Calculating the Fertilizer Value of Manure from Livestock Operations

Livestock producers know that manure can be applied to croplands as a soil amendment agent as well as a fertilizer.

This circular outlines a method for calculating appropriate manure application rates for particular crops and soil conditions. It also identifies losses of nutrient value that can occur at different stages in the management and application system—from collection, to storage, to land application of manure. A worksheet and example are included for your use at the end of this circular.

Benefits

Increased crop production can result from the addition of the nutrients contained in manure. A manure slurry will also provide some water to the soil. Adding manure to soil can lessen wind and water erosion, improve soil aeration, and promote the growth of microorganisms that are beneficial to crops.

Hazards

On the other hand, excess applications of manure can be harmful to crops, soil, and surface and ground water quality. In some cases, most commonly with fresh poultry manure, high nitrogen content can burn crops. Heavy applications of manure also can cause excess accumulation of soluble salts in the soil, especially in some of eastern Oregon's arid regions where little or no leaching occurs. High salt content in soil can impair soil structure and decrease water movement rates, inhibiting plant growth. In addition, a large volume of manure in one application can cause temporary soil sealing, particularly in low spots. The soil sealing

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increases the potential hazard of manure runoff with any subsequent rainfall.

Plant Nutrient Content of Manure

A laboratory analysis of a representative sample of the manure will determine its nitrogen, phosphorus, and potassium (N-P-K) content. The economic value of the manure can then be calculated according to its plant nutrient content. Although other nutrients and trace elements in the manure are of benefit to crops, it is difficult to say how much benefit.

To determine the concentration of nutrients in manure, sample at different places in the storage unit to get a representative value. Mix these together and put a sample in a plastic jug or jar with screw lid. Keep the sample in a cool location to prevent gas build-up and rupture of the container. A local feed store, health department, or county Extension agent can help you locate a laboratory that will analyze the sample.

Some studies have been conducted on the production and nutrient content of fresh manures from farm animals (Table 1). Multiply the nutrient value from Table 1 times the number of animals times the number of days the manure has been collected and stored to get the total weight originally available.

Nutrient Losses during Collection and Storage

Nutrient losses from manure occur in collection, during storage, while spreading, and after land application. These losses vary widely, and under some conditions up to 80 or 90 percent of the initial concentration can be lost. Table 2 lists some percentage ranges of original nutrient concentrations retained by various collection and storage units.

In addition to the frequency and method of manure collection, the type of animal housing and handling system affects the final nutrient composition by influencing the addition of bedding, wastewater, and other materials. The duration, type, and location of storage also affect the final concentrations of nutrients in manure. Covered storage units generally are cooler and have less biological activity than open units. Open storage units are subjected to precipitation, resulting in leaching and runoff. Less nitrogen, for example, is lost from deep pits and roofed areas that are protected from high temperatures and rainfall.

Nitrogen is subject to the greatest losses from the animal to field application of all the plant nutrients contained in manure. Roughly 50 percent of the nitro-

Table 1
Total Production and Nutrient Content of Manure from Various Farm Animals

Animal	Animal size (lb)	Total manure production lb/day	cu ft/day	gal/day	% water	Nutrient content N lb/day	P lb/day	K lb/day
Dairy	150	12	0.19	1.5	87	0.06	0.010	0.04
	250	20	0.32	2.4	87	0.10	0.020	0.07
	500	41	0.66	5.0	87	0.20	0.036	0.14
	1000	82	1.32	9.9	87	0.41	0.073	0.27
	1400	115	1.85	13.9	87	0.57	0.102	0.38
Beef								
Cattle	500	30	0.50	3.8	88	0.17	0.056	0.12
	750	45	0.75	5.6	88	0.26	0.084	0.19
	1000	60	1.0	7.5	88	0.34	0.11	0.24
	1250	75	1.2	9.4	88	0.43	0.14	0.31
Cow		63	1.05	7.9	88	0.36	0.12	0.26
Swine								
Nursery Pig	35	2.3	0.038	0.27	91	0.016	0.0052	0.010
Growing Pig	65	4.2	0.070	0.48	91	0.029	0.0098	0.020
Finishing Pig	150	9.8	0.16	1.13	91	0.068	0.022	0.045
	200	13	0.22	1.5	91	0.090	0.030	0.059
Gestate sow	275	8.9	0.15	1.1	91	0.062	0.021	0.040
Sow & litter	375	33	0.54	4.0	91	0.23	0.076	0.15
Boar	350	11	0.19	1.4	91	0.078	0.026	0.051
Sheep	100	4.0	0.062	0.46	75	0.045	0.0066	0.032
Poultry								
Layers	4	0.21	0.0035	0.027	75	0.0029	0.0011	0.0012
Broilers	2	0.14	0.0024	0.018	75	0.0024	0.00054	0.00075
Horse	1000	45	0.75	5.6	79	0.27	0.046	0.17

Source: *Livestock Waste Facilities Handbook*, Midwest Plan Service No. 18.

