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HEARTLAND Regional Water Coordination Initiative

Impact of Feeding Distillers Grains on Nutrient Management Planning on Dairy Farms

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Introduction

The inclusion of distillers grain with solubles (DGS) in the formulations of dairy feed ration is increasing and may continue to grow as the knowledge of these products improves. Benefits of DGS as a ration ingredient include increased availability and competitive pricing relative to other ingredients. Feeding DGS will potentially increase nitrogen (N) and phosphorus (P) excretion in manure and require changes in a nutrient management plan (NMP)[1].

An increase in excreted N and P is expected to not only increase costs associated with land application of manure but also the value of the manure (if sufficient land is available). This publication will summarize:

- the implications of using DGS on an NMP,
- the costs associated with its implementation, and
- the changes necessary to comply with environmental regulations.

Manure nutrient excretion other than American Society of Agricultural and Biological Engineers (ASABE) and Natural Resources Conservation Service (NRCS) book values are estimated using a mass-balance procedure based upon the specific dietary and animal performance assumptions for each diet evaluated.

[1]References to a change in an NMP apply to both NMPs and Comprehensive NMPs (CNMPs).

Benefit and Limitations of Using DGS in Dairy Cattle

Inclusion of DGS in a lactating dairy diet is a practice receiving increasing attention from researchers. DGS inclusion rate of 20 percent (Schingoethe, 2006), and 26 percent (Linn and Chase, 1996) of total ration dry matter base was reported. Schingoethe and co-workers also suggested including more than the 20 percent of the ration as DGS for diets containing higher proportions of corn silage. For other dairy cattle, a DGS inclusion rate of 15 percent is recommended for replacement heifers while distillers grains are not commonly recommended for calves less than 6 months old.

In most studies, milk production remained the same or showed a small increase in response to DGS inclusion (Schingoethe, 2004). A drop in feed intake, milk yield, and milk protein concentration was reported for DGS inclusion rates greater than 30 percent of the dietary dry matter. Most recently Kleinschmit and co-workers (2006) reported that feeding DGS at 20 percent did not significantly decrease the concentration of milk fat, but significantly reduced milk protein percentage. Reduced dry matter intake and reduced milk production were also reported at DGS rates exceeding 25 percent of the ration dry matter. Other positive impacts of feeding distillers grains to dairy cattle could be protection against acidosis, laminitis and liver abscesses. However, feeding high levels of DGS may inhibit some fiber-digesting bacteria normally found in the rumen, which could lead to depressed milk fat, a component used to make butter.

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In deciding the inclusion of DGS in dairy feed, producers have historically evaluated the variability of DGS nutrient content, ingredient costs, and issues related to on-farm storage and handling of DGS. The following information will allow the impacts of DGS use on the Nutrient Management Plan to also be considered.

DGS Inclusion Effect on Manure Nutrient Excretion

Current Natural Research Council recommendations for lactating dairy cows range from 0.30 to 0.40 percent P in the diet, depending primarily on milk production (NRC, 2001). Corn grain commonly has 0.3 percent P. This is further concentrated by the removal of starch during ethanol processing by a factor of about three. With the inclusion of DGS, the ration P concentration will commonly increase. Ration crude protein concentrations may also increase with inclusion of DGS. The additional nutrients are not retained by the animals which results in more N and P in the manure.

To estimate the change in N and P excretion, and subsequent changes in the NMP, four rations were evaluated for two case-study farms, a 200- and 2000-head lactating dairy herd. The low P baseline diet (0 percent DGS) was formulated for a crude protein and P concentration of 18.5 percent and 0.33 percent, respectively. This diet was modified to allow a 15 percent and 30 percent DGS inclusion rate. Diets were formulated with DGS substituted for corn silage, corn, hay and haylage, soybean and soy supplement. The 30 percent DGS inclusion rate exceeded recommendations at the time of this publication but was considered within the realm of possibility for the near future. A high P diet (0.5 percent P) is more representative of past feeding practices and was included for comparison. Assumptions made in this study are summarized in *Table 1*.

