January 2002

Managing Swine Dietary Phosphorus to Meet Manure Management Goals

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Summary and Implications

A demonstration was carried out for 15 months at a 1,200-head growing-finishing facility in Holt County, Neb. The purpose was to document the impact of diet formulation on phosphorus excretion and the associated land area needed to utilize the phosphorus in the accumulated manure. The demonstration facility had four 300-head rooms. Prior to the demonstration, pigs in all rooms were fed diets formulated to contain 0.55-0.57% total phosphorus for all phases of growth. For the demonstration, two rooms were fed diets formulated to the University of Nebraska recommended levels for available phosphorus. The other two rooms were fed diets formulated to have the same amounts of all nutrients except phosphorus as the University of Nebraska diets using reduced amounts of dicalcium phosphate and phytase. Analysis of feces samples taken twice per month for the first 11 months, and monthly thereafter, indicated a 34% reduction in phosphate in the excreted feces of growing-finishing pigs fed diets containing phytase. Based on the phosphorus needs for 180 bu/acre corn, the switch from the previous diets containing 0.55 to 0.57% total phosphorus to diets formulated with decreasing amounts of phosphorus according to the University of Nebraska recommendations resulted in 49 fewer acres needed per year for land application of the manure. Formulating the diets according to the University of Nebraska recommendations and utilizing phytase and reduced amounts of dicalcium phosphate resulted in an additional reduction of 65 acres per year. In this demonstration, phytase was effective in reducing phosphorus excretion by growing-finishing pigs, even in diets formulated according to the University of Nebraska recommendations. Phytase use, combined with the reduction in estimated phosphorus excretion when switching from the previous nutrition program of 0.55 to 0.57% total phosphorus to decreasing amounts of phosphorus according to the University of Nebraska recommendations, resulted in an estimated 114 fewer acres needed per year for application of the accumulated manure at agronomic rates.

Introduction

Nitrate contamination of groundwater was first detected in Holt County, Neb. in the mid-1960s. From 1976 to 1990, nitrate-N concentrations increased in 90 percent of the wells sampled by the Natural Resource Districts (NRD) in the county. As a consequence of the concerns associated with this increase, the Holt County Groundwater Education Project was initiated in 1995.

The Holt County Manure Management Education Project, a spin-off from the Groundwater Education Project, is a three-year effort funded by an EPA-319 grant with cooperation among

UNL Cooperative Extension, UNL Conservation and Survey Division, USDA-NRCS, the Lower Niobrara NRD, and the Upper Elkhorn NRD. The goal of the project is to educate producers on cropping and manure best management practices to protect water resources from contamination. The project centers around demonstrating best management practices that are cost effective and that can be used in existing production facilities.

Best management practices include whole-farm nutrient planning when animal manures are spread on irrigated crop land. Whereas nitrogen management was the primary goal of the funded demonstration effort, large amounts of phosphorus are also present in beef and swine manures. A typical analysis of swine slurry has a phosphorus content, expressed as P_2O_5, that is as high or higher than the available nitrogen content, expressed as ammonium-N (Table 1).

Table 2 lists the average nutrient removal by crops. Applying high rates of swine slurry to meet the nitrogen needs of crops such as corn results in the over-application of phosphorus and potassium relative to the crop needs. With the US Environmental Protection Agency proposing to regulate Animal Feeding Operations based in part on the phosphorus content of the collected and land applied manures, a demonstration site was identified to examine the role of dietary manipulation of phosphorus on the phosphorus content of swine manure.

Table 1. Typical nutrient content of liquid swine manure.[a]

	% Dry matter	NH_4-N	Organic-N	P_2O_5	K_2O
		lb/1000 gal			
Deep pit	5	17	10	19	15
		lb/acre-inch			
Anaerobic lagoon	0.25	50	29	17	86

[a]USDA-SCS Agricultural Waste Management Field Book (1992). Due to extreme variability, manure analysis is recommended for each situation.

Table 2. Average nutrient removal by crops.[a]

Crop	N content	P_2O_5 content	K_2O content
	lb/bu grain		
Corn grain	0.90	0.39	0.22
Soybean	3.76	0.82	1.20
Grain sorghum	0.90	0.38	0.21
Oats	0.38	0.24	0.15
Wheat	1.36	0.50	0.27
	lb/ton forage		
Alfalfa hay	57.2	11.8	55.1
Corn silage	8.6	3.2	7.7

[a]University of Nebraska NebGuide 97-1334.

