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Includes representation from UNL, Nebraska Department of Environmental Quality, Natural Resources Conservation Service, Natural Resources Districts, Center for Rural Affairs, Nebraska Cattlemen, USDA Ag Research Services, and Nebraska Pork Producers Association.

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Managing Swine Dietary Phosphorus to Meet Manure Management Goals

Michael C. Brumm, Charles A. Shapiro, William L. Kranz[1]

Introduction

Nitrate contamination of groundwater was first detected in Holt County, Nebraska in the mid-1960's. 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 Manure Management Education Project was 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 was to educate producers on cropping and manure best management practices to protect water resources from contamination. The project centered around demonstrating best management practices that were cost effective and that could be used in existing production facilities.

Best management practices included whole-farm nutrient planning when animal manures were 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. With the US Environmental Protection Agency proposing to regulate Animal Feeding Operations based on the phosphorus content of the collected and land applied manures, a site was identified to demonstrate the role of dietary manipulation of phosphorus on the phosphorus content of swine manure. In addition to the change of diet, the use of the enzyme phytase was demonstrated. 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.

Swine slurry from an underslat storage pit typically has enough phosphorus that when the slurry is applied at rates that provide sufficient nitrogen to a corn crop

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phosphorus will be over-applied. Typical nutrient contents for deep pit and anaerobic lagoons are given in Table 1. With typical nitrogen availabilities the producer would apply over 300 pounds of P_2O_5 if all the corn crop's nitrogen needs were supplied by the pit manure in Table 1. Table 2 lists the average nutrient removal by crops. 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.

The demonstration site was a slatted growing-finishing unit with 4 300-head rooms. Prior to the demonstration the original phosphorus content of the diets formulated with a base mix 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 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 3). 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 13 pounds of dicalcium phosphate per ton of diet.

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. 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 2-step analysis was conducted. For the analysis, it was assumed there was no difference in performance between the producers 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 of 1,484 pounds of phosphorus entering the facility in the feed per year. Adding phytase to the University of Nebraska recommended diets resulted in a further reduction in phosphorus in the feed of 1976 pounds 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 pounds of phosphate per year.

If the long term irrigated corn need at this site is 70 lb/acre of P_2O_5 (180 bu/a 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

Reviewing the feeding program to keep up with the most recent nutrition recommendations and including phytase as a replacement for some of the dicalcium phosphate 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 need 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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The complete article from the 2002 Nebraska Swine Report can be found on page 18 in the following pdf document on the Web: www.ianr.unl.edu/pubs/swine/ec02-219.pdf

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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	P_2O_5	K_2O
	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.

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