NebGuide
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Managing Manure Phosphorus from Feedlots

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This NebGuide presents recommendations designed for managing dietary phosphorus in the feedlot and the impact on nutrient management plans.

Phosphorus (P) is involved in a variety of functions in the animal, including the building structure and strength of bones and cell walls, buffering systems, and energy transfer. Feedlot cattle require about 0.15 percent of dietary P. This requirement is easily met by common feedstuffs in the diet and, consequently, P should never be supplemented for finishing cattle. If excess P is fed and excreted in the manure, the amount of land area needed to distribute the manure also increases. Manure is a valuable fertilizer when applied correctly.

Managing P throughout the feedlot can be easy and economical when these recommendations are followed:

- Do not supplement phosphorus finishing diets.
- The nutrient management plan should reflect dietary nutrient intake and excretion.
- Apply manure as a fertilizer on a P rather than nitrogen (N) basis where soil test P is high.
- Apply manure on a four-year rotation compared with annual application.

Do Not Supplement Phosphorus in Diet

Phosphorus should not be supplemented in the ration of finishing cattle. Previous research has demonstrated that the nutrient requirements of beef cattle overestimates P requirements. Results from UNL research show that P requirements for calf-feds (spring born and placed in feedlot at weaning) and yearlings (backgrounded before feedlot entry) are 0.16 percent and 0.14 percent of diet dry-matter, respectively. Most common feedlot diets exceed these requirements. *Table I* shows P content of common feedlot diet ingredients. Corn is about 0.32 percent P, which is well above dietary P requirement when used as the primary ingredient in finishing rations.

Table I. Phosphorus content (% of DM)

Feedstuff[1]	*% DM*	*% CP*	*% P*
DRC	86.0	9.5	0.32
WCGF	44.7	19.5	0.66
Sweet Bran	60.0	24.0	0.99
DDGS	90.4	33.9	0.81
MDGS	46.2	30.6	0.84
WDGS	34.9	31.0	0.84
CCDS	32.5	23.5	1.72
Steep	49.4	35.1	1.92

[1]DRC=dry-rolled corn, WCGF=wet corn gluten feed, Sweet Bran = Cargill wet corn gluten feed, DDGS=dry distillers grains plus solubles, MDGS=modified distillers grains plus solubles, WDGS=wet distillers grains plus solubles, CCDS=condensed corn distillers solubles (corn syrup), Steep = steep liquor from wet milling plants

In the production of distillers grains (DGS) from corn, starch is fermented into alcohol and carbon dioxide (CO_2), which concentrates the remaining nutrients, including P, by three times. As a result, DGS contains about 0.85 percent P. In a common diet where wet distillers grains (DGS) is fed at a 40 percent inclusion level, the resulting diet will contain about 0.55 percent P, which is more than three times the requirements for growth. Supplementation of mineral P in finishing diets is unnecessary and results in economic costs for the feedlot and possibly environmental challenges.

Cattle do not retain more P when excess dietary P is fed. Therefore, all P not retained (or fed in excess of requirements) results in the excess being excreted in the manure. This is shown in *Tables II* and *III* when DGS was fed to calves or yearlings at 15 or 30 percent of the diet dry-matter. Phosphorus intake, retention, excretion, and amount of P in the manure are presented as lb/steer throughout the finishing period. Nutrient excretion is calculated by subtracting the amount of nutrient retained in the body from the amount of nutrient consumed (intake). Once excreted, P will be in the manure, runoff (erosion or retention ponds), or perhaps stored in the soil. In some cases with very high concentrations of P and the right soil conditions, P may leach through the soil. As DGS replaces corn in the diet, P intake increases. Since retention does not increase at the same rate as intake, excretion increases with inclusion of DGS. Additionally, as DGS inclusion increases in the diet, manure P also increases. For more information refer to the UNL Extension publication RP190, *Impact of Feeding Distillers Grains on Nutrient Planning for Beef Cattle Systems*.

