With Increasing Availability of Distillers Grains Will Phosphorus Be a Problem for Iowa Livestock Producers?

A.S. Leaflet R2124

Allen Trenkle, professor of animal science

Summary and Implications

Retention and excretion of phosphorus were calculated using NRC equations for metabolism of phosphorus in beef cattle fed 0, 20 or 40% distillers grains (DGS). These estimates of phosphorus excretion were similar to quantities of phosphorus excretion measured in experiments with cattle. The predictions of phosphorus retention and excretion were used to estimate phosphorus balance of a 1000-head feedlot in which the cattle were fed 0, 20 or 40% DGS. Feeding 20 or 40% DGS increased phosphorus in the manure from the feedlot 60 and 120%, respectively. However there was not adequate phosphorus in the manure to replace soil phosphorus removed in the crops to produce the feeds for the cattle. The areas of land needed for manure disposal were calculated to be 470, 554 & 608; 756, 890 & 977 and 1,052, 1239 & 1,359 acres for crop rotations of continuous corn, corn-corn-soybeans and corn-soybeans when the cattle were fed 0, 20 or 40% DGS. These results indicate that feeding DGS does not innately cause an environmental problem, but will require each feedlot to develop manure management plans. Use of farm phosphorus balance seems to be a plausible approach to develop reliable manure management plans for feedlots feeding DGS.

Introduction

Iowa is projected to produce over a billion gallons of ethanol in 2005, making it the largest ethanol producer in the nation. Annual production capacity in Iowa will soon reach 1.6 billion gallons. Nearly 70 percent of this production will be in dry grind ethanol plants using over 400 million bushels of corn and resulting in 3.4 million tons (dry basis) of distillers grains with solubles (DGS). A large portion of the DGS is dried and shipped out of state as a feed for livestock. Current feeding recommendations on a dry basis are to feed poultry up to 5%, swine 5 to 10%, dairy cows up to 20% and beef cattle 10 to 20% of the diet as DGS. If price of DGS declines with increasing supply, there will be interest in feeding higher concentrations than recommended or the increased supply might be an incentive to increase livestock production.

Using corn to produce ethanol does not create more phosphorus that Iowa must contend with, but feeding more DGS to livestock in the state will require more precise management of livestock and poultry manure. Fermenting the starch in corn to ethanol concentrates phosphorus in DGS about three times. Phosphorus in corn ranges from 0.27 to 0.33%, varying with variety and phosphorus concentration in the soil. Concentration of phosphorus in DGS therefore ranges from 0.8 to 1.0%. Concern has been expressed that feeding DGS will result in overfeeding phosphorus and increase its concentration in manure causing an environmental problem.

The potential of creating a problem with phosphorus associated with feeding DGS to livestock will vary with species and the diet being fed. Most of the phosphorus in corn and soybean meal is present in phytic acid, a form that has limited availability to swine and poultry. The microorganisms in the rumen produce phytase, an enzyme that digests phytic acid making the phosphorus available to the animal.

Swine and poultry

Corn and soybean meal diets must be supplemented with bioavailable forms of phosphorus. The supplemental forms are used by the animal and that in the corn and soybean meal excreted. The bioavailability of phosphorus in DGS is much greater than corn, about 90%, so diets containing DGS require less supplemental phosphorus. If phytase, is fed in diets containing DGS, very little if any supplemental phosphorus is needed. With proper formulation of diets containing DGS for swine and poultry, less phosphorus will be excreted in the manure.

Dairy cows

Because milk contains phosphorus, lactating cows have a relatively high dietary requirement for phosphorus and most diets fed to dairy cows require some supplementation. If supplemental phosphorus is reduced with the addition of DGS to lactation diets, feeding DGS to dairy cows should not result in overfeeding and increased excretion of phosphorus.

Beef cows and growing cattle

In general grains contain greater concentrations of phosphorus than forages. The concentration of phosphorus in forages can vary widely depending on maturity and soil concentration of phosphorus. Straws and corn stover contain low concentrations of phosphorus and require supplementation. Therefore overfeeding of phosphorus by feeding DGS to beef cows or growing cattle is dependent upon the diet. DGS is an excellent supplement for high fiber, low protein and low phosphorus feeds (i.e. straws and corn stover) and with

removal of supplemental sources would not result in overfeeding of phosphorus.

