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PHOSPHORUS-REDUCING TECHNOLOGIES IN SWINE PRODUCTION

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Summary

Soil phosphorus levels have increased as swine production has become concentrated. Phosphorus-based manure management regulations for land application have been proposed by policy makers. The objective of this research was to determine benefits/costs of adopting phytase for reducing phosphorus. Results were derived using different manure storage and application systems. Although phytase was a least-cost ingredient, it became profitable when producers were constrained by land. Land requirements were 2 to 5 times greater under a phosphorus application regulation than a nitrogen application regulation.

(Key Words: Management, Manure, Nitrogen, Phosphorus, Phytase.)

Introduction

Pig numbers in the United States have not increased dramatically, but technological advances have greatly reduced the number of production operations. Although large confinement facilities have significantly increased production efficiency, they also have presented new management challenges in the collection, storage, and treatment of larger manure quantities. The quantities of manure and manure nutrients generated on a per acre basis have increased dramatically because of an increase in the number of hogs per operation that has not been matched by a proportional increase in the cropland acres associated with those operations. The European Union has recognized manure problems by

imposing a tax on excreted phosphorus that corresponds to the number of animals.

Most regulations for livestock and poultry operations are targeted specifically to protect water resources from nonpoint source pollution. The nutrients of greatest concern from a water-quality perspective are nitrogen and phosphorus. Because nitrate contamination of drinking water is a potential health concern for people and animals that use groundwater for their water supply, most state guidelines and regulations for land application of manure are based on nitrogen requirements for crops.

Phosphorus generally does not pose a direct threat to human health, but excessive levels can degrade surface water quality by causing algal blooms. Such events increase the cost of water treatment for local municipalities. Because phosphorus is not subject to dissipation between excretion and land application, low nitrogen-to-phosphorus requirements in manure and high nitrogen-to-phosphorus requirements in plants make the land area required to distribute manure based on crop phosphorus needs two to four times as great as the land area required to distribute manure based on crop nitrogen needs. A Minnesota study found that less than 25% of producers surveyed had ever analyzed their manure for nutrient content, and that less than 20% had ever calibrated their manure spreaders. Thus, even where manure is applied, many producers still may apply their standard rate of inorganic fertilizer nutrients based on nitrogen and further increase soil phosphorus levels.

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Corn and soybean meal, which are the primary ingredients in swine diets, contain phytic acid as the predominant form of phosphorus. Producers also add inorganic phosphorus to diets to meet the nutritional requirements. Phytic acid constitutes approximately 75% of total phosphorus in a typical swine diet. However, nonruminant animals like swine cannot utilize phytic acid, so it is excreted and contributes to the phosphorus problem.

Four methods have been proposed to reduce phosphorus application in excess of crop needs. One method is to apply manure over more acres at the phosphorus rate of uptake by the crop. The second method is to use synthetic amino acids as a replacement for soybean meal to reduce phosphorus intake of swine. Synthetic amino acids are expensive, and only lysine is used commonly. Phytase and low-phytic acid corn are two methods that increase availability of phytic acid phosphorus and reduce excretion and inorganic phosphorus intake. Phytase was approved for use in 1996, but low-phytic acid corn has not been released commercially. Thus, in the short run, the use of synthetic amino acids and phytase are the two alternatives available for producers who may be constrained by land.

The objective of this research was to determine benefits and costs of adopting phytase for a profit-maximizing feeder pig producer.

Procedures

A optimization model was used that included information on: 1) feed nutrient and ingredient relationships, 2) feed nutrient conversion, 3) types of storage and application systems, 4) fertilizer nutrient conversion, and 5) regulations for storage and application. The crop grown by these producers was assumed to be continuous corn (which is used as a source of feed ingredients) and adjusted for a producer who disks or cultivates during the spring. Crop fertilizer requirements for this type of continuous corn are 140 lbs (NH_4) and 45 lbs (P_2O_5). Producer returns were assumed to be returns to

management and operator labor. The number of market hogs on feed amounted to 2851 animals per market herd inventory with approximately three inventory turns per year.