Table II. Effect of dietary treatment on phosphorus mass balance during the WINTER.[a]

Dietary Treatment[b]	*CON*	*15*	*30*
P intake	11.5	14.4	17.2
P retention	3.0	3.1	3.2
P excretion[c]	8.6	11.3	14.0
Manure P	6.1	8.4	9.9
N:P Ratio	3.06	2.81	2.65

[a]Values are expressed as lb/steer over 167-day feeding period.
[b]CON=Control corn-based diet with no DGS, 15=15% DGS (DM basis), 30=30% DGS (DM basis).
[c]Excretion=Intake-Retention.

Table III. Effect of dietary treatment on phosphorus mass balance during the SUMMER.[a]

Dietary Treatment[b]	*CON*	*15*	*30*
P intake	11.4	13.5	16.0
P retention	3.1	3.3	3.3
P excretion[c]	8.3	10.2	12.7
Manure P	4.5	5.7	9.5
N:P Ratio	3.06	4.03	3.95

[a]Values are expressed as lb/steer over 133-day feeding period.
[b]CON=Control corn-based diet with no DGS, 15=15% DGS (DM basis), 30=30% DGS (DM basis).
[c]Excretion=Intake-Retention.

Nutrient Management Plans Should Reflect Dietary Nutrient Intake and Excretion

Increasing dietary P will increase manure P and the amount of land needed for manure application. When manure is applied on a N-basis to meet the N needs of crops, P is often overapplied. As by-products increase in the diet, nutrient management plans should address:

- Greater land requirements.
- Greater travel distances and time requirements for land application of manure, which increases labor, transportation, and equipment needs.
- Management practices for minimizing soil erosion and runoff for fields receiving higher P-content manures.

Land Requirements

Land requirements for manure application are influenced by dietary nutrient levels. For instance, a 0.55 percent P diet would increase the land requirement by about 90 percent compared to a 0.30 percent P diet with no by-products for P-based application. Land required for P-based applications typically increases by a factor of about four over N-based applications. Soil and manure tests for N and P will help producers determine application rates for crop production. Tools to help determine the soil P index are available at *http://water.unl.edu/web/manure/software*.

Labor, Machinery, and Operating Costs

Nutrient management plans should account for additional labor and equipment requirements when by-products are added to the diet. Land application based on a one-year P-basis increases land, expenses, and time needed for application compared to applying manure on a one-year N-basis.

Controlling Soil Erosion and Runoff

Application of P in excess of crop nutrient requirements may increase runoff from fields, which can cause eutrophication if an N-based application is used. Eutrophication enhances undesirable algae growth in lakes and streams which depletes oxygen levels in the water leading to fish kills. The best way to minimize problems is to avoid soil P build-up due to overapplication of P using the Nebraska P index found at the website listed above.

Table IV illustrates the value, cost, and net return of manure from a corn-based diet compared to one containing DGS, during the summer and winter at three different N volatilization (gaseous ammonia and nitrous oxide) losses. Distillers grain diets show greater values of manure by $8/steer compared to corn-based diets. However, there is also greater labor, machinery, and operating costs associated with DGS diets. Nonetheless, DGS diets yield greater net returns by approximately $5/steer. Manure is more valuable when less N is volatilized. The most valuable manure is from steers fed a DGS diet, and only 20 percent of N is lost via volatilization. Lower volatilization losses depend on timing of application (winter vs. summer) and incorporation into the soil.

Apply Manure as a Fertilizer on a Four-Year Phosphorus Basis

If manure is applied every year to the same ground on an N basis, P is being overapplied by three to six times. *Table V* illustrates that manure from cattle fed a WDGS diet in the winter would require about 0.19 acres/head if applied on an annual N basis compared to 0.80 acres/head on an annual P basis. Land, expenses, and time needed for application increases when manure is applied annually on a P basis compared to N basis, at $29.04 and $10.92, respectively. These estimates will vary depending on fuel, equipment, and labor costs.

