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Heartland Regional Water Coordination Initiative

Impact of Feeding Dry Distillers Grains on Comprehensive Nutrient Management Plans for Swine

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Introduction

Ethanol industry growth is expanding the use of distillers grains in livestock diets including dry distillers grains with solubles (DDGS) in swine diets. This publication will discuss the implications of feeding DDGS on nutrient management plans (NMPs) for swine enterprises. It will evaluate the differences, as diet changes, in excreted manure, land requirements, labor and equipment costs, and the value of manure as a fertilizer. At currently proposed inclusion rates of DDGS in swine diets, excretion of nitrogen should increase modestly, while little or no increase is expected for phosphorus. Minimal changes are anticipated in most NMPs for swine operations as a result of feeding DDGS.

Benefits and Limitations of Using Distillers Grain in Swine Diets

Research has shown that DDGS levels ranging from 0 to 30 percent may be fed to grow/finish pigs before performance is reduced. However, typical industry ranges for DDGS use in the production phase include: nursery 5 to 20 percent; grow-finish 10 to 20 percent; gestating sows 5 to 30 percent; and lactating sows 5 to 20 percent.

Typical nutrient concentrations of DDGS are about three times greater (by weight) in protein, fat, fiber and minerals when compared to corn, with similar energy values (Stein et al., 2006). Lysine, the most limiting amino acid in swine diets, is low relative to both crude protein and the overall level of crude protein in diets where DDGS has increased, but can be overcome by using increased levels of crystalline lysine, a common practice among nutritionists.

Phosphorus (P) in DDGS is more available to the animal. Only 14 percent of the phosphorus in corn is bioavailable, compared to 77 percent of the phosphorus in DDGS. The fermentation process in ethanol plants breaks the bonds that bind phosphorus to the phytate complex in corn, thus increasing P's bioavailability. This improved digestibility allows for the replacement of most supplemental (inorganic) P in a typical swine diet, reducing diet costs and the P excreted in the manure (Stein, 2006). Swine dietary phosphorus is reduced when DDGS is included at levels up to 20 percent. However, at dietary inclusion levels above 20 percent, the dietary phosphorus levels slightly increase.

Potential limitations of using DDGS in swine feeding include:

- reduced carcass yield and increased carcass fat softness (Whitney et al., 2006);
- variability in DDGS quality and nutrient concentration;
- low protein (lysine) quality possibly resulting from drying;
- possible incidence of mycotoxin contamination; and
- physical factors for handling such as flowability.

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For additional information on feeding of DDGS in swine diets, refer to a University of Minnesota publication, Feeding DDGS to Pigs: Overcoming Barriers and Finding Value Added Features, found at *http://www.ddgs.umn.edu/articles-swine/2005-Shurson-%20DGQuarterly.pdf;* Distillers Grains By-Products in Livestock and Poultry Feeds, found at *http://www.ddgs.umn.edu/info-swine.htm*; or the University of Illinois publication *Distillers Dried Grains With Solubles (DDGS) in Diets Fed to Swine,* found at *http://www.distillersgrains.org/files/feedsource/swine_brochure.pdf*.

DDGS Inclusion Effects on Manure Nutrient Excretion

Feed programs have a significant impact on nitrogen (N) and phosphorus (P) excretion and the subsequent NMP/CNMP. To evaluate the impact of feeding DDGS to swine, case studies of a 2,400- and 10,000-head swine finisher, using four rations, are presented:

1. traditional corn-soybean meal ration (base),
2. contemporary corn-soybean ration with supplemental phytase and crystalline lysine (base + p/l),
3. 15 percent; and
4. 30 percent DDGS inclusion rate on a dry matter basis.

Assumptions for these case studies are shown in *Table 1*. The traditional corn-soybean meal ration (base) is not commonly used for current swine diet formulation but was included here to illustrate the trend and make a futuristic comparison with 30 percent DDGS inclusion.