Finishing cattle

Research conducted at the University of Nebraska and that reported in A.S. Leaflet R2123 indicates that cattle fed high-corn diets do not require supplemental phosphorus. Replacing a portion of the corn grain with DGS that contains higher concentrations of phosphorus will result in overfeeding and increased excretion of phosphorus. It is not possible to change concentrations of other ingredients in the diet to decrease phosphorus intake.

Feeding DGS to swine, poultry and dairy cows will not increase phosphorus excretion if supplemental phosphorus is reduced or removed from the diets. Feeding DGS to growing and finishing cattle fed high-corn diets will result in increased phosphorus excretion that must be recognized and managed. Excretion of phosphorus from cattle fed high-corn diets is related to concentration in the diet (A.S. Leaflet R2123). Adding DGS to corn-based diets increased phosphorus excretion but did not change the relationship between intake and excretion.

Results

Equations from the 1996 NRC Nutrient Requirements of Beef Cattle can be used to predict phosphorus retention and excretion of finishing cattle growing at different rates and at different stages of maturity. The equations developed in A.S. Leaflet R2123 relating excretion with intake can also be used to predict excretion. Phosphorus metabolism of finishing steers fed corn-based diets with and without DGS is shown in Figure 1. Estimated phosphorus excretions during a 195-d finishing period were 7.6, 11.9 and 16.6 lbs/steer for diets containing 0, 20 and 40% DGS, respectively. Using equations developed from metabolism trials estimated phosphorus excretions would be 6.8, 10.5 and 15.7 lbs/steer for the diets containing 0, 20 and 40% DGS, respectively.

The phosphorus excretions derived in Figure 1 were used to calculate phosphorus balance on a farm with a simulated 1000 head feedlot in which steers were fed from 650 to 1350 lbs during a 195-d finishing period. It was assumed the lot was occupied 90% of the time and the diet without DGS contained on a dry basis 86.7% dry rolled corn, 5% corn silage, 5% grass hay and 3.3% supplement (0.285% phosphorus). Corn grain and supplemental nitrogen were replaced with addition of 20 or 40% DGS on a dry basis increasing concentration of phosphorus to 0.405 and 0.526% in the diets. The results are summarized in Table 1. Phosphorus fed to the cattle ranged from 9.4 to 17.1 tons per year. Tissue growth of cattle during the finishing period sequestered 3.1 tons of phosphorus. The difference between what was fed and that in tissue growth would be excreted in the manure and ranged from 6.25 to 14.0 tons of phosphorus per year. Data are given for areas needed to grow the individual feeds as well as if the corn was grown in rotations of continuous corn, corn-soybeans or corn-corn-soybeans. If corn to produce the DGS fed the cattle also is grown on the farm, the area of the farm becomes greater when DGS is included in the diet. If the feedlot was located on the farm from which all the feed was harvested and concentrations of phosphorus in the soils were adequate but not excessive, manure from the feedlot would not replace all the phosphorus removed by the corn crop needed to feed the cattle and produce the grain for ethanol. The percentage of phosphorus removed by the crop that could be replaced by manure ranged from 70 to 84% for continuous corn, 55 to 66% for corn-corn-soybeans and 45 to 54% for corn-soybeans. It is clear from these calculations that a farm producing all the crops for feeding the cattle and production of DGS would need to continue importing some phosphorus fertilizer to maintain adequate concentrations of soil phosphorus for crop production.

Another approach would be to consider the area of land needed to spread manure from the feedlot to replace phosphorus removed with the crops. This is summarized in Figure 2. The areas needed for spreading manure from the 1000-head feedlot and not increase soil phosphorus are 470, 756 or 1052 acres of continuous corn rotation if the cattle are fed 0, 20 or 40% DGS, respectively. Adding soybeans to the rotation increases the area of land needed for application of manure.

This analysis of phosphorus balance resulting from feeding DGS to cattle indicated that all the DGS produced in Iowa could be fed to cattle without causing an environmental problem if the manure is returned to the land supplying the corn to feed the cattle and produce the DGS. If adjustments are made in the quantity of supplemental phosphorus fed, feeding a portion of DGS to swine, poultry or dairy cows would not compound the problem. The area needed to spread manure from the cattle feedlot increases when DGS is fed, but if the area to grow the corn to produce the DGS is available, excess soil phosphorus will not accumulate. A problem arises if a feedlot imports most of the corn and/or DGS fed to cattle and does not have access to enough land to spread manure. The balance presented in this paper is based on one set of crop yields and one scenario for a feedlot. Adjustments need to be made for circumstances different from those used in these calculations.

