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HEARTLAND Regional Water Coordination Initiative

Impact of Feeding Distillers Grains on Nutrient Planning for Beef Cattle Systems

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Introduction

Current ethanol industry expansion could significantly affect animal feed management and manure nutrient planning in the beef industry. The economic and performance advantages of feeding distillers grains with solubles (DGS) and corn gluten feeds (CGF) have resulted in rapid adoption of these feeds in beef diets. Feeding co-product increases nitrogen (N) and phosphorus (P) excretion and effects significant changes in land requirements, labor and equipment needs, and manure application rates. A regulatory Nutrient Management Plan (NMP) or a USDA Comprehensive NMP (CNMP) must be adapted to the specific levels of distillers co-product feeding in individual cattle feeding programs. This publication summarizes the NMP/CNMP changes necessary when distillers grains co-products are included in a beef ration and introduces implications to public policy. It will evaluate the differences, as diet changes, in excreted manure, land requirements, labor and equipment costs, and value of the manure as a fertilizer.

Benefits and Limitations of Using Distillers Grains with Solubles (DGS) in a Beef Diet

DGS is a feed option that can improve performance and reduce feed cost for beef cattle. The reduction in feed cost when feeding wet DGS has been significant relative to historical average net returns in cattle feeding of $10 per head or less *(Figure 1)*. Distillers grains are high in energy, protein, and phosphorus. Nutrients are typically concentrated three-fold compared to corn, due to the conversion of starch in corn to ethanol. Increased nutrient levels in DGS can serve as substitutes for other traditional ingredients in the diet. Additional characteristics of DGS may also improve feed intake and help to prevent digestive disturbances in beef cattle. University research currently suggests limits to the proportion of DGS used in beef cattle rations without compromising performance. Current recommendations suggest limiting diet inclusion to 40 percent on a dry matter basis for wet DGS in beef feedlot diets consisting of dry-rolled or high-moisture corn, and 20 percent wet DGS for diets based on steam-flaked corn (Vander Pol et al., 2006; Corrigan et al., 2007).

Dry distillers grains do not contain as much energy as wet distillers grains, but inclusions of 20 percent of the diet work well (Buckner et al., 2007b). High dietary sulfur levels may lead to a condition called polio-encephalomalacia (a neurologic disease caused by excess production of hydrogen sulfide gas in the rumen from fermentation) which can be a challenge with high inclusions of DGS. High fat levels in distillers grains may also become a limiting factor for DGS inclusion rates above 40 percent. However, potential ethanol plant processes for removing sulfur and oil, as well as feeding a combination of DGS with corn gluten feeds may provide opportunities for inclusion rates above the current 40 percent limit (Loza et al., 2005; Buckner et al., 2007a).

A guide to feeding co-products to beef cattle is available at *http://beef.unl.edu* under byproduct feeds (Erickson et al., 2006; 2007).

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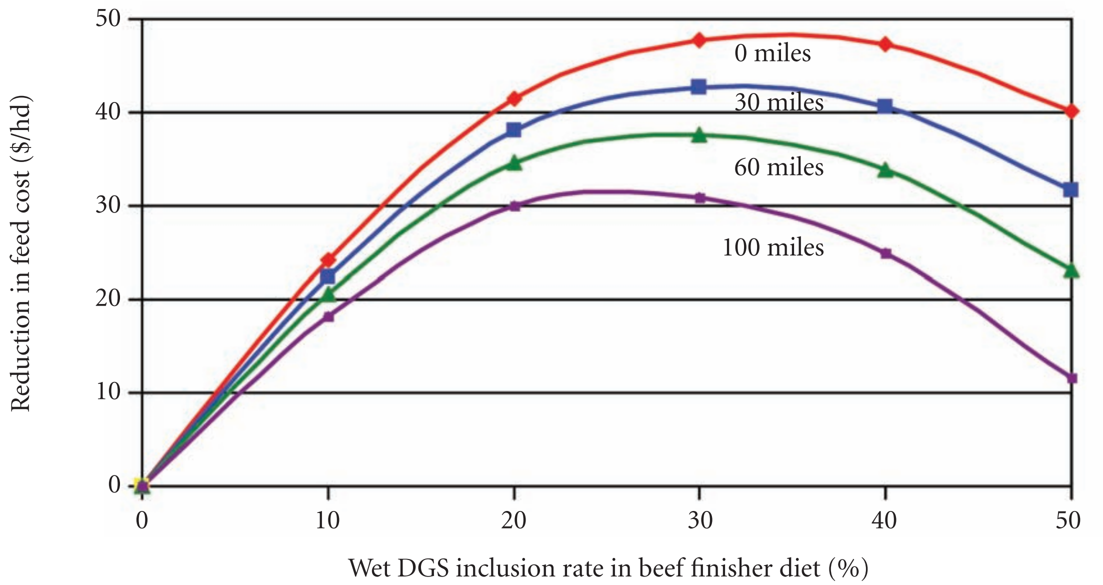