Table 2
Percent of Original Nutrient Content of Manure Retained by Various Storage Systems

	Beef			Dairy			Poultry			Swine		
Storage system	N	P	K	N	P	K	N	P	K	N	P	K
Daily spread				70-85	85-95	85-95	60-70	85-95	85-95			
Dry (with roof)				60-80	80-95	80-95	55-70	80-95	80-95			
Earthen storage				60-80	80-95	80-95						
Lagoon/flush				20-35	30-50	40-70	20-30	30-50	40-70	20-30	30-50	40-70
Open lot	50-70	60-80	50-70	50-70	60-80	50-70				50-70	60-80	50-70
Pits (slats)	70-85	90-95	90-95	70-85	90-95	90-95	80-90	90-95	90-95	70-85	90-95	90-95
Scrape/above ground storage	70-85	85-95	85-95	70-85	85-95	85-95				70-85	85-95	85-95
Tear-drop flume	20-35	30-50	40-70									

gen is in the organic form and appears as partially digested feed and microorganisms. The other 50 percent is in the inorganic form, usually as ammonia. This inorganic form is subject to significant losses during collection and storage.

In most manure management systems about 5 to 15 percent of the original phosphorus and potassium content is lost in handling. However, in open lots as much as 50 percent of the phosphorus and 40 percent of the potassium can be lost through runoff and leaching. Up to 80 percent of the phosphorus and nitrogen can be lost in lagoon systems.

Nutrient Losses during Field Application

Nitrogen can volatilize when manure is spread on cropland. (The odor from fresh manure is mostly the volatilized ammonia.) Essentially all the phosphorus and potassium applied will be available for the crop. Runoff can remove a portion of all three nutrients; however, this type of loss is very site-specific and is not included in these calculations. Table 3 outlines the percent of original nutrient content delivered to cropland by various application methods.

Denitrification and Leaching Losses in the Field

Nitrogen may also be lost by denitrification (loss of inorganic nitrogen by biological conversion to nitrogen gas) and leaching (loss of nitrate nitrogen as water moves below the root zone).

Table 3
Percent of Original Manure Nutrient Content Delivered to Cropland by Application Method

Application Method	N	P	K
Injection	95	100	100
Broadcast	80	100	100
Broadcast with immediate cultivation	95	100	100
Sprinkling	70	100	100

Anaerobic bacteria, which work in the absence of oxygen, break down nitrate nitrogen to release nitrogen gas; thus the more oxygen, the less nitrogen that is lost. This loss is related to the soil type and the rainfall pattern. Heavy, wet soils provide the ideal condition for maximum nitrogen loss through denitrification. Soil drainage rate can be used to calculate denitrification losses. Values range from 5 percent loss in well-drained soils to 50 percent loss in poor drainage conditions. The wide rainfall patterns and diverse soil types make a complex set of coefficients for Oregon, and for that reason are not included in this publication.

Leaching loss of nitrate nitrogen is caused by percolating water moving below the root zone. Again, soil type and rainfall are the major influencing factors. Soil permeability can range from less than 0.06 inches per hour for clay soils to greater than 20 inches per hour for gravelly sand soils.

Availability of Nutrients for Crops

Nitrogen is a vital nutrient, and its availability influences both microbial activity and plant growth. The carbon-nitrogen ratio (C/N) of applied wastes affects this availability and therefore affects plant growth. If a material with a high C/N ratio, such as manure with a lot of bedding, is added to a soil, organisms which decompose the organic matter grow until limited by available minerals and nitrogen. All the immediately available nitrogen may be bound by the microorganisms, and more chemical fertilizer may have to be added to the soil than before the manure was applied.

Inorganic nitrogen is the form of nitrogen that is taken up by the plant root system and used for growth. The organically bound nitrogen in the soil breaks down with time to form inorganic nitrogen. With enough time, the organic nitrogen present in manure will be converted to plant-usable inorganic nitrogen. This process is called mineralization. Since livestock feeds have a variety of particle sizes and compositions, manures have different mineralization rates, and some manures may be in the soil several years before all the organic nitrogen is converted to plant-usable inorganic nitrogen. Therefore, not all the nitrogen contained in manure which has been incorporated into the soil can be used by the plants during the first year after manure application. The rate of mineralization depends on the soil moisture content, organic matter level, and temperature. Table 4 provides general mineralization rates for nitrogen, phosphorus, and potassium for two broad areas in Oregon.

Table 4
General Mineralization Rates for Nitrogen, Phosphorus, and Potassium for Oregon

Nutrient and Location	Percent mineralized (years after application) 1st	2nd	3rd
Nitrogen			
West of Cascades	50	20	15
East of Cascades, irrigated	60	25	10
East of Cascades, dry land	45	20	15
Phosphorus			
West of Cascades	75	10	5
East of Cascades	80	8	5
Potassium			
West of Cascades	80	8	5
East of Cascades	85	8	5

For efficient use of nutrients, apply manure so nutrients added do not greatly exceed those removed by crops (see Table 5). This table will serve as a general guide. However, fertilizer guide sheets or specific recommendations should be used in determining local rates when that data is available. Manure nutrients, especially nitrogen, are utilized more efficiently by grasses and cereals than by legumes. Inoculated legumes get most of their nitrogen from the air, so additional nitrogen is not normally needed.