Either the NRC equations used in this analysis or the phosphorus excretion equation developed in A.S. Leaflet R2123 would be adequate for determining the area of land needed for spreading manure from a cattle feedlot. Tests would be needed to establish initial concentrations of soil phosphorus to determine how much manure could be

applied until soil phosphorus and crop yields are brought into balance. Once in balance it should be possible with use of soil phosphorus tests, crop yield data and phosphorus balance of the feedlot to prevent over application of manure to Iowa soils. Use of phosphorus balance for a farm and feedlot should allow feeding DGS to finishing cattle without causing an environmental problem.

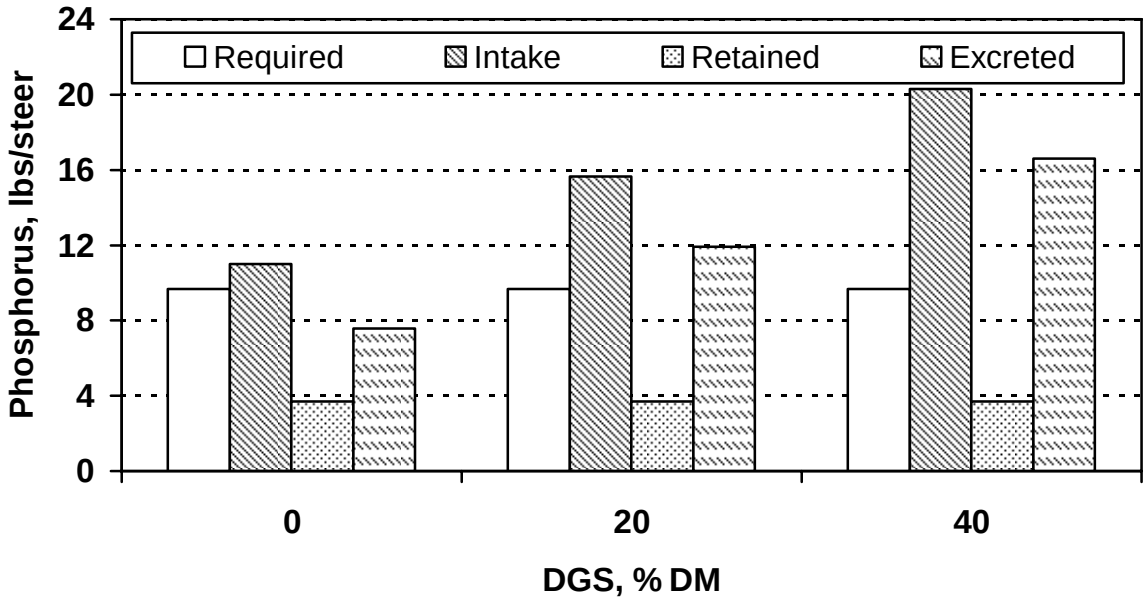

Figure1. Phosphorus metabolism of finishing steers fed diets containing corn or corn and DGS. Units are lbs of phosphorus for a finished steer fed from 650 lb to 1350 lbs during a 195-d period. The NRC equations were used to develop these data. Using equations developed from metabolism trials with steers estimated phosphorus excretions were 6.8, 10.5 and 15.7 lbs/steer for the diets containing 0, 20 and 40% DGS, respectively.

Table 1.Phosphorus balance for a 1000-head feedlot[a]