Figure 1. Value of wet DGS relative to a corn-based ration versus inclusion rates and hauling distance from ethanol plant. Assumes corn at $3.50/bu and wet DGS at 95% of corn price based upon 2007 market conditions.

DGS Inclusion Effects on Manure Nutrient Excretion

University of Nebraska–Lincoln research (Geisert et al., 2004) has documented that phosphorus requirements for beef finishers are met by diets containing 0.1 percent phosphorus *(Figure 2)*. Because corn grain contains 0.3 percent phosphorus, it is difficult to formulate diets below 0.25-0.30 percent dietary phosphorus. Diets with DGS and corn gluten feeds will result in phosphorus concentration of 0.4 percent or greater. The animal does not retain any of the excess dietary phosphorus resulting in all of the excess being excreted in manure. Thus, several aspects of an NMP/CNMP must be adjusted to reflect greater nutrient excretion with higher DGS inclusion rates in the diet.

To further understand the impact of feeding DGS on NMP/CNMPs, a case study is presented to illustrate these changes for dietary inclusion rates of 0 percent, 20 percent, and 40 percent DGS on a 2,000- and 20,000-head beef open lot production system. The assumptions are summarized in *Table 1*.

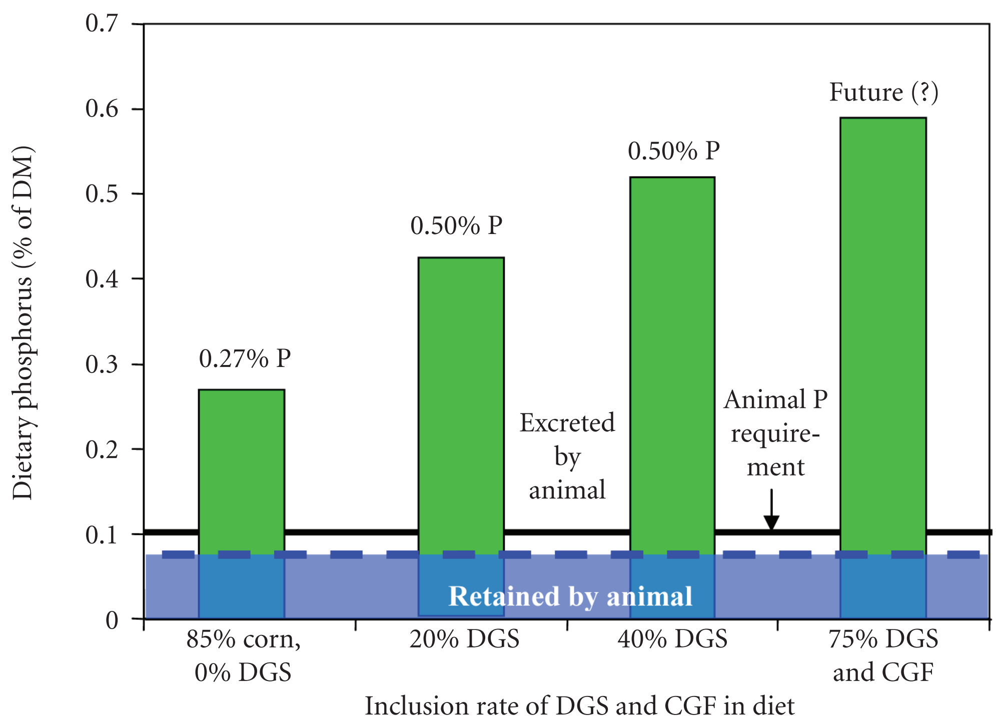

Figure 2. Dietary phosphorus in beef feedlot diets.

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Table 1. Case study assumptions for beef feeding and manure management scenarios with 20 percent and 40 percent DGS inclusion rates.