Table 3. University of Nebraska dietary recommendations for total and available phosphorus in corn-soybean meal diets.[a]

Pig body wt., lb:	45-80	80-130	130-190	190-market
Total P, %[b]	0.58	0.51	0.47	0.43
Available P,%	0.29	0.22	0.19	0.16

[a]*Nebraska and South Dakota Swine Nutrition Guide* EC95-273.
[b]Assumes corn and soybean meal based diet formulations.

Methods

The demonstration site was a 1,200-head, 4-room, fully slatted finishing facility with pull-plug gutters to an outside concrete manure storage tank. Pigs typically enter the facility at 45-55 lb and are sold for slaughter weighing 255-265 lb. The finishing facility is located on a corner of an irrigated quarter section (160 acres) in Holt County. The manure management goal of the producer is to use the center pivot irrigated portion of the quarter section (132 acres) for manure utilization by a cropping system of continuous corn.

Prior to the demonstration, the producer was feeding diets formulated using corn, soybean meal and a base mix containing 7.8% phosphorus. When the base mix was added to the corn-soybean meal diets at the recommended rate of 55 lbs/ton, the complete diets for pigs from 45 pounds to market weight contained 0.55% to 0.57% total phosphorus and 0.27% to 0.28% available phosphorus.

This type of dietary formulation is quite common in the pork industry. Based on an estimated 1.5 gal of manure per pig space per day and the values in Tables 1 and 2, the producer needed an estimated 300 acres each year to utilize the phosphorus in the manure when harvesting 180 bu/acre in a continuous irrigated corn cropping system.

In contrast to the phosphorus content of the diets formulated with the base mix, the current University of Nebraska recommendations for total and available phosphorus in corn-soybean meal diets are given in Table 3. Including 55 lb of the base mix in the diet met the phosphorus needs of 45-lb pigs, but provided excess phosphorus for all other stages of growth.

Because the goal of the demonstration was to reduce the amount of

(Continued on next page)

Table 4. Holt County demonstration diets.

Pig body wt., lb:	45-80		80-130		130-190		190-market	
Ingredient, lb Phytase:	No	Yes	No	Yes	No	Yes	No	Yes
Corn	1338	1347	1415	1424	1528	1537	1680	1689
Soybean meal (46.5% CP)	590	590	520	520	410	410	260	260
Fat	20	20	20	20	20	20	20	20
Dicalcium phosphate	22	9	16	3	14	1	13	0
Limestone	18	20	17	19	16	18	15	17
Salt	6	6	6	6	6	6	6	6
Vitamin/trace mineral mix	5	5	5	5	5	5	5	5
L-lysine	1	1	1	1	1	1	1	1
Phytase[a]	0	2	0	2	0	2	0	2
	2000	2000	2000	2000	2000	2000	2000	2000
Calculated composition								
Lysine, %	1.07	1.07	0.98	0.98	0.83	0.83	0.64	0.64
Ca, %	0.72	0.60	0.62	0.50	0.56	0.44	0.51	0.39
Total P, %	0.59	0.48	0.53	0.41	0.48	0.37	0.45	0.33
Avail P, %	0.29	0.17	0.23	0.11	0.20	0.08	0.18	0.06

[a]Natuphos, BASF Corp, Mt Olive, NJ 07828. According to the manufactures recommendations, when added at 500 FTU/kg, the product provided .12% available P and Ca in cereal grain based diets.

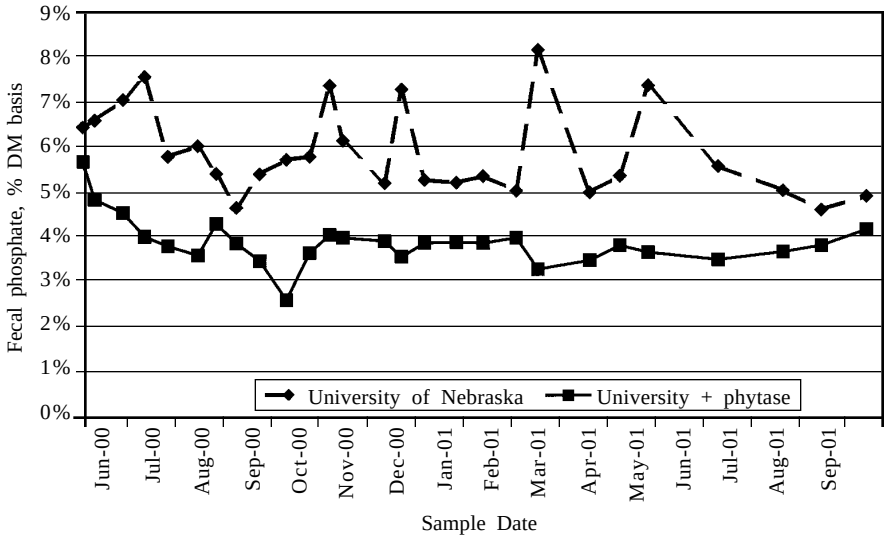

Figure 1. Impact of phytase on fecal phosphate, Holt County Demonstration Project.