The increased bioavailability of phosphorus allows dietary P to remain relatively constant for inclusion rates up to 30 percent DDGS in spite of the high phosphorus concentration in this feed. As a result, P excretion changes little for current swine diets using DDGS *(Table 2)*. Crude protein levels for swine diets with DDGS will increase one to two percentage units compared to current diets using crystalline lysine, resulting in an increase in nitrogen excretion. However, these crude protein levels

Table 1. List of assumptions made when studying different swine feeding and manure management scenarios.

Characteristics	Assumptions
Cropping System:	
Corn - Soybean yield	175 bu/ac - 60 bu/ac
Manure	91-92 percent moisture liquid/slurry stored in a pit beneath slatted floor
	Manure is injected into the soil and applied only to corn
Retention of nutrients	85 percent N retention and 100 percent P retention in storage
	70 percent and 95 percent of organic and ammonium N, respectively, would be crop-available
Field application	Application duration (hours per rig) did not exceed about 300 hours/rig for 2,400 head swine and 500 hours/rig for 10,000-head swine. Tractor with 3,000-gallon tank used with 2,400-head finisher. Tractor with 4,200-gallon tank used with 10,000-head finisher.
Animal System:	
Pigs	Entering finisher at 50 lb
	Marketed at 265 lb
Days on feed	120 days per turn with 2.7 turns per year
Diets	Base Diet: Corn and soybean meal based
	Base + P/L: Dietary averages of 500 FTU/kg phytase and 3 lb/ton L-lysine
	15 percent DDGS: Dietary averages of 400 FTU/kg phytase and 5.5 lb/ton L-lysine
	30 percent DDGS: Dietary averages of 100 FTU/kg phytase and 8.0 lb/ton L-lysine
Economics:	
Manure value	N was estimated to cost $0.30 per pound
	P_2O_5 was estimated to cost $0.50 per pound
	Fertilizer value of potassium was not included
Input cost	Farm labor was estimated to cost $12 per hour
	Fuel cost was estimated to be $3 per gallon; the differences in feed cost were not considered
Software for modeling comparisons	*Feed Nutrient Management Planning Economics (FNMP$)* authored by R. Koelsch, R. Massey, V. Bremer, and G. Erickson. Koelsch, et al., 2007)

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should not exceed typical diets used five or more years ago, prior to regular use of crystalline lysine. Thus, nitrogen excretion for use of 30 percent DDGS inclusion will be similar to plans used in the industry five or more years ago.

Traditional book value estimates by the Natural Resources Conservation Service, American Society of Agricultural Engineers, and Midwest Plan Service publications on nutrient excretion typically underestimate N excretion and overestimate P excretion by swine *(Table 2)*. Use of these traditional standards will produce even greater errors for N as DDGS is added to swine diets. The new American Society of Agricultural and Biological Engineers standard (ASABE, 2006) provides a more accurate estimate of N and P excretion for current diets (and non-DDGS-containing diets) using phytase and crystalline lysine, but will still increasingly underestimate N as DDGS is added to the diet.

Impact of DDGS Inclusion on Nutrient Plans

Many planners and regulators have never adapted their nutrient planning tools to recognize the use of synthetic amino acids or phytase with swine production. They have commonly underestimated N excretion and overestimated P excretion and the resulting land requirements for managing these nutrients. NMP/CNMP improvements will result from using new nutrient planning tools that reflect actual animal performance and feeding programs. Adjusting an NMP/CNMP for feeding DDGS will add some improvement in N planning but not impact P planning decisions.

Some aspects of an NMP/CNMP will need adjustment to account for dietary inclusion rates of DDGS in swine diets. As DDGS inclusion rates increase, plans should recognize:

- Modest increases in land requirements for nitrogen-based plans.
- Book values for manure excretion and nutrient concentration may not be representative of manure produced by swine.
- Recent farm-specific manure samples should be representative of manure P and slightly underestimate manure N.
- Application rates might need to be re-calculated, especially if based upon book values.
- For systems that conserve nitrogen (e.g., manure storage as opposed to anaerobic lagoons and manure injection as opposed to surface application), manure N- and P-based rates will be relatively similar. Manure application at an N-based rate will produce modest accumulation of phosphorus in soils and require possibly less emphasis on phosphorus risk management.