Characteristics	*Assumptions*
Crop Production	175 bu corn/ac and 60 bu soybeans/ac
Nutrient Plan	Manure is applied only to corn. A nitrogen credit of 45 lbs N/ac is credited to corn nitrogen requirements following soybeans. A 20 lb N/acre starter fertilizer application is assumed for corn production.
Retention of Nutrients	50 percent of organic N, 23 percent of ammonium N, and 95 percent of P is crop-available.
Field Application	Average field speed is kept under 10 mph and calculated discharge rate is kept under 3 tons/min. Application rigs are added until application duration (hours per rig) is less than 300 hours for a 2,000-head feedlot and 500 hours for a 20,000-head feedlot.
Input Cost	N cost of $0.30 per pound P_2O_5 is estimated to cost $0.50 per pound K_2O is estimated to cost $0.20 per pound Farm labor is estimated to cost $12 per hour Fuel cost is estimated to be $3 per gallon
Beef Cattle Performance	Cattle fed from 745 to 1,220 lbs over 153-day average feeding period. Two turns of cattle were assumed per year.
Feed Program	A standard corn/forage ration of 13 percent crude protein and 0.29 percent phosphorus concentration is used as a baseline. Twenty percent DGS inclusion produced a ration with 15.3 percent crude protein and 0.39 percent phosphorus concentration in diet. Forty percent DGS inclusion produced a ration with 18.7 percent crude protein and 0.49 percent phosphorus concentration in diet.
Excretion Estimate	Based upon standard procedures from ASABE, 2006.
Software for Modeling Comparisons	*Feed Nutrient Management Planning Economics (FNMP$)* software authored by R. Koelsch, R. Massey, V. Bremer, and G. Erickson. Not available for public use at time of fact sheet's preparation. R. Koelsch, et al., 2007.

Excreted and crop-available nitrogen and phosphorus increase in response to changes in diet *(Table 2)*. Nitrogen excreted increases by 21 percent to 51 percent for DGS at 20 and 40 percent inclusion rates, respectively. The increase in excreted phosphorus is 46 percent and 92 percent for a 20 percent and 40 percent inclusion rate, respectively.

Impact of DGS Inclusion on Nutrient Plan

Several aspects of an NMP/CNMP will need adjustment in order to account for dietary inclusion rates of DGS in beef cattle diets. Failure to consider these nutrient plan changes may produce a plan incapable of

Table 2. Nutrient content of manure excreted (lb/year) by 2,000 heads[1] of beef fed diet containing 0, 20 and 40 percent DGS.

	DGS Inclusion Rate[2]					*Book Value*	
	0%	*20%*		*40%*		*ASABE[3], 2006*	*NRCS[4]*
		(lb/year)	*% change*	*(lb/year)*	*% change*		
N Excreted	215,000	260,000	21	325,000	51	220,000	180,000
Crop-Available N	47,900	57,800	21	72,400	51		
P Excreted	26,300	38,400	46	50,400	92	29,200	54,100
Crop-Available P	25,000	36,400	46	47,900	92		

[1]Nutrient excreted by 20,000 heads of beef is multiplied by a factor of 10.
[2]Excretion estimated using species-specific equations from ASABE, 2006.
[3]ASABE — American Society of Agricultural and Biological Engineers.
[4]NCRS — Natural Resources Conservation Service.

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Table 3. Land requirements (acres/head of capacity) for field application of manure from a beef cattle feedlot fed diets with 40 percent DGS under continuous corn and corn-soybean cropping rotation.

	Continuous Corn			*Corn-Soybean Rotation*		
Application Rate	***DGS Dietary Level***		***Change***	***DGS Dietary Level***		***Change***
	0%	***40%***	***%***	***0%***	***40%***	***%***
Total Land Required	(acres/head of capacity)			(acres/head of capacity)		
N-Based	0.16	0.24	51	0.46	0.68	51
1-Year P-based[1]	0.54	1.02	92	1.07	2.05	92
4-Year P-based[2]	0.64[3]	1.02	61	0.90[3]	1.37	51
Single Year Land Required						
N-Based	0.16	0.24	51	0.23	0.34	51
1-Year P-based[1]	0.54	1.02	92	0.54	1.02	92
4-Year P-based[2]	0.16[3]	0.26	61	0.23	0.34	51
Maximum Distance to Field	0.4-1.1	1.6-1.6	—	1.0-1.7	1.3-2.5	—

[1]Manure applied every year prior to corn. Rate is determined by 1 year crop phosphorus removal or 1 year crop nitrogen requirement, whichever is less.
[2]Manure applied every fourth year prior to corn. Rate is determined by 4 year crop phosphorus removal or 1 year crop nitrogen requirement, whichever is less.
[3]Application rate is limited by nitrogen.

achieving intended environmental goals or regulations. As DGS inclusion rates increase, strategic or long-term planning issues should address:

- Greater land requirements.
- Greater travel distances and time requirements for manure distribution, impacting labor and equipment needs as well as capital and operating costs.
- Management practices for minimizing soil erosion and runoff for fields receiving higher phosphorus-content manures. Land treatment components of an NMP/CNMP should be reviewed and possibly revised.

