University of Nebraska–Lincoln Extension RP194

Impact of Feeding Distillers Grains on Comprehensive Nutrient Management Planning For Poultry Layer Production Systems

Teshome Regassa, Extension Water Quality Specialist
Rick Koelsch, Extension Livestock Environmental Engineer
Sheila Scheideler, Extension Poultry Specialist
Mahmoud Masa'deh, Poultry Nutrition Graduate Student

Introduction

Dry distillers grains with solubles (DDGS) is being used in laying-hen diets because of its feed value as well as its price advantage over traditional feed sources such as corn. DDGS is a good source of energy, fiber, and nutrients. In fact, the non-starch nutrient content of distillers grains is about three times more concentrated than the original grain before fermenting. However, increased feeding of DDGS may increase nitrogen (N) and phosphorus (P) excretion for some species, requiring changes in the Nutrient Management Plan (NMP)[1].

This publication will summarize how including DDGS in laying hen diets changes manure nutrient excretion, land requirement for field manure application, the cost of manure application, and the fertilizer value of manure. It will also review the implications of a transition from an N- to a P-based method for determining application rates on costs of land application of layer hen manure.

Benefit and Limitations of Using Distillers Grains for Layers Poultry

Research at the University of Nebraska showed feeding laying hens with up to a 25 percent DDGS inclusion rate in their feed did not affect feed intake, body weight, or egg production. However, egg weight dropped at a DDGS inclusion rate of more than 15 percent (Masa'deh, 2007, unpb.). Benabdeljelil and Jensen (1989) included up to 30 percent DDGS in laying-hen diets and reported no effect on egg numbers but found a drop in egg size.

Lumpkins et al (2005), suggested maximum DDGS inclusion rates of 10 to 12 percent DDGS for a commercial layer's diet whereas research by Roberson et al (2004), recommended 15 percent DDGS inclusion without reducing egg production or quality. In 2007, Iowa State University researchers reported up to a 69 percent inclusion rate for a short-term feeding trial without adversely affecting egg production and egg quality. The potential long-term effect of such a high level of DDGS inclusion rate is not clear. Roberts et al (2007), reported that inclusion of 10 percent DDGS in a laying-hen diet considerably lowered ammonia emissions from hen manure.

Protein and metabolizable energy of DDGS are almost midway between those of corn and dehulled soybean meal, the two principal ingredients in poultry feed (Dale, 2007). The concentration of essential minerals and vitamins increases in the distillers products compared to corn. However, the existing variability in DDGS composition and quality limits its use in poultry diets. For the two most limiting amino acids in poultry diets, the coefficient of variation is as high as 17 percent for lysine and 14 percent for methionine. Lysine content is the most variable across different DDGS sources, possibly attributed to the susceptibility of lysine to heat damage during ethanol production. Threonine and cystine may also be susceptible to heat damage incurred during

[1]Reference to a change in NMP apply to both the NMP and the Conprehensive NMP (CNMP).

CSREES · Iowa State University · K-State Kansas State University · University of Missouri Columbia · University of Nebraska Lincoln · EPA Region 7 · National Water Program

DDGS processing. There is a concern about drops in feed efficiency, decrease in body weight, and marginal lysine deficiency at higher DDGS inclusion rates because of a change in feed density resulting from added DDGS.

DDGS Inclusion Effect on Manure Nutrient Excretion

Corn grain contains 0.3 percent phosphorus. This is further concentrated after ethanol processing, which results in high P concentration in DDGS. Replacement of corn with DDGS may increase dietary P levels for some species. Moreover, the laying hen does not retain any excess dietary P, potentially resulting in increased P excreted in manure. Thus, aspects of an NMP may need to be adjusted to reflect the greater nutrient excretion with the inclusion of DDGS in diet.