Table IV. Manure economics: comparing corn-based and 40 percent DGS diet with either 70, 50, or 20 percent N loss and applying manure on an annual N basis.

	Value, $/steer	*Cost, $/steer*	*Net, $/steer*
Summer (70% N Loss)			
Corn (13.0% CP; 0.3% P)	$12.42	$ 7.22	$ 5.20
DGS (18.2% CP; 0.5% P)	$17.86	$ 8.40	$ 9.46
Winter (50% N Loss)			
Corn (13.0% CP; 0.3% P)	$14.78	$ 8.98	$ 5.80
DGS (18.2% CP; 0.5% P)	$21.34	$10.92	$10.42
Reduced N Loss (20% N Loss)			
Corn (13.0% CP; 0.3% P)	$18.34	$11.36	$6.98
DGS (18.2% CP; 0.5% P)	$26.58	$14.46	$12.12

Assumptions: 5,000 head feedlot; 750-1,300 lb steer; 23 lb DMI; 144 DOF; 100 head/pen; open lot; winter; 80-acre fields; 50 percent in crops; 50/50 corn and soybeans; corn yield=120 bu/acre; soybean yield=35 bu/acre; $0.40/lb N; $0.27/lb P_2O_5; $0.20/lb K_2O.

Table V. Comparing manure economics from a WDGS diet with 50 percent N losses (winter) when spread on one-year nitrogen, one-year phosphorus, or four-year phosphorus basis.

Manure Economics 50% N loss, WDGS Diet					
$/head				*Acres/head*	
	Value	*Cost*	*Net*	*Total Land*	*Single Year*
1-Year N-Based	$21.34	$10.92	$10.42	0.19	0.19
1-Year P-Based	$21.34	$29.04	- $7.70	0.79	0.79
4-Year P-Based	$21.34	$11.76	$9.58	0.80	0.20

Values expressed as $/steer.
Assumptions: 5,000 head feedlot; 750-1,300 lb steer; 23 lb DMI; 144 DOF; 100 head/pen; open lot; winter; 80-acre fields; 50 percent in crops; 50/50 corn and soybeans; corn yield=120 bu/acre; soybean yield=35 bu/acre; $0.40/lb N; $0.27/lb P_2O_5; $0.20/lb K_2O.

Applying manure on an annual P basis is expensive, unnecessary, and discouraged. Applying manure on an annual N basis can pose environmental problems if excessive P application leads to moderate risk of P loss from the soil. *Table V* shows that the cost of applying P annually is the most expensive at $29.04/head, resulting in a loss of -$7.70/head. This application scheme also requires the greatest amount of land to spread annually (0.79 acres/head). When applying manure on an annual P basis, crop N requirements will not be met, resulting in extra costs to cover the same ground with synthetic fertilizer N. Additionally, applying P annually is unnecessary because multiple years of crop P requirements can be applied in a single application and will be available to crops in following years.

Phosphorus should be applied on a four-year basis, applying the equivalent of four years of P removal from harvested crops in a single application. Applying on a four-year P basis can also meets crop requirements for N for the equivalent of one year. The following three years N should be applied as synthetic fertilizer N, after accounting for residual N supply from the manure. By implementing this method, manure nutrient potential is maximized and crop P requirements are met, without being exceeded. This is a more cost efficient method.

Conclusions

Phosphorus should not be supplemented in a feedlot diet. Increasing P in the diet increases the amount of P excreted and removed as manure. Manure can serve as a valuable fertilizer source by maximizing the net return when it is spread on a four-year P basis. Sampling manure and determining the P index of soil and applying based on agronomic needs are sustainable management practices.

Additional information can be found in UNL Extension publication G2251, *Impact of Feeding Byproducts on Nutrient Management;* G2252, *Beef Feedlot Nitrogen Management;* and RP190, *Impact of Feeding Distillers Grains on Nutrient Planning for Beef Cattle Systems.*

This publication has been peer reviewed.

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