	55	250
Pangola grass	12 tons	299	108	430
Sorghum-sudan grass	8 tons	319	122	467

Table 4. Approximate average (and range) dry matter and fertilizer nutrient composition of swine manures at time applied to the land.*

Manure handling system	Dry matter	Available N†	P_2O_5‡	K_2O§	Total N#
Solid	%		lb./ton manure		
Without bedding	18 (15-20)	7 (6-9)	9 (7-13)	8 (6-10)	10 (9-11)
With bedding	18 (17-20)	6 (5-8)	7 (5-10)	7 (6-9)	8 (7-10)
Liquid	%		lb./1,000-gal. manure		
Anaerobic pit	4 (2-7)	26 (21-31)	27 (13-30)	22 (12-30)	36 (28-55)
Oxidation ditch	2.5 (1-4)	16 (12-22)	27 (10-30)	22 (10-24)	24 (18-34)
Lagoon**	1 (.3-2)	4 (2-5)	2 (1-4)	4 (2-6)	4 (3-6)

*Application conversion factors: 1 bu. manure spreader = 40-60 lb. solid manure; 1,000 gal. = about 4 tons; 27,154 gal. = 1 acre in.

†Primarily ammonium-N and 35% organic nitrogen which is available to the plant during the growing season.

‡To convert to elemental P, multiply by 0.44.

§To convert to elemental K, multiply by 0.83.

#Ammonium-N plus organic N, which is slow releasing.

**Includes feedlot runoff water and is sized as follows: *single cell*—2 cu.ft./lb. animal weight; *two-stage anaerobic* (cell 1)—1-2 cu.ft./lb. animal weight; and *aerobic* (cell 2)—1 cu.ft./lb. animal weight.

Table 5. Approximate nutrient value of swine manure per animal unit (1,000-lb. average liveweight) per year.*

Handling and disposal method	Total N	P_2O_5	K_2O
	lb./animal unit		
Manure pack			
Broadcast	84	107	124
Broadcast & cultivation	102	107	124
Open lot			
Broadcast	58	61	80
Broadcast & cultivation	70	61	80
Manure pit			
Broadcast	95	111	119
Knifing	124	111	119
Irrigation	92	111	119
Lagoon			
Irrigation	24	25	89

*Based on initial nutrient content and subsequent losses due to method of handling and disposal.

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. Heavy-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, application may have to be restricted to smaller amounts during the growing season to minimize the chance of soluble nutrients entering ground water. Organic matter in the manure is decomposed more rapidly in light-textured than heavy-textured soil and during warm moist conditions rather than cold and dry conditions. However, heavier textured soils will retain the nutrients longer in the upper profile (where plants can get them).

Table 3 shows the amount of N, P_2O_5 and K_2O that various crops utilize during the growing season. Grasses and cereal grain crops generally respond most favorably to the nutrients (especially N) in manure. For greatest dollar benefit, therefore, apply manure to land in corn, small grains and sorghum; then, if more is available, to land cropped to forages and pasture land.

Not all manure nutrients are readily available to a crop in the year of application. To be utilized by plants, nutrients must be released from the organic matter in manure and be in a water-soluble form. Manure nitrogen is in ammonium and organic forms. Potentially, all of the ammonium-N, except that lost to the air, can be utilized by plants in the year of application. Nitrogen in the organic form, however, must be "released" before plants can use it. From 20 to 50% of this organic N may become available the year of application with some N carried over and available the next cropping season. Nearly all of the P and K in manures are available for plant use the year of application. Table 4 shows the average and range percent dry matter and fertilizer nutrient composition of solid and liquid swine manures at the time of land application (wet basis). The nutrient content of manure from your farm might differ considerably from the values presented here; however, these figures can serve as a guideline in determining land application rates if a nutrient analysis of the manure is not available. Table 5 shows the annual approximate fertilizer value of manure from your swine operation expressed as pounds per animal unit (1,000 lb. of live animal weight).