Land Requirement

Compared to a base diet without phytase and crystalline lysine, the inclusion of up to 30 percent DDGS in a swine diet has minimal impacts on land requirements for manure management both under continuous corn and corn-soybean cropping systems *(Figure 1)*. A marginal increase in land requirement occurs when the two DDGS inclusion rates are compared with the base diet containing phytase and crystalline lysine. For the assumptions made in this case study and current diets with or without DDGS, 143 to 165 acres/1,000 finished pigs is needed for N-based plans and 189 to 218 acres/1,000 finished pigs is needed for P-based plans in a continuous corn system. A corn-soybean rotation would require between 406 and 470 acres/1,000 head of finished pigs for both N- and P-based plans.

Table 2. Nutrient content of manure (lb/year) excreted by 2,400 head of swine fed base diet and base diet containing phytase and crystalline lysine (+P/L) and two DDGS inclusion rates. Nutrient excreted by 10,000 head of swine is multiplied by a factor of 4.167.

			DDGS Inclusion Rate		Book Values	
Item, lb/year	**Base Diet**	**Base + P/L**	**15% DDGS**	**30% DDGS**	**ASABE[1] 2006**	**NRCS[2]**
N Excreted	82,000	71,000	77,000	82,000	65,000	51,000
Crop-Available N	59,000	52,000	52,000	60,000		
P Excreted	16,000	11,000	11,000	12,000	11,000	20,000
Crop-Available P	16,000	11,000	11,000	12,000		

[1]American Society of Agricultural and Biological Engineers.
[2]Natural Resources Conservation Service.