total phosphorus in the manure, pigs in two of the four rooms were fed diets formulated with limestone, dicalcium phosphate, salt and a vitamin-trace mineral premix according to the University of Nebraska recommendations (Table 4). Pigs in the other two rooms were fed diets formulated to the available phosphorus requirement utilizing phytase. In this demonstration, phytase was added at 500 FTU/kg of diet and replaced up to 13 lb of dicalcium phosphate per ton of diet.

Phytase increases the availability of phytate-phosphorus in corn and soybean meal so lesser amounts of inorganic phosphorus are needed in diets. This results in a decrease in the amount of phosphorus excreted in the manure.

Results and discussion

Manure was sampled by taking grab samples of feces on top of the slats twice per month in each of the four rooms from mid-June 2000 through mid-May 2001, and monthly thereafter. Samples were sent to a commercial laboratory for analysis. Results of the manure sampling are shown in Figure 1. The inclusion of phytase in the diets reduced fecal phosphorus excretion an average of 34% for the demonstration period compared to diets formulated to the University of Nebraska recommendations without phytase.

To calculate the impact of the dietary changes implemented at the demonstration site, a two-step analysis was conducted. For the analysis, it was assumed there was no difference in performance between the producer's previous base mix formulated diets, the University of Nebraska recommended diets and the recommended diets formulated with phytase. Assuming a 2.98 feed:gain ratio, 2.7 turns or groups of pigs per year, and 1,200 pigs per turn, changing from diets formulated with the 55 lb base mix to diets formulated according to the University of Nebraska recommendations resulted in a total estimated reduction in phosphorus entering the facility in the feed of 1,484 pounds per year. Adding phytase to the University of Nebraska recommended diets resulted in a further estimated reduction in phosphorus in the feed of 1,976 lb per year.

If it is assumed that all diets met the growing pigs requirements for digestible phosphorus, the reductions in phosphorus in the feed translate directly into reductions in the amount of phosphorus excreted in the manure. Thus, changing from formulating diets with a 55 lb inclusion of a base mix containing 7.8% phosphorus to formulating diets according to the University of Nebraska

recommendations and using phytase to enhance phosphorus availability resulted in 3,460 fewer pounds of phosphorus in the manure yearly. Using a conversion factor of 2.3 to convert elemental phosphorus to P_2O_5, the change in diet formulations results in a total reduction of 7,958 lb of phosphate per year.

If the long term phosphate need for irrigated corn at this site is 70 lb/acre (180 bu/acre x 0.39 lb P_2O_5/bu), the change from the 55 lb inclusion product to the University of Nebraska recommended diets represented 49 fewer acres needed per year for utilization of the phosphorus in the manure. Adding phytase to the University of Nebraska recommended diets represented an additional 65 fewer acres. In summary, converting from a nutrition program using a 55 lb inclusion rate base mix containing 7.8% phosphorus to a program using the University of Nebraska recommendations and phytase resulted in 114 fewer acres needed per year for proper utilization of the phosphorus in the manure at this site.

Conclusion

While the producer was unable to achieve the goal of applying all the manure from the demonstration facility on land under one center pivot system (132 acres), altering the phosphorus sources in growing-finishing diets from a 55 lb inclusion rate of a base mix containing 7.8% phosphorus to diets formulated for decreasing amounts of phosphorus using dicalcium phosphate and phytase resulted in a major reduction in the amount of crop land needed to properly utilize the phosphorus in the manure. Based on the estimated original cropping acres needed for continuous irrigated corn and the reductions in phosphorus associated with the dietary changes demonstrated, the new land base needed is estimated to be 186 acres if the phytase containing diets are fed to all pigs in the facility, down considerably from the original 300 acre estimate. The 34% reduction in phosphorus content in the feces for the phytase fed pigs versus pigs fed University of Nebraska recommended diets formulated with dicalcium phosphate is similar to reductions reported in the scientific literature.

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