Determining How Much Swine Manure Can Be Applied

If you know the fertilizer needs of the crops grown on your land (Table 3) and the approximate nutrient value of the swine manure at the time of application from your farm (Table 4), you can determine how much manure can be applied beneficially to the land and if additional commercial fertilizer will be needed for efficient crop production. In addition, knowing the crop nutrient needs (Table 3) and the approximate amount of fertilizer nutrients available from the swine operation per year (Table 5), you can determine how much land is needed for manure disposal. Swine manure should be applied to the land at such a rate that the amount of available nutrients does not greatly exceed the amount removed by the growing crop. This not only insures efficient use of manure nutrients but it also minimizes the chances of their leaching into ground water. Check with local regulatory agencies concerning specific restrictions on land application rates in your area.

The Worksheet

A worksheet (with example) is provided to help you arrive at the proper application rates. The phosphorus and potassium analysis of a soil test, along with the crop nutrient requirement figures in Table 3, should be used to adjust these rates to your soil conditions. In addition, a laboratory analysis is the most accurate way to ascertain the nutrient value of the manure from your swine operation. For names of commercial laboratories that provide soil and/or manure analyses, contact your local Agricultural Extension Office. Check with the laboratory for specific procedures on obtaining and sending representative samples for analyses.

The worksheet calculations show that the proper manure application rate on 150-bu. corn land would be 9,773 gal. per acre per year if using the manure as a complete fertilizer *or* 2,963 gal. if maximizing the fertilizer value (Step 3a). In the case of our worksheet example, this 1,500-head swine feeding operation would require a minimum of 96 acres or a maximum of 260 acres for manure disposal (Step 5d).

If you apply manure to maximize its fertilizer value, the worksheet indicates an additional 108 lb. of N and 150 lb. of K_2O are needed per acre to meet corn nutrient requirements (Step 4b). This can be supplied with commercial fertilizer as follows: 240 lb. of urea (45% N) or 132 lb. of anhydrous ammonia plus 250 lb. of 0-0-60 potash.

Some additional management recommendations to help insure safe and effective application of manure to cropland follow:

- Unless immediately incorporated into the soil, surface apply manure at reasonable distances from streams, ponds, open ditches, neighboring residences and public buildings to minimize runoff and odor problems. Use good management to avoid neighbor complaints.
- To minimize any odor problems, spread raw manure frequently, especially during the summer. Spread early in the day when the air is warming up and rising rather than later when the air is cooling and settling, and do not spread on days when the wind is blowing toward populated areas or when the air is still and seems to hang.
- During frozen ground conditions, apply manure only to relatively level or flat land.
- Agitate or mix liquid manures thoroughly in pits to facilitate removal of settled solids and thus insure uniform application of the nutrients.
- Consider irrigating dilute manures (lagoon or runoff liquids) during dry weather to apply needed water and nutrients to growing crops.
- When irrigating manure on growing crops, wash the plants off with clean water to avoid leaf burn.
- Avoid spreading liquid manure on water-saturated soils where runoff is apt to occur.
- In arid regions, the salt content of manure is of potential concern. Sufficient water must be applied sometime during the year to avoid soluble ion accumulation in the root zone.
- Use good safety measures when removing manure from tanks or pits. Because of oxygen deficiency or toxic gas accumulation, avoid entering storage structures when agitating the liquid manure.

Worksheet for Determining Animal Manure Application Rates and Size of Disposal Area

Example: A swine producer has a 1,500-head animal unit capacity growing-finishing operation (average weight 125 lb. per animal) in an enclosed confinement building. Manure is handled in a liquid pit and is surface-applied to the land without immediate cultivation. To maximize use of the manure as fertilizer, what should be the manure application rate, how much supplemental commercial fertilizer will be needed, and how many acres of cropland can utilize the manure?