In addition, the annual plan (application rates, fields, application methods) will commonly need adjustment as DGS inclusion increases. Some of the key considerations include:

- Book values of nutrient concentration will not be representative. In addition, past manure samples may not be representative of manure if DGS use has increased. New, farm-specific manure samples will be needed.
- Application rates will need to be recalculated.
- If manure is applied at a nitrogen-based rate, field selection for manure application may need to be reconsidered. Some fields with a higher phosphorus index score may need to transition to a phosphorus-based rate immediately. The transition time for most fields to a phosphorus-based rate will also be shorter due to higher phosphorus applications resulting from nitrogen-based rates.

The following discussion reviews several of these changes for our case studies using 2,000- and 20,000-head capacity beef feedlots.

Implications for Cattle Producers

Land Requirements

Land requirement for manure application is influenced by the proportion of DGS in the diet *(Table 3)*. Adding DGS produces an increase in excreted and crop-available nitrogen. Most of the additional nitrogen excreted in open lot systems will be volatilized as ammonia gas and not crop available. Only a modest increase in land requirement for nitrogen management is needed due to likely volatilization. However, land requirement will increase by 46 percent and 92 percent for phosphorus-based manure application for a 20 percent and 40 percent DGS inclusion rate *(Table 3)*.

Land required for phosphorus-based applications typically increases by a factor of about four over nitrogen-based applications *(Table 3)*. If phosphorus-based rates allow an application to meet multiple-crop-year phosphorus use, the number of acres required for any one-year approaches that required for a nitrogen-based rate.

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However, because the same land cannot receive manure again for several years, a phosphorus-based rate will require additional land over a four-year cycle when compared to a nitrogen-based plan. In addition, the analysis assumed that manure was only applied prior to corn in a corn-soybean rotation. These factors account for the differences in total and single-year land requirements observed in *Table 3*.

Phosphorus-based plans will require roughly 0.25 to 0.50 acre per head for high-yield continuous corn and corn-soybean rotations, if no DGS use is planned. Between 0.50 and an acre per head is needed if feeding a 40 percent DGS inclusion. Feeding a 40 percent DGS inclusion and applying manure prior to planting corn only in a corn-soybean rotation (one acre per finished head) requires the most land. Applying manure only to non-legume crops maximizes the nitrogen value of the manure but can add to land requirements for a corn-soybean rotation.

Labor, Machinery, and Operating Costs

Labor and equipment time is a critical consideration in the management of farm manure and an issue often ignored in a CNMP/NMP. Use of DGS in the diet will require additional time for manure application, if applied at agronomic rates. NMPs/CNMPs will need to account for the additional labor and equipment requirements as DGS is added to the diet and farms transition from nitrogen-based to phosphorus-based application rates. Spreading manure on a single-year, phosphorus-based application rate also impacts labor and machinery requirements. Failure to plan for these additional labor and equipment needs will create difficulties in implementing a proposed NMP/CNMP *(Figure 3)*.

In our two case-study farms, the highest total cost is observed for manure application on a one-year phosphorus-basis *(Figure 4)*. Use of DGS further accentuates the additional manure application cost as cattle operations move from nitrogen- to phosphorus-based plans. The increased cost is much smaller if the transition is from a nitrogen-based plan to a phosphorus-based plan that allows single manure applications of multiple-year phosphorus requirements.

Value of Manure

Estimated gross and net value of manure application is shown in *Table 4* for 2,000- and 20,000-head capacity beef feedlots. In all situations, the gross value of manure has increased significantly for cattle fed distillers grains. The increased value of phosphorus in manure is significant, assuming that manure can be transported to more distant fields with soil phosphorus deficits and neighboring crop producers value manure at or near its fertilizer replacement value. Phosphorus-based application plans may recover the greatest value from manure because of their ability to gain economic value for all of the phosphorus in manure. Because of the transportation costs and the nuisance issues associated with manure, valuing manure at its fertilizer replacement value is not always possible.