Get your soil tested to determine specific fertilizer requirements for your land. Your county Extension office has a publication, entitled "How to Take a Soil Sample and Why" (Extension Circular 628), which explains the procedure. Adjust manure application rates for your soil conditions to balance crop nutrient needs with the soil test results. In some cases, if you apply manure at a rate to satisfy the nitrogen requirements, you will overapply phosphorus or potassium. Apply manure to satisfy the requirements of the least needed nutrient and supplement the other two.

Table 5
Suggested Nutrient Application Rates for Various Crops

Crop	Yield per acre	lb/acre N	P	K
Corn silage	32 tons	200	35	203
Wheat	80 bu	60	24	125
	100 bu	100	24	153
	120 bu	150	24	177
Oats	100 bu	90	24	125
Barley	100 bu	150	24	125
Alfalfa	8 tons	40	40	398
Grass Seed Production (Removing straw)		150	25	100

NOTE: 1 lb. P_2O_5 = 0.44 lb. P; 1 lb. K_2O = 0.83 lb. K

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Calculating Land Application Rates

The following example and worksheet will help you use all the information in the circular to determine how much nitrogen, phosphorus, and potassium from manure you may use on your cropland.

Example

1) Operator in western Oregon has 100 milking cows (1400 lbs each) with a liquid flush/lagoon system. Annually sprinkles this on cropland of corn silage. How much land should he utilize to receive his manure?

No. Animals	*Animal Wt.*	*Storage*
100	1400 lb	365 days

2) Nutrient Production Rate (from Table 1)

N: 0.57 lb/cow/day
P: 0.102 lb/cow/day
K: 0.038 lb/cow/day

3) Total Nutrient Production
no. animals x days x rate = total produced

N:	100	x	365	x	0.57	=	20,805 lb
P:	100	x	365	x	0.102	=	3,723 lb
K:	100	x	365	x	0.38	=	13,870 lb

4) Storage Losses (from Table 2)

	produced	x	*rate retained in storage*	=	*total retained in storage*
N:	20,805 lb	x	0.25	=	5,201 lb
P:	3,723 lb	x	0.40	=	1,489 lb
K:	13,870 lb	x	0.55	=	7,628 lb

5) Application Losses (from Table 3)

	retained in storage	x	*rate retained in application*	=	*total in field*
N:	5201 lb	x	0.70	=	3641 lb
P:	1489 lb	x	1.00	=	1489 lb
K:	7628 lb	x	1.00	=	7628 lb

Your Farm

1) ______________________________
____
____
____
____

No. Animals	*Animal Wt.*	*Storage*
________	________	________

2) Nutrient Production Rate (from Table 1)

N: ______________________________
P: ______________________________
K: ______________________________

3) Total Nutrient Production
no. animals x days x rate = total produced

N: ______________________________
P: ______________________________
K: ______________________________

4) Storage Losses (from Table 2)

produced x *rate retained in storage* = *total retained in storage*

N: ______________________________
P: ______________________________
P: ______________________________

5) Application Losses (from Table 3)

retained in storage x *rate retained in application* = *total in field*

N: ______________________________
P: ______________________________
K: ______________________________

6) Nutrient Availability (from Table 4)

N:	3641 lb	x	0.5	=	1820 lb
P:	1489 lb	x	0.75	=	1116 lb
K:	7628 lb	x	0.8	=	6102 lb

7) Crop Nutrient Needs (from Table 5)

	amount available	÷	*amount needed/A*	=	*no. of A needed*
N:	1820	÷	200 lb/A	=	9.1 A
P:	1116	÷	35 lb/A	=	31.9 A
K:	6102	÷	203 lb/A	=	30.1 A

8) Largest Acreage Needed (from 7 above)

31.9 A for P requirements

9) Acres Needing Supplemental Nutrients

	acres served	–	*satisfied*	=	*needed*
N:	31.9	–	9.1	=	22.8 A
P:	31.9	–	31.9	=	0
K:	31.9	–	30.1	=	0.18 A

10) Additional Nutrients Needed

	area (A)	x	*rate (lb/A)*	=	*bought*
N:	22.8	x	200 lb/A	=	3160 lb
P:	0	x		=	0 lb
K:	1.9	x	203 lb/A	=	365 lb

6) Nutrient Availability (from Table 4)

N: ______________________________

P: ______________________________

K: ______________________________

7) Crop Nutrient Needs (from Table 5)

amount available ÷ *amount needed/A* = *no. of A needed*

N: ______________________________

P: ______________________________

K: ______________________________

8) Largest Acreage Needed (from 7 above)

____

9) Acres Needing Supplemental Nutrients

acres served — *satisfied* = *needed*

N: ______________________________

P: ______________________________

K: ______________________________

10) Additional Nutrients Needed

area (A) x *rate (lb/A)* = *bought*

N: ______________________________

P: ______________________________

K: ______________________________