This case study was developed to illustrate expected changes in manure nutrient excretion resulting from inclusion of 8 percent and 16 percent DDGS in poultry diet formulations. At this point the industry is using about 8 percent DDGS inclusion rate and the 16 percent is a possible rate based upon current research. Assumptions made for a 800,000-bird case study farm are shown in *Table 1*.

Table 1. List of assumptions made for case study of laying-hen farm analysis.

Characteristics	Assumptions
Crop Production	175 bu corn/ac and 60 bu soybeans/ac Corn-soybean rotation with manure applied only to corn
Nutrient Credits	A nitrogen credit of 45 lb N/ac was credited to corn N requirements following soybeans. 20 lb N/acre for corn starter fertilizer
Manure Nutrient Credits	During storage, 85% N and 100% P retention was assumed, 80% of organic N, 23% of ammonium N, and 100% of P were assumed to be crop available during land application
Manure Application	An average of 80-acre field unit size was chosen with 80% of it to be cropped and 50% of the cropped land accessible for manure application. Manure was assumed to be surface-broadcasted using a truck-mounted 16-ton spreader on a cool soil. Average field speed was 5 mph and application swath width was 25 feet. Application duration did not exceed about 500 hours/rig
Input Cost	N cost of $0.30 per pound P_2O_5 was estimated to cost $0.50 per pound Farm labor was estimated to cost $12 per hour Fuel cost was estimated to be $3 per gallon
Layers' Average Body Weight	3.42 lb per animal

Feeding program

Feeding Phase	Days on feed	Intake (lb dry wt/bird/day)	Energy intake (kcal/bird/day)	% Producing egg in a day
1	182	0.240	303	93
2	175	0.253	316	75

% DDGS Inclusion	Feeding phase	Dietary crude protein (% dry matter)	Dietary phosphorus (% dry matter)
0%	1	16.7	0.75%
	2	16.2	0.74%
8%	1	16.7	0.78%
	2	16.2	0.77%
16%	1	16.7	0.81%
	2	16.2	0.80%

Table 2. Excreted and crop available manure nutrients produced by an 800,000-layer hen case-study farm fed a standard diet and diets with two DDGS inclusion rates.

	DDGS Inclusion Rate			Book Values	
Item, lb/year	**0%**	**8%**	**16%**	**ASABE 2006**	**NRCS**
Excreted N	1,250,000	1,260,000	1,270,000	994,000	806,000
Crop-Available N	547,000	551,000	556,000		
Excreted P	452,000	475,000	498,000	312,000	301,000
Crop-Available P	452,000	475,000	498,000		

Manure nutrient excretion is estimated using a mass balance procedure defined by the American Socioety of Agriculture and Biological Engineers (ASABE) based upon the specific dietary and animal performance assumptions for each diet evaluated. Manure excretion was also estimated using typical book values published by ASABE (2006) and Natural Resources Conservation Service (NRCS).

A marginal increase in excreted N and P resulted from diets including DDGS *(Table 2)*. Including DDGS increased P excretion by no more than 10 percent and N excretion by less than 2 percent for the highest inclusion rates. Traditional book values based on typical or average nutrient excretion estimates by ASABE and NRCS methods underestimated N and P excretion *(Table 2)*. The ASABE typical value used the same procedure as used in this analysis. However, differences in feed intake, P concentration in the feed, and animal performance produced differences in nutrient excretion. Without farm-specific information on the feeding program and animal performance, estimates of nutrient excretion by traditional book values were off by as much as 65 percent.

Land Requirement

The use of up to 16 percent DDGS in poultry diets did not result in a significant increase in the land requirement for manure management *(Figure 1)*. Approximately 13 acres of land in a corn-soybean rotation (manure applied only to corn) is needed per 1,000 layers to manage manure nitrogen. This land requirement doubles (26 to 28 acres per 1,000 layers) if manure is applied at a 4-year phosphorus-based[1] rate. For a one-year P-based rate[1], approximately 50 acres of land per 1,000 birds is necessary to manage manure P in a corn-soybean rotation. The 1-year P-based rate is twice that of a two- or four-year P-based rate because manure P is not used to meet soybean P requirements (assuming manure is applied only prior to corn production). Thus, the method used for estimating application rate is far more significant to the

[1]Four-year P-based rate refers to applying sufficient P in a single manure application to meet four years of P removal by the harvested crops. One-year P-based rate assumes a single manure application provides one year of P removal.