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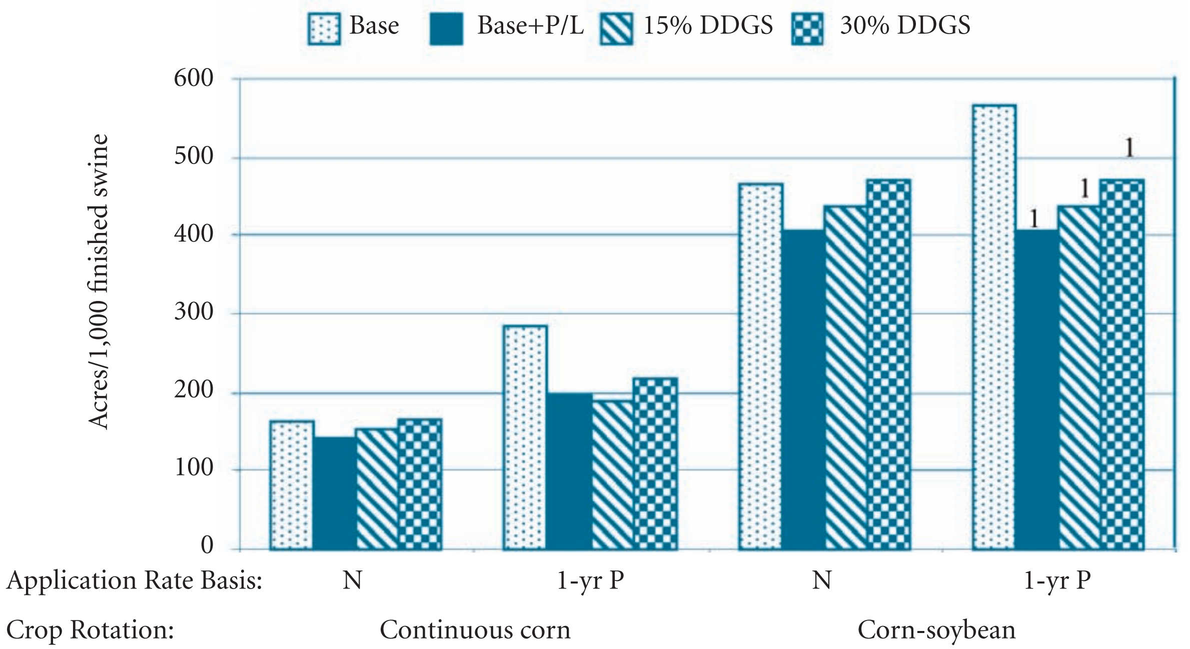
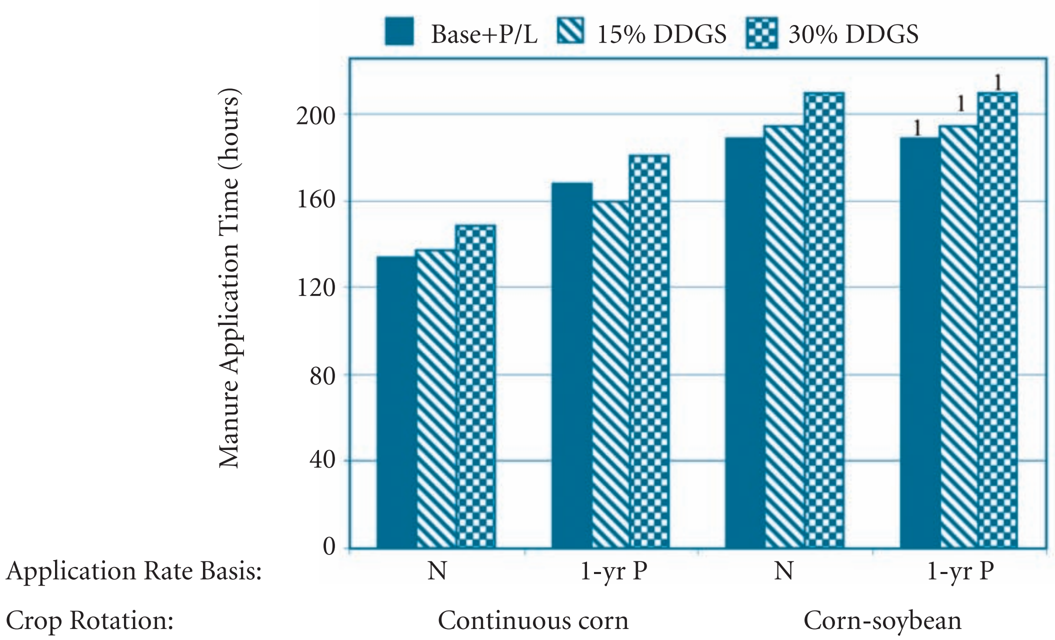


1. Rate is limited by crop nitrogen requirements.

Figure 1. Land required for manure application for grow-finish pigs fed four diets (two including DDGS).

Annual Costs and Benefits

Similar to nutrient excretion and land requirements, inclusion of DDGS in a swine diet has minimal impact on application time requirements and associated costs. For a manure management system that conserves nitrogen, the transition from an N-based to a P-based nutrient application plan has minimal impact on time requirements and associated costs for a corn-soybean rotation *(Figure 2)*. Modest increases in time and costs (less than a 25 percent increase for 2,400-head finisher) were noted for this transition in a continuous corn



1. Rate is limited by crop nitrogen requirements.

Figure 2. Time required for field manure application at different DDGS inclusion rates for 2,400-head finisher with a continuous corn and corn-soybean rotation.

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rotation. For nitrogen-conserving manure management systems, an N-based rate and a one-year P-based rate were generally similar and possibly limited by the crop nitrogen requirements.

For the conditions evaluated, potential nutrient value in manure exceeds the cost of manure application *(Table 3)*. Increased value was obtained from manure applied on continuous corn as compared to a corn-soybean rotation.