The model maximizes the total value of an animal converted to the market herd inventory that moves through the system multiplied by the number of litters plus the fertilizer value of the manure (adjusted for losses), less the costs of feed, manure storage and application, and variable inputs. Constraints included additional manure storage capacity; minimum regulatory storage capacity; land application of manure nutrients according to their crop requirements; and the nutrient content of different ingredients (i.e., the standard least-cost feed ration constraints) The animal's live weight value included premiums and discounts, manure value, and costs, all functions of live weight.

Results and Discussion

Figures 1 and 2 present the land requirements for nitrogen and phosphorus applications in the first year for different storage and application systems. As expected given the losses associated with each system, slurry tanks (lagoons) and injection (irrigation) yielded the highest (lowest) land requirements for either nitrogen or phosphorus application. Under a phosphorus-based scenario, this producer would require 2.02 (tank storage and injection application) to 5.03 (pit storage and irrigation application) times as much land than under a nitrogen-based scenario. This result suggests that a phosphorus-based application requirement on land has the potential to significantly affect pork producers who might be constrained by land.

Figures 3, 4, and 5 present the net returns (which were varied by the animal inventory number) for broadcast, injection, and irrigation applications. The results are reported by storage method (deep pits, slurry tanks, and lagoons) with land acreage held constant (100 acres). Several important results should be noted. First, in all cases, the total returns per animal are less than the results of our previous research, which did not include a

manure component, indicating that the cost of manure storage and application is greater than the value of the manure as a nutrient in crop production. Because the value of manure is negative after all economic costs and benefits are included, adopting a best management practices approach for manure may not be feasible without economic incentives.

A second result is that despite the cost of phytase being higher (\$.195/lb of dicalcium phosphorus replaced) than the cost of dicalcium phosphorus (\$.12/lb), a small proportion of phytase was an optimal ingredient when not enough land was available to utilize the nitrogen and phosphorus nutrients in crop production. The addition of phytase permitted more low-phytic acid phosphorus to be available in the corn for the animal, and corn is inexpensive relative to other ingredients containing phosphorus. This result suggests that the additional cost of manure storage is high enough so that producers who are constrained by land could consider using phytase, even though the unit cost is greater than that of the ingredients they are replacing. For producers who have excess land, phytase is not economically practical at these prices. Land requirements using phytase under a phosphorus-based application requirement declined by an average of approximately 30% from the numbers in Figure 2. This result further suggests that phytase is an alternative that producers might consider for reducing phosphorus excretion, if their state regulatory agency institutes a phosphorus-based application requirement and they are constrained by land.

Finally, when an additional inventory of animals was added and land acreage was held constant, net returns decreased dramatically because of the increased costs of constructing manure storage facilities. In this example, producers would rapidly suffer economic losses without expanding the amount of land because of the high cost of

storage (returns would be less than \$10 per year as shown in Figures 3 to 5). Additional storage is not a viable long-term strategy, so producers will be forced to find additional land for purchase or rent (average costs would decline more slowly), lease manure application rights from surrounding producers, hire custom manure disposal, or simply not increase the number of animals. This information can be used by policy makers to demonstrate to producers why simply increasing the size of a storage facility is not economically feasible when considering expansion without accounting for possible changes in land requirements.

Furthermore, policy makers should note that as the number of animals increased beyond the amount required for the market inventory, lagoon storage and irrigation application became the least-cost method to manage manure. However, this method maximizes nutrient losses to the environment rather than minimizing losses to ensure maximum use as fertilizer. Policy makers in the National Environmental Dialogue on Pork Production mediation process have strongly supported requiring producers to use storage methods that minimize environmental losses, such as tank storage or injection application.