Excreted and crop-available N increased due to an inclusion of DGS in dairy diet. Excreted N increased by 3 percent and 16 percent, respectively, for DGS inclusion rates of 15 percent and 30 percent *(Table 2)*. When compared to the currently recommended low P baseline dairy diet formulations, excreted P increased by 33 percent and 67 percent for DGS inclusion rates of 15 percent and 30 percent, respectively. However, when compared to a traditional high P diet, phosphorus excretion was 33 percent and 17 percent for 15 percent and 30 percent inclusion rates, respectively. The extent of the observed change depends on which comparison is used, the traditional high P diet or the low P baseline diet.

Book values traditionally used to estimate manure N and P excretion are based on blanket average value and are not accurate in estimating excretion. Natural Resource Conservation Service book value estimated only half the N excretion on feeding DGS while the ASABE commonly over-estimated P excretion.

Impact of DGS Inclusion on Nutrient Plan

DGS inclusion at a 15 percent rate will likely have minimal effect on an NMP for a manure system that conserves N. The moderate increase in P excreted might have some implications for systems less conservative of N than the manure system modeled for the case study. Phosphorus may become the limiting nutrient in these situations and determine land requirements. However, for the N-conserving manure management system modeled, N was the limiting nutrient at 15 percent DGS inclusion.

With inclusion of DGS in dairy rations at 30 percent, the strategic (or long-term) plan will benefit by considering:

- Greater land requirement,
- Greater travel distance and time requirements for manure application impacting labor and equipment needs as well as capital and operating costs,
- The land treatment component of an NMP including practices for minimizing soil erosion and runoff for fields receiving higher P content manure should be reviewed, and
- Book values for manure excretion are often inaccurate in estimating land requirements.

With inclusion of DGS in dairy rations at 30 percent, the annual plan (application rates, fields, and application methods) should consider:

- Book values of manure nutrient concentration and past manure samples (prior to DGS inclusion) are not likely to be representative. New, farm-specific manure samples will be needed,
- Application rates will need to be recalculated,
- If manure is applied at an N-based rate, field selection for manure application may need to be reconsidered due to higher P-application rates. Some fields with a higher P-Index score may need to transition to a P-based rate immediately. The transition time for most fields to a P-based rate will be shorter.

Significant reductions in dietary P recommendations have reduced excreted P since the 1990s. These changes should have produced significant modification in NMPs over the last 10 years. However, many planners have not had the tools necessary for such adjustment in the past. Thus, current NMPs for farms feeding a recommended P level or some level of DGS are likely to contain errors overestimating land requirements and the potential need to transition to a P-based manure application rate.

Table 1. List of assumptions made for case study dairy farm analysis.

Characteristics	Assumptions
Cropping system	Corn silage and alfalfa rotation
Corn silage yield	24 ton/ac
Alfalfa hay yield	6 ton/ac
Manure Application	Manure is applied only for corn silage (for most analysis)
Legume credit	N credit of 120 lb N/ac for alfalfa followed by corn and no manure applied to alfalfa
Dairy cows	200 or 2,000 dairy cows, all lactating
Average body wt	1,400 lb
Average milk	90 lb/day/animal
Average milk true protein	3%
Average feed intake	50 lb dry wt/head-day
Feed Parameters	(see feed parameter table below)
Manure	Liquid/slurry in uncovered storage
Incorporation	Manure is injected into the soil at application
Retention of nutrients	During storage, 75 percent N retention and 100 percent P retention was assumed. 70 percent and 95 percent of organic and ammonium N, respectively, were assumed crop-available
Application equipment	Tractor and 3,000-gallon tank injector for the 200-head dairy and tractor and 4,200-gallon tank injector for the 2,000-head dairy
Field application	Average field speed of 5 mph and application duration (hours per rig) did not exceed about 300 hours/rig for 200-head and 500 hours/rig for 2,000-head dairies
Input cost	Fertilizer N was estimated to cost $0.30 per pound Fertilizer P_2O_5 was estimated to cost $0.50 per pound Fertilizer application cost not included Farm labor was estimated to cost $12 per hour Fuel cost was estimated to be $3 per gallon

Feed Parameters:

	Crude protein %	P %
High P baseline	18.5	0.50
Low P baseline	18.5	0.33
15% DGS	18.8	0.39
30% DGS	20.4	0.45

Table 2. Nutrients (lb/year) excreted by 200-head of dairy, fed traditional diet, a currently recommended diet and a diet with 15 and 30 percent DGS inclusion. Nutrients excreted by 2,000-head dairy are multiplied by a factor of 10.