	Diet, % DGS		
	0	20	40
Phosphorus in feeds fed to cattle, lbs			
Corn grain	17,111	13,013	9,181
Corn silage	662	662	662
Hay	972	972	972
Distillers grains		11,704	23,409
Total	18,745	26,351	34,224
Phosphorus removed with cattle gain	6,225	6,225	6,225
Total phosphorus excreted, lbs	12,520	20,126	28,000
Acres required to produce feed			
Corn grain	643	489	345
Corn silage	23	23	23
Hay	80	80	80
Corn for distillers grains		425	850
Area needed to produce corn from different crop rotations			
Continuous corn			
Corn, acres	666	937	1218
Phosphorus removed, lbs	17,773	25,379	33,252
Percentage of removed phosphorus from manure	70.4	79.3	84.2
Corn-Corn-Soybeans			
Corn, acres	666	937	1218
Soybean, acres	333	469	609
Phosphorus removed, lbs	22,628	32,217	42,131
Percentage of removed phosphorus from manure	55.3	62.5	66.5
Percentage of removed phosphorus from manure	45.5	51.6	54.5
Corn-soybeans			
Corn, acres	666	937	1218
Soybean, acres	666	937	1218
Phosphorus removed, lbs	27,483	39,040	51,010
Acres required to spread manure removed by crop			
Continuous corn rotation	470	756	1052
Corn-soybean rotation	608	977	1,359
Corn-corn-soybean rotation	554	890	1,239
Corn silage	435	699	972
Soybeans	859	1,380	1,920

[a]A simulated 1000 head feedlot in which steers were fed from 650 to 1350 lbs during a 195-d finishing period. The lot was occupied 90% of the time and the diet without DGS contained 86.7% dry rolled corn, 5% corn silage, 5% grass hay and 3.3% supplement (0.285% P) on a dry basis. Additions of 20 or 40% DGS replaced corn and supplemental nitrogen on a dry basis, increasing concentration of phosphorus to 0.405 and 0.526% in the diets. Concentrations of phosphorus in feeds were 0.3, 0.3, 0.2 and 0.9% of DM for corn, hay, corn silage and distillers grains respectively. Crop yields were 180 bu/A for corn, 45 bu/A for soybeans and 18 tons (40% DM) for corn silage.

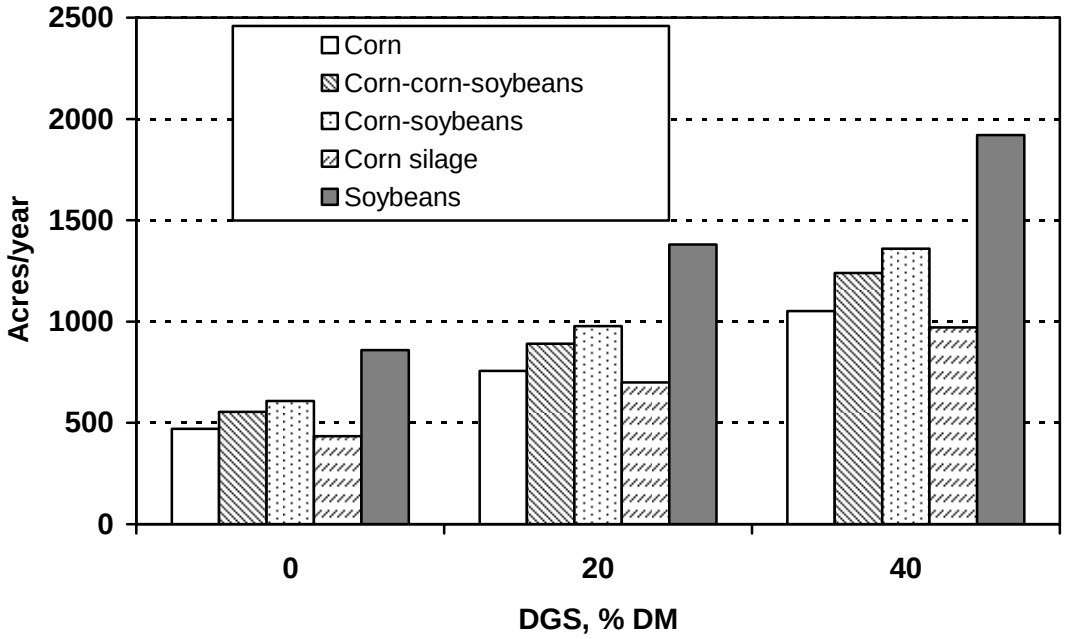

Figure 2. Area needed to spread manure from a 1000-head cattle feedlot. Steers fed 0, 20 or 40% of diet dry matter as DGS from 650 to 1300 lbs during a 195-day feeding period. Crop yields were 180 bu/A for corn, 45 bu/A for soybeans and 18 tons (40% DM) for corn silage.