Clearly, implementation of a phosphorus-based application requirement may impose hardships on producers who are constrained by land. Phytase is one alternative that can assist producers who might have difficulty meeting a phosphorus-based application requirement. Other technologies will also be likely available in the near future. Extension specialists and extension educators and financial lenders, who require a business plan with a manure management component, can use these results to show producers who are considering expansion that their projected returns must account for these potential policy considerations.

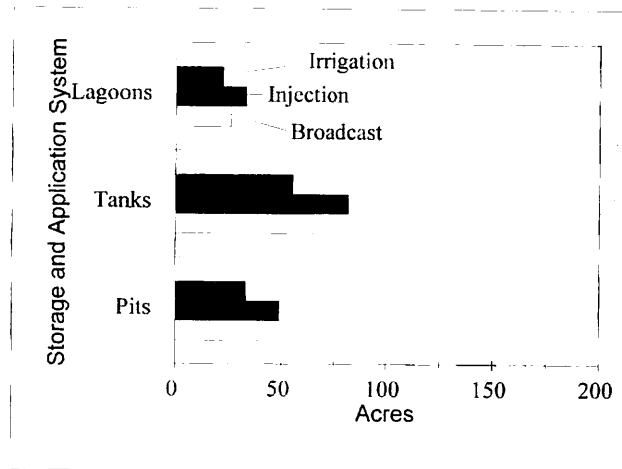


Figure 1. Land Requirements for a Nitrogen-Based Land Application Requirement, by Storage and Application System.

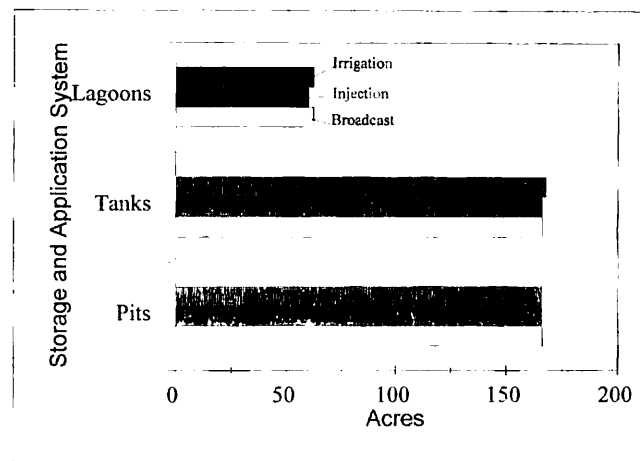


Figure 2. Land Requirements for a Phosphorus-Based Land Application Requirement, by Storage and Application System.

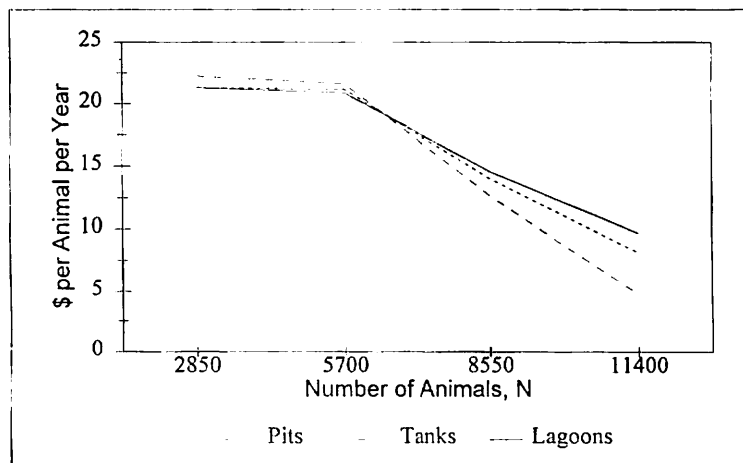


Figure 3. Returns per Animal per Year for Broadcast Application, by Market Herd Inventory and Storage System.