	Alternative Rations[1]				Book Values	
Nutrients (lb/year)	High P Traditional (No DGS)	Low P Baseline (No DGS)	15% DGS	30% DGS	ASABE 2006	NRCS
Excreted N	76,000	76,000	78,000	88,000	72,000	47,000
Crop-Available N[2]	49,000	49,000	50,000	56,000		
Excreted P	12,000	6,000	8,000	10,000	12,000	7,000
Crop-Available P[2]	12,000	6,000	8,000	10,000		

[1]See *Table 1* for percent crude protein and percent P of each ration.
[2]See *Table 1* for assumptions to estimate crop availability.

Land Requirement

Access to sufficient land is essential to successfully implementing a nutrient management plan. An adequate land base creates the "opportunity" for utilization of manure at agronomic rates. For a crop rotation that is predominantly corn silage and alfalfa hay, where manure is applied prior to corn silage only, a dairy will need access to at least three acres per cow *(Figure 1)*. For the low P rations, manure application rate is limited by N-based manure application rates. Thus, the same application rates and land requirements resulted for both the N- and P-based manure application rate analysis.[1] Further reductions in land requirements will be limited by reductions in excretion of N first.

The inclusion of 15 percent DGS in dairy diet had minimal effects on the land required for manure management. Nitrogen-based application rates

[1]P-based application rates are not allowed to exceed single year crop N requirements.

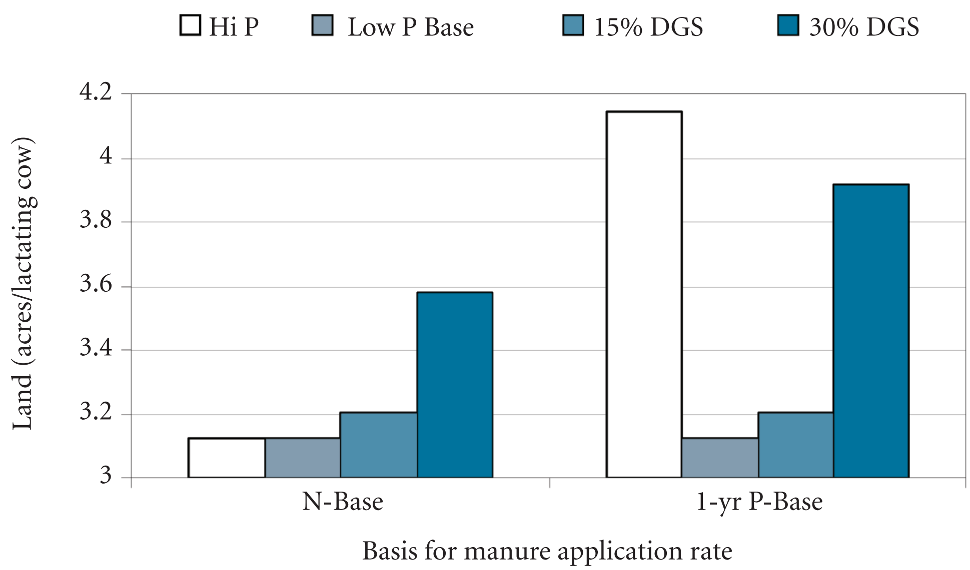

Figure 1. Land required for manure application for dairy cattle fed four diets. Corn silage and alfalfa rotation is assumed with manure applied to corn silage only.