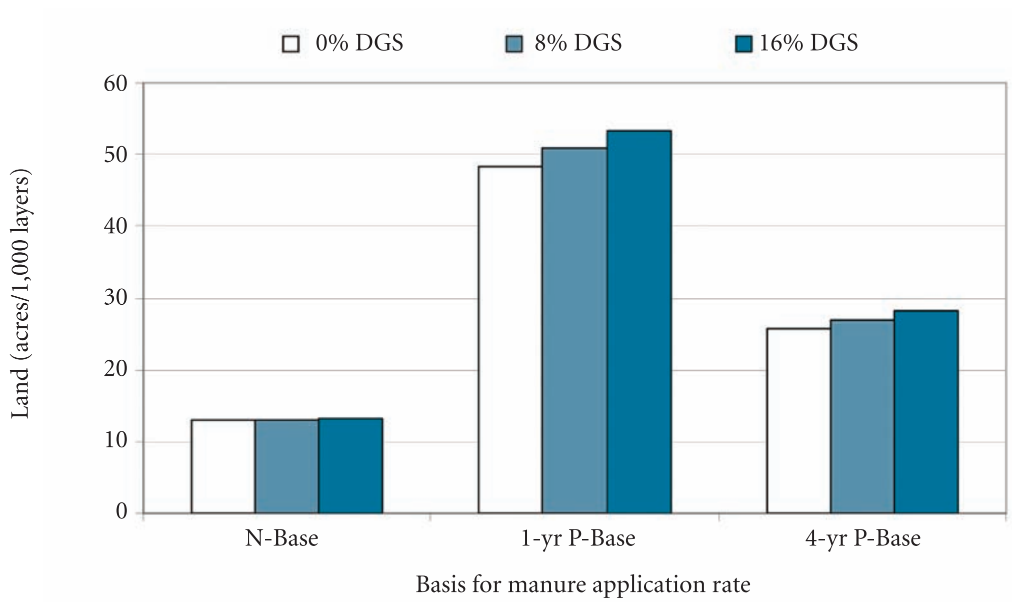

Figure 1. Total land required (acres/1,000 layers) for field application of manure from layers fed diets that vary in DDGS inclusion. Land required is estimated for a corn-soybean rotation where manure is applied only to corn.

Table 3. Land requirement, time, and maximum distance traveled for land applying manure nutrients from an 800,000-laying hen operation utilizing a standard diet and diets with 8 percent and 16 percent DDGS inclusion. Assumes cropping system based on corn-soybean rotation with manure applied only to corn.

% DDGS:	0% DDGS			8% DDGS			16% DDGS		
	N	1-yr P	4-yr P	N	1-yr P	4-yr P	N	1-yr P	4-yr P
Land required Total	10,300	38,700	20,700	10,400	40,700	21,500	10,500	42,600	22,600
Land required (acres/year)	5,200	19,300	5,200	5,200	20,300	5,400	5,300	21,300	5,600
Total time (hours/year)	1,600	4,100	1,900	1,600	4,300	1,900	1,600	4,400	2,000
Max distance (miles)	4.1	8.3	6.0	4.2	8.6	6.1	4.2	8.8	6.3

NMP than the inclusion of DDGS in the diet. Similar trends are seen with maximum distance traveled for land applying manure *(Table 3)*.