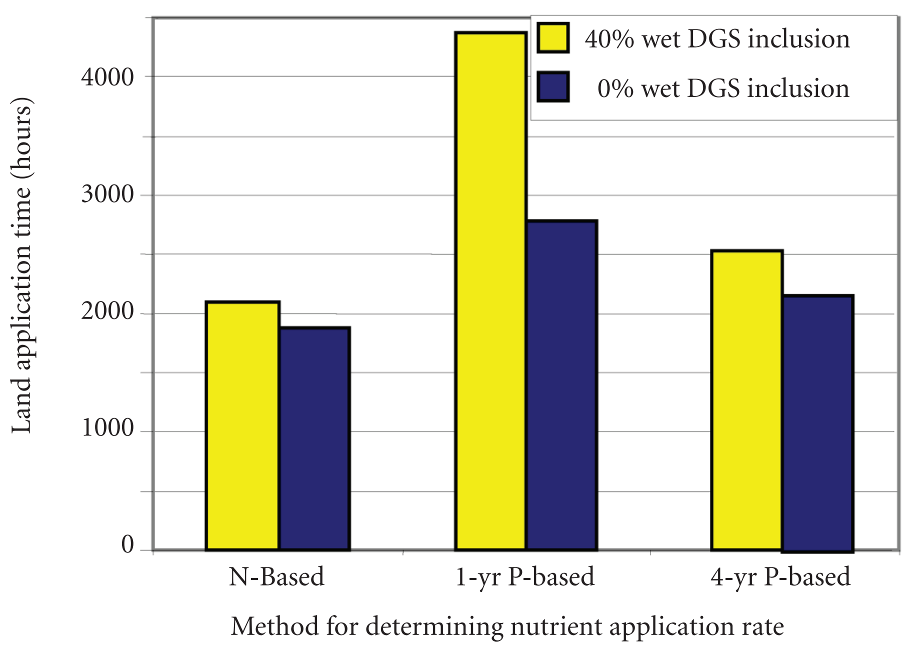

Figure 3. Time (labor and equipment) for manure application vs. method for determining nutrient management rate (20,000-head feedlot, corn-soybean rotation).

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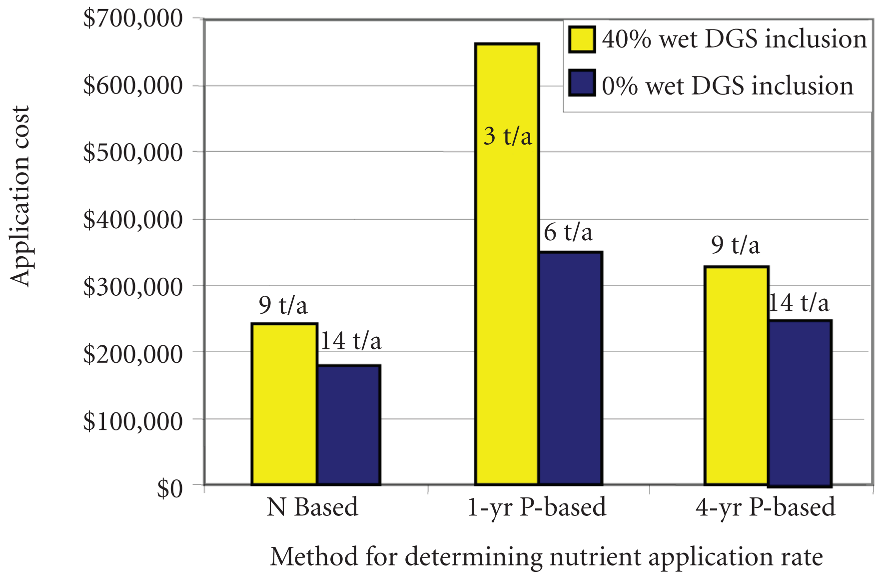

Figure 4. Cost of manure application vs. method for determining nutrient management rate (20,000-head feedlot, corn-soybean rotation).

It is plausible for feedlot owners to reap financial benefits from feeding and distributing manure resulting from high DGS inclusion rates. Net value increases with the addition of DGS, for all situations (continuous corn and corn-soybean rotations) for our 2,000- and 20,000-head case study feedlots. Net value increased by $10,000 to $33,000 for the 2,000-head example and between $10,000 and $250,000 for the 20,000-head feedlot *(Table 4)*.

The greatest benefit is for phosphorus-based application rates designed to provide for multiple years of phosphorus in a single application. Achieving this increased value will require innovation in manure marketing; however, the high phosphorus content of manure from feedlots using DGS can be of greater value to neighboring crop producers.