Calculations	Example	Your situation
1. Determine nutrient needs of the crop.		
a. Crop grown on the land receiving the manure.	150 bu. Corn	
b. Nutrient needs of that crop, *expressed as pounds per acre* (from Table 3).		
N =	185 lb.	
P_2O_5 =	80 lb.	
K_2O =	215 lb.	
2. Determine nutrient value of the manure.		
a. Type of manure to be applied.	Anaerobic Pit	
b. Nutrient value of the manure, *expressed as pounds per ton for solid handling systems or as pounds per 1,000 gal. for liquid handling systems* (from Table 4, or recent laboratory analysis.)		
N =	26 lb./1000 gal.	
P_2O_5 =	27 lb./1000 gal.	
K_2O =	22 lb./1000 gal.	
3. Determine amount of manure to meet crop needs.		
a. Manure to meet the crop's N, P_2O_5 and K_2O requirements, *expressed as tons per acre for solid handling systems or as 1,000 gal. per acre for liquid handling systems.*		
N value from 1.b. ÷ N value from 2.b. =	7.115	
P_2O_5 value from 1.b. ÷ P_2O_5 value from 2.b. =	2.963	
K_2O value from 1.b. ÷ K_2O value from 2.b. =	9.773	
b. If the manure is to be used as a complete fertilizer, select the *highest* of the three values as your application rate per acre. If your aim is to maximize use of the swine manure, select the *lowest* of the three values, then supplement with commercial fertilizer to supply the remainder of the two nutrients still deficient.	2.963	

Calculations	Example	Your situation
4. Determine supplemental fertilizer needed.		
a. Amount of N, P_2O_5 and K_2O, *expressed as pounds per acre,* supplied at the manure application rate selected in 3.b.		
N value from 2.b. x Application rate from 3.b. =	77 lb./A	
P_2O_5 value from 2.b. x Application rate from 3.b. =	80 lb./A	
K_2O value from 2.b. x Application rate from 3.b. =	65 lb./A	
b. Amount of commercial fertilizer needed, *expressed as pounds per acre,* to meet deficient crop nutrient requirements.		
N value from 1.b. - N value from 4.a. =	108 lb./A	
P_2O_5 value from 1.b. - P_2O_5 value from 4.a. =	0 lb./A	
K_2O value from 1.b. - K_2O value from 4.a. =	150 lb./A	
5. Determine total cropland acreage which can be fertilized by the manure produced.		
a. Average animal units per year, *expressed as 1,000 lb. liveweight,* in the livestock enterprise (average weight per animal x average number of animals per year ÷ 1,000).		
125 lb. x 1500 ÷ 1000 = 187½ =	187½ a.u.	
b. Annual manure nutrient production per animal unit, *expressed as pounds per animal unit* (from Table 5; manure pit - broadcast).		
N =	95 lb./a.u.	
P_2O_5 =	111 lb./a.u.	
K_2O =	119 lb./a.u.	
c. Total animal manure nutrient production from the livestock enterprise, *expressed as pounds per year.*		
Animal units from 5.a. x N value from 5.b. =	17,812½ lb.	
Animal units from 5.a. x P_2O_5 value from 5.b. =	20,812½ lb.	
Animal units from 5.a. x K_2O value from 5.b. =	22,312½ lb.	
d. Total cropland area, which can be fertilized, *expressed as acres.**		
N value from 5.c. ÷ N value from 1.b. =	96 A	
P_2O_5 value from 5.c. ÷ P_2O_5 value from 1.b. =	260 A	
K_2O value from 5.c. ÷ K_2O value from 1.b. =	104 A	

*Manure application rate can be expressed as (a) number of animals sold per acre per year or (b) number of acres required per 1,000 animals sold per year.

Using our example and assuming 2.5 groups produced from the operation (Note: the number of groups must be increased or decreased, depending on the intensity of the operation).

(a) 1,500 growing-finishing hogs (building capacity) x 2.5 groups/year = 3,750 hogs sold/year.
3,750 hogs sold/year ÷ 96 acres (from 5.d.) = 39 hogs/acre/year.

(b) 96 acres ÷ 3,750 hogs sold/year = .0256 acres/hog sold x 1,000 hogs = 25.6 acres/1,000 hogs sold.