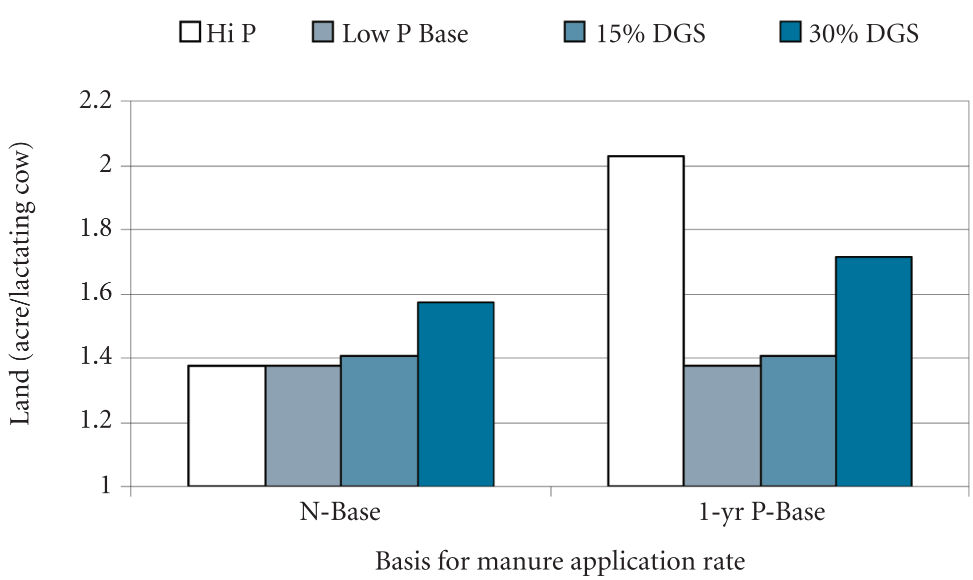

Figure 2. Land required for manure application for dairy cattle fed four diets. Corn silage and alfalfa rotation is assumed with manure applied to both crops.

continued to limit manure application for 15 percent DGS inclusion. A 15 percent DGS inclusion produced minimal increase in the ration's crude protein and the resulting N excretion.

Increasing the DGS inclusion rate to 30 percent increased land required for manure application by 0.45 to 0.8 acres per cow for N-based and P-based application rates, respectively, as compared to the low P-baseline ration. Phosphorus excretion again becomes the limiting factor for application rate at the 30 percent DGS inclusion rate. However, compared to the traditional high P diet, the total land required for managing manure nutrients is slightly lower than past land requirements. The additional dietary P in the 30 percent DGS ration and the traditional high P rations produced P excretion levels where a P-based rate establishes the maximum land requirement.

A single application of manure at a multiple-year-crop P requirements rate did not improve the net value of manure for the farms evaluated. When lower P rations were considered, manure application rate was limited by the N requirements of the crop. For the higher P rations, however, it was not possible to apply two or more years if crop P requirement in a single manure application without exceeding the crop N requirements.

These results shown apply to manure handling systems that conserve N, such as manure storage systems with minimal treatment and land application by injection or direct incorporation. P-based rate limits would become more common for manure systems that lose significant N during storage or land application. The results are also relevant to crop rotations dominated by corn silage and alfalfa hay where manure is applied prior to corn production only. In regions where access to land is a challenge, manure may be applied to alfalfa as a means of utilizing the manure phosphorus and disposing of the nitrogen. Similar trends in land requirements are observed under this situation *(Figure 2)*, but land requirements are less than half of that observed previously. Differences in alfalfa vs. corn silage nutrient removal and in nitrogen credits for the legume crop produced the differences between *Figures 1* and *2* (see *Table 1* for assumptions). The remaining analysis will focus on situations where manure is applied only to corn silage.

Labor, Machinery and Operating Cost

Labor and equipment time for manure application can be shadowed by the emphasis on land required for field manure application in an NMP. However, it is an important component of the plan, often determining the plan's success. DGS inclusion at 15 percent of ration dry matter produced minimal change in time for field application of manure for both the 200- and 2,000-head case studies (*Figures 3* and *4*). However, a significant change in time required for diets including 30 percent DGS was observed. That change will be the most significant for P-based application rates.

A comparison of the traditional High-P diet with the low P baseline diet illustrates the value of a shift to lower dietary P levels. As nutrient plans shift to a P basis, signifi-