Implications for Public Policy

The "nutrient" book value of manure, calculated using both the American Society of Agricultural and Biological Engineers (ASABE) and Natural Resources Conservation Service (NRCS) formulas is shown in

Table 4. Annual net value of manure, spreading cost and total fertilizer value of manure (1,000 per year) for a 20,000- and 2,000-head beef open lot under corn-soybean rotation.

	No DGS Inclusion in Diet			***40% DGS Inclusion in Diet***		
Basis for Manure Application	***N-Based***	***1-Yr P-Based***	***4-Yr P-Based***	***N-Based***	***1-Yr P-Based***	***4-Yr P-Based***
20,000 head feedlot						
Annual fertilizer value of manure	373	430	430	563	766	766
Total value of N[1]	144	144	144	217	217	217
Total value of P_2O_5	85	286	286	346	548	548
Annual cost	177	344	244	240	669	329
Net value of manure	195	86	185	323	97	437
2,000 head feedlot						
Annual fertilizer value of manure	37	43	43	56	77	77
Total value of N[1]	14	14	14	22	22	22
Total value of P_2O_5	23	29	29	35	55	55
Annual cost	25	29	26	25	52	27
Net value of manure	13	14l	17	31	24	50

[1]Increased value of nitrogen in manure is likely over-estimated due to greater nitrogen volatilization for higher DGS additions to diet.

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Table 2. Book values will commonly produce significant errors in estimates of manure excretion and land requirements because the values are based on diets without DGS. Planners and plan reviewers must avoid using book values in NMPs/CNMPs and begin using estimating procedures that reflect the rate of DGS inclusion in the diet. Future efforts to inventory beef cattle feedlots for nutrient planning should include a collection of information on the rate of DGS inclusion, the resulting crude protein and phosphorus content of diets, and performance characteristics of cattle being feed. Regulations and nutrient plans based on book values rather than on excretion model estimates (ASABE, 2006) will significantly underestimate phosphorus content of manure and the land required for application.

Policy decisions relative to the method for determining manure application rates will have significant impact on the labor and equipment requirements and associated costs for implementing a nutrient plan (*Figures 3* and *4*). For the 2,000- and 20,000-head case-study feedlots, the transition from a nitrogen-based application rate to a one-year phosphorus-based application increases costs by $7 and $11, respectively, per head marketed, at a 40 percent DGS inclusion rate. That same transition cost is $0.50 to $2 per head marketed if a four-year phosphorus-based application rate is used. Single versus multiple-year phosphorus application rates significantly impact costs and the ability of feedlots to successfully complete this transition.

Phosphorus is not normally mobile in the soil. If the land where manure is applied is not prone to soil erosion, applied manure phosphorus can be banked for use by subsequent crops with little or no environmental impact (Wortmann et al., 2006). The environmental benefits (if any) of applying manure to meet single versus multiple-year crop phosphorus needs should be balanced against the labor, equipment, and economic costs. In addition, it should be noted that if a reasonable fertilizer value can be recovered from the manure, the transition to a phosphorus-based application rate should produce economic benefits greater than the additional application costs.

Summary Points

The economic benefits of DGS in beef diets is well established. However, there are multiple implications to the NMP/CNMP that cattle producers and advisors must consider. Key "Take Home Messages" from this discussion include:

- Feed cost benefits from feeding DGS in cattle rations will cause a rapid adoption by feeding programs to include DGS, especially wet DGS, at rates currently approaching 40 percent of ration dry matter.

- Adding distillers grain in beef diets increases excreted nutrients, land requirements, labor and equipment requirements, and manure handling costs.

- NMPs and CNMPs must reflect the degree of DGS inclusion in the cattle feeding program. Use of book values for estimating excretion, land requirements, and manure nutrient concentration will cause significant errors in nutrient plans. Nutrient plans must recognize how feed ration influences manure characteristics.

- The increased cost incurred to manage manure from cattle fed DGS may be offset by the added nutrient value of substituting manure for commercial fertilizers. The opportunity to market manure with higher phosphorus content should increase interest among neighboring crop producers.

- Policy decisions to allow manure application for a single- or multiple-year crop phosphorus requirement has a major impact on costs, labor, and equipment requirements for implementing a nutrient plan. Use of DGS adds to these higher costs; however, use of DGS and the transition to phosphorus-based plans have the potential for increasing manure value by amounts greater than the increased cost of application.

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