Annual Costs and Benefits

Labor, machinery, and other costs associated with manure management and field manure application are very important in an NMP and its implementation. Such costs are important to integrating manure nutrient management into farming operations. Similar to land requirements, the inclusion of DDGS does not affect application time and associated costs *(Figure 2)*. Average annual expense in terms of application time was the least for a N-based rate followed by the four-year P-based rate. Applying manure at a one-year P-based rate required 2.5 times greater equipment time and labor than an N-based rate. Costs of land application followed a similar trend *(Table 4)*.

Value of Manure

Estimated gross value of manure increased slightly for P-based rates, as a result of including DDGS in layers diets, while remaining constant for N-based rates. The gross manure value increased substantially when manure is applied at a P-based rate as opposed to an N-based rate. If manure is fully valued at its fertilizer replacement value, a significant incentive exists to transition from an N-based to a P-based rate.

The net value of manure, assuming N and P value equal to that of commercial fertilizer, is positive for all situations modeled *(Figure 3)*. The effect of DDGS on the net value is small.

The basis for determining the application rate is significant on the net value of manure *(Table 4)*. The four-year P-based rate proved to be the most economical. The transition from an N-based rate to a one-year P-based application rate resulted in less net return. Two factors contributed to a four-year P-based application rate demonstrating the highest net value:

- A four-year P-based rate captures the full value of both N and P while an N-based rate only partially captures the P value.

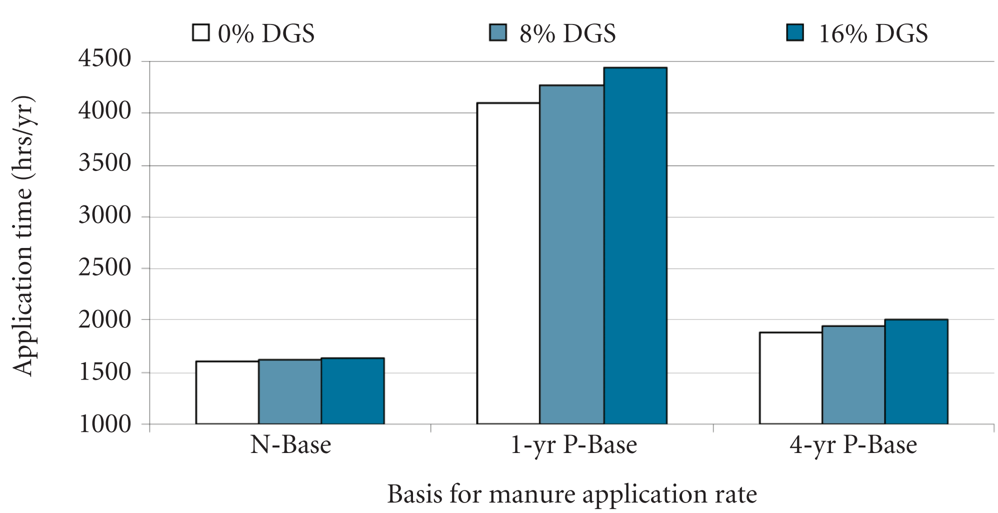

Figure 2. Time required for field manure application for an 800,000-laying-hen operation.