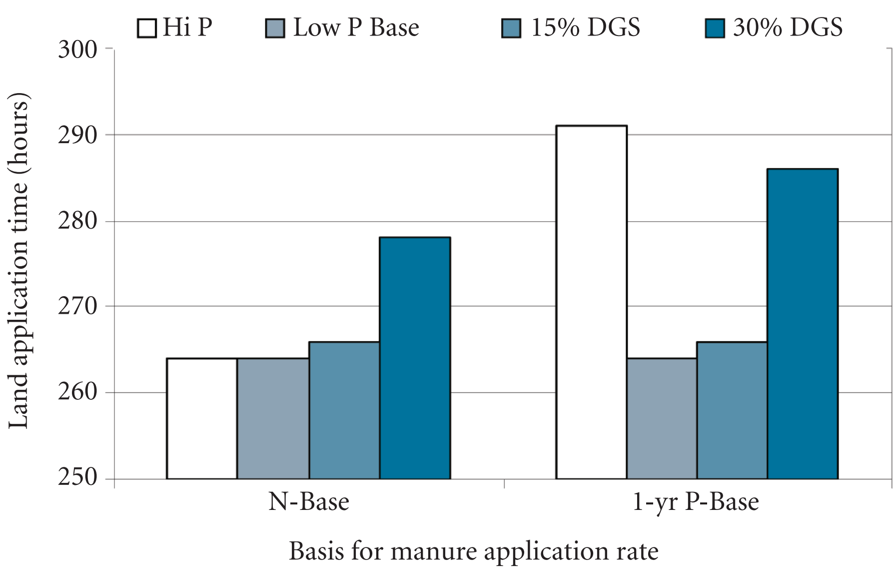

Figure 3. Time (labor and equipment) needed for manure application at N-based and 1-year P-based application rates for 200-head dairy.

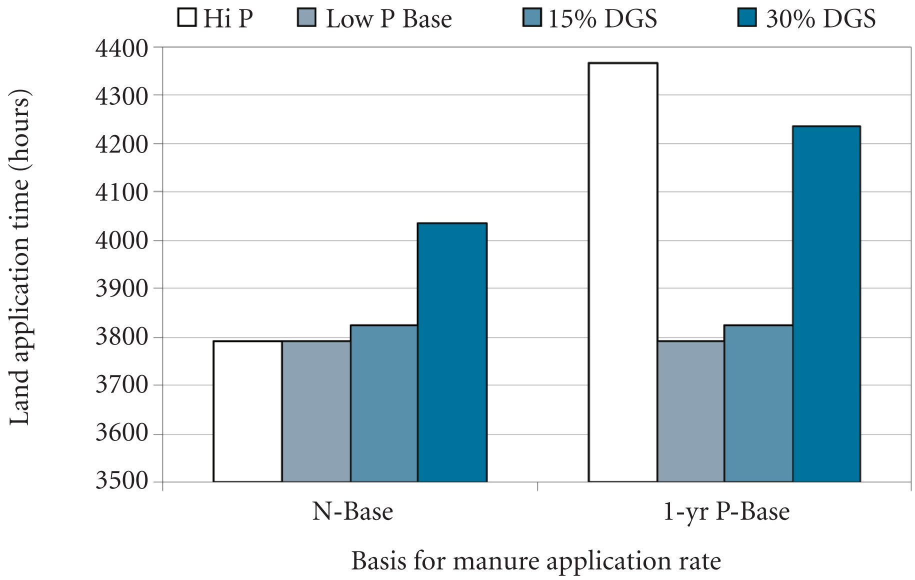

Figure 4. Time (labor and equipment) needed for manure application at N-based and 1-year P-based application rates for 2,000-head dairy.

cantly less equipment time and labor is needed for manure application. This dietary shift to lower P levels in a ration allows a N-based application rate without over-applying P, thus lowering equipment and labor requirements.

Value of Manure

Net fertilizer value was less than land application costs under current diet and 15 percent DGS but marginally above breakeven point for the 30 percent DGS ration for the 200-cow dairy *(Table 3)*. Net value of manure was negative for all diet formulations for the 2,000-head dairy. The negative net value of manure is associated with handling manure as slurry and the large volumes that must be transported. Higher levels of DGS inclusion did increase the value of the manure and more than offset the additional costs of spreading manure at a lower application rate over additional acres. This would hold true as long as manure is valued on its full N and P values.

Implications for Public Policy[1]

The inclusion of 15 percent DGS in dairy diet did not significantly change how much land was required for manure application or land application costs. For N-conserving manure systems, it is likely that N-based application rates will limit manure application. Since feeding of DGS at a 15 percent rate causes minimal change in dietary crude protein levels and the resulting N excretion, an NMP is unlikely to change. Approximately three acres per lactating cow is needed for managing manure nutrients in a corn silage/alfalfa rotation where manure is applied only to the corn silage. This land requirement is less than half if manure is also supplied to meet alfalfa N and P uptake. Less land might be required for manure systems that lose significant nitrogen. Currently, most research results do not recommend more than 20 percent DGS inclusion in formulating dairy diet.