Implications for Public Policy

The inclusion of DDGS in swine rations has not increased P excretion and modestly has increased N excretion *(Table 2)* in grow-finish swine production. Therefore, there are few additional resources needed in the form of land *(Figure 1)*, time *(Figure 2)*, or application cost *(Table 3)* to constrain the producer from complying with NMP/CNMP regulations.

Nutrient plans based on N- or P-application rates will have only modest differences for those swine manure systems that conserve nitrogen. The value of a single manure application supplying multiple years crop nutrient requirements may be modest because N-based rates may often prove limiting for such a practice. These same conclusions may not be appropriate for manure systems that do not conserve nitrogen.

Book values for nutrient excretion and manure nutrient concentration, especially from time periods prior to the use of phytase and synthetic amino acids in swine diets, are problematic. Planners and reviewers will need to base such estimates on procedures that recognize farm-specific animal performance and feed program characteristics.

Summary

The inclusion of DDGS in swine diets is less well-established than with ruminants and current research suggests rates lower than observed with some species. Key "Take Home Messages" for inclusion of up to 30 percent DDGS in swine finisher diets include:

- The use of DDGS in grow-finish swine diets should not significantly affect the NMP/CNMP.
- DDGS is shown to have greater bioavailability P and similar energy content compared to corn. Slight increases in N excretion and little or no change in P excretion are anticipated.
- Planners may need to update their planning tools to reflect farm-specific animal performance and feed technologies such as feeding of phytase and synthetic amino acids that have caused significant reductions in N and P excretion in recent years.
- Book values for manure excretion and typical manure concentrations from five years ago or more are likely to not be representative of current nutrient values in manure production by swine.

Table 3. Total value, spreading cost, and total annual fertilizer value of manure ($1,000 per year) for a diet based upon 15 percent DDGS for a 2,400- and 10,000-head finisher.

2,400-head Swine Finisher	**Corn-Soybean**		**Continuous Corn**	
	N Rate	**P Rate**	**N Rate**	**P Rate**
Annual fertilizer value of manure	29	29	27	29
Total value of N	17	17	17	17
Total value of P_2O_5	12	12	10	12
Annual cost	22	22	20	21
Net value of manure	7	7	7	8
10,000-head Swine Finisher	**Corn-Soybean**		**Continuous Corn**	
	N Rate	**P Rate**	**N Rate**	**P Rate**
Annual fertilizer value of manure	120	120	110	119
Total value of N	69	69	69	69
Total value of P_2O_5	51	51	41	50
Annual cost	84	84	66	72
Net value of manure	36	36	44	47

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Further Resources

ASABE. 2006. *Manure production and characteristics.* ASABE D384.5 MAR05. In ASABE Standards 2006. ASABE. St. Joseph, MI. 709-727.

Koelsch, R., R. Massey, G. Erickson, and V. Bremer. 2007. Software Tool for Integrating Feed Management. International Symposium on Air Quality and Waste Management for Agriculture. Broomfield, CO. *asae.frymulti.com/*

Stein, H. 2006. DDGS: *Energy and nutrient content and digestibility.* Proceedings of Midwest Swine Nutrition Conference. September 7, 2006. Indianapolis, Indiana. *www.livestocktrail.uiuc.edu/uploads/porknet/papers/MWSNC%20Proceedings-2006.pdf* accessed 08-23-07.

Stein, H.H., M.L. Gibson, C. Pedersen, and M.G. Boersma. 2006. *Amino acid and energy digestibility in ten samples of distillers dried grain with solubles fed to growing pigs.* Journal of Animal Science 84:853-860.

Whitney, M.H., G.C. Shurson, L.J. Johnston, D.M. Wulf, and B.C. Shanks. 2006. *Growth performance and carcass characteristics of grower-finisher pigs fed high-quality corn distillers dried grain with solubles originating from a modern Midwestern ethanol plant.* Journal of Animal Science 84:3356-3363.

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