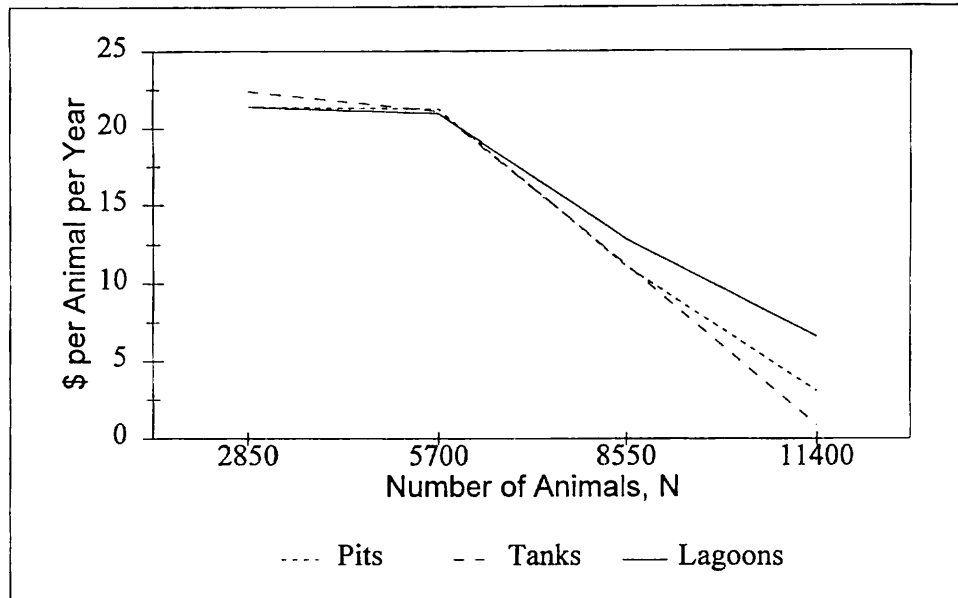


Figure 4. Returns per Animal per Year for Injection Application, by Market Herd Inventory and Storage System.

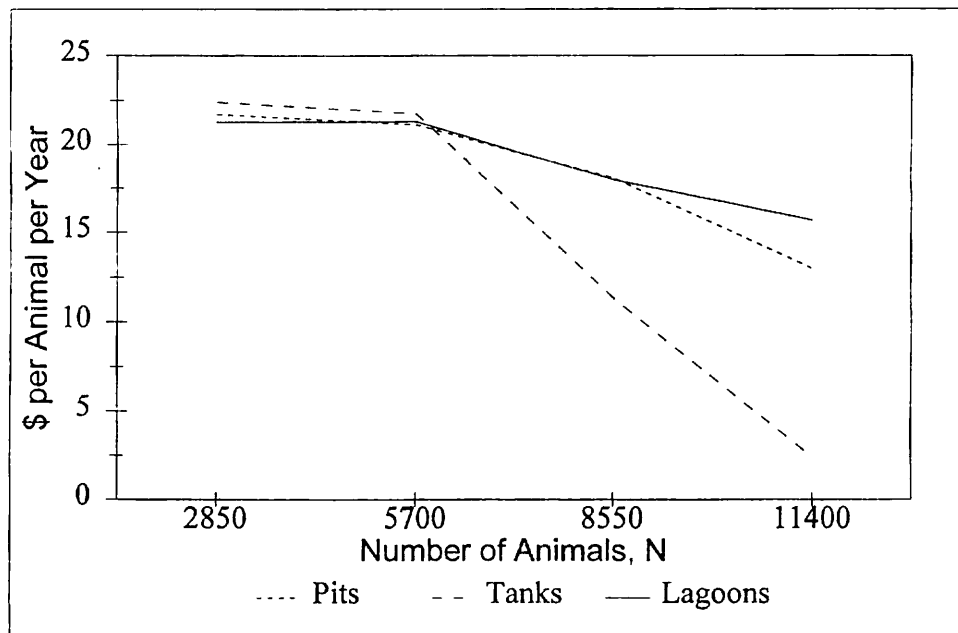


Figure 5. Returns per Animal per Year for Irrigation Application, by Market Herd Inventory and Storage System.