An NMP should be adjusted for a 30 percent DGS inclusion rate. Higher dietary P levels in this ration may often result in P becoming the limiting nutrient requiring plans to be developed on a P-based application rate. Field application of manure will require approximately 3.5 to 4.0 acres per lactating cow for no manure on alfalfa in corn silage/alfalfa rotation *(Figure 1)* and 1.5 to 1.7 acres per lactating cow for manure on both crops in corn silage/alfalfa rotation *(Figure 2)*. Additional labor and equipment will also be needed to insure implementation of an NMP.

Planners and regulators should avoid using book value. Book value of excreted manure estimated using ASABE and NRCS methods, commonly introduces a significant error in the NMP, the magnitude of which varies depending on feeding program. It is not practical to expect a single book value to accurately predict the range of diets commonly used in the dairy industry. Base nutrient plans on a current manure sample. Estimates of excretion should take into account animal performance and phosphorus and protein content of the diet.

[1]References to a change in an NMP apply to both NMPs and CNMPs.

Table 3. Total value, spreading cost, and total annual fertilizer value of manure ($1,000 per year) for diet based upon currently recommended diet, 15 percent, and 30 percent DGS inclusion rate for (a) 200- and (b) 2,000-head dairy.

<table>
<tr><th>200-head</th><th colspan="2">No DGS</th><th colspan="2">15% DGS</th><th colspan="2">30% DGS</th></tr>
<tr><th></th><th>N-Based</th><th>P-Based</th><th>N-Based</th><th>P-Based</th><th>N-Based</th><th>P-Based</th></tr>
<tr><td>Annual fertilizer value of manure</td><td colspan="2">21</td><td colspan="2">24</td><td colspan="2">28</td></tr>
<tr><td>Total value of N</td><td colspan="2">15</td><td colspan="2">15</td><td colspan="2">17</td></tr>
<tr><td>Total value of P_2O_5</td><td colspan="2">6</td><td colspan="2">9</td><td colspan="2">11</td></tr>
<tr><td>Annual cost</td><td colspan="2">25</td><td colspan="2">26</td><td>26</td><td>27</td></tr>
<tr><td>Net value of manure</td><td colspan="2">-5</td><td colspan="2">-2</td><td>2</td><td>1</td></tr>
<tr><th>2,000-head</th><th colspan="2">No DGS</th><th colspan="2">15% DGS</th><th colspan="2">30% DGS</th></tr>
<tr><th></th><th>N-Based</th><th>P-Based</th><th>N-Based</th><th>P-Based</th><th>N-Based</th><th>P-Based</th></tr>
<tr><td>Annual fertilizer value of manure</td><td colspan="2">209</td><td colspan="2">237</td><td colspan="2">280</td></tr>
<tr><td>Total value of N</td><td colspan="2">136</td><td colspan="2">150</td><td colspan="2">168</td></tr>
<tr><td>Total value of P_2O_5</td><td colspan="2">63</td><td colspan="2">88</td><td colspan="2">113</td></tr>
<tr><td>Annual cost</td><td colspan="2">349</td><td colspan="2">351</td><td>365</td><td>379</td></tr>
<tr><td>Net value of manure</td><td colspan="2">-140</td><td colspan="2">-113</td><td>-85</td><td>-99</td></tr>
</table>

For an NMP based upon book values from a time when higher levels of dietary P were commonly fed, the required land was greater or equal to that needed for currently recommended dietary P-levels with up to 30 percent DGS inclusion. Planners not updating their estimates with changes in industry practice may currently be over-estimating land requirements for dairies that have modified diets to be closer to current recommendations.

Summary

The results found in this publication apply to manure handling systems that conserve N- manure storage systems with minimal treatment and land application by injection or direct incorporation. The important points from this evaluation of the effect of feeding distillers grains on an NMP of a dairy farm include:

- Including DGS at 15 percent did not increase land requirement for field manure application under the assumptions of this case study and should not require a change in the NMP provided initial excretion estimates for the plan were accurate.
- DGS inclusion rate of 30 percent increases the land requirement and application time, requiring adjustments to labor and equipment need for manure application.
- Farm-specific animal performance and feed programs should guide estimating manure nutrient excretion, not book values. Using book value to estimate excretion leads to erroneous results for the dairy. The discrepancy can be worse for diets including DGS.
- Farm-specific and current manure analysis should be used in estimating the amount of nutrient (N and P) in manure. Manure application rates should be adjusted to those samples.
- The use of DGS increases the value of the manure and has the potential for offsetting increases in land application costs.

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