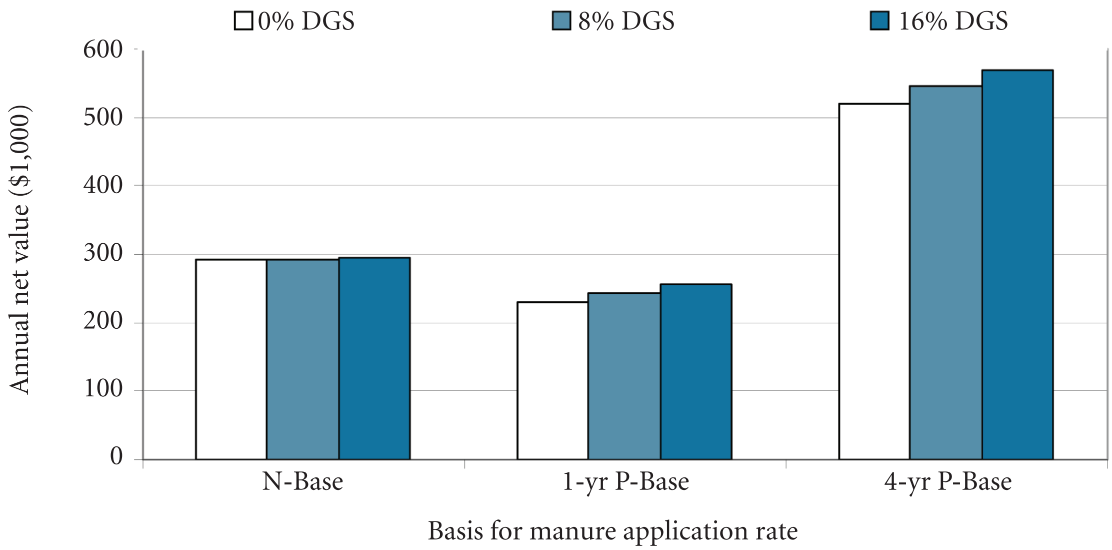

Figure 3. Annual net value ($1,000) from field-applied manure from layers fed diet with and without DDGS inclusion based on N, 1-year P and 4-year P crop requirement application rates.

- The four-year P-based rate has lower application costs than a one-year P-based rate.

Thus, a transition to a four-year P-based rate appears to have economic advantages.

Implication for Nutrient Plans and Public Policy

NMP adjustments for feeding DDGS of up to 16 percent diet dry matter adds no improvement in N planning and modest improvement in P planning. If the starting point for P in the ration is approximately 0.75 percent, replacing ration ingredients with DDGS with approximately 0.9 percent P is likely to have a modest impact on P-excretion. As phytase or other P reducing strategies are used to lower dietary P, inclusion of DDGS may have greater impact on excretion and other aspects of the NMP.

Book value methods for estimating nutrient excretion or manure nutrient concentration are problematic and may even be inaccurate depending upon layer diet and bird performance. If possible, always use farm-specific estimates of excretion based upon individual farm diet and performance. If not possible, farm-specific manure samples combined with records of manure production could provide an option for nutrient planning decisions such as land requirements.

Policy decisions relative to how you determine manure application rates will significantly impact the labor, equipment requirements, and associated costs for implementing a nutrient plan (*Figures 2* and *3*). The

Table 4. Total annual value, spreading cost, and gross fertilizer value of manure ($1,000 per year) for diets based upon the currently recommended diet, 8 percent and 16 percent DDGS inclusion rates for a 800,000-laying hen operation.

	0%			8%			16%		
Basis for application rate:	**N-based**	**P-based 1-yr**	**P-based 4-yr**	**N-based**	**P-based 1-yr**	**P-based 4-yr**	**N-based**	**P-based 1-yr**	**P-based 4-yr**
Fertilizer value of manure	425	681	681	428	709	709	432	736	736
Total value of N	164	164	164	165	165	165	167	167	167
Total value of P_2O_5	261	517	517	263	543	543	265	570	570
Land application cost	134	450	160	135	466	164	137	481	168
Net value of manure	291	231	521	293	243	545	296	255	568

transition from N-based to multi-year P-based applications includes some increase in labor and equipment requirements, but also a significant economic incentive to the layer operation, if sufficient land is available. Application of a single-year P-based application will produce labor, equipment, and economic disadvantages.

Phosphorus is not normally mobile in the soil. If you apply manure on land not prone to soil erosion, applied manure P 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 P needs should be balanced against the additional labor, equipment, and economic costs associated with a single-year P-based application rate.

A corn-soybean rotation in which manure is only applied to corn will require 25 fewer acres per 1,000 layers if manure is applied at a four-year P-based rate as compared to a single-year P application. The reduced travel distance and time required for a four-year P-based rate will facilitate successful NMP implementation. The extra equipment, time, and neighboring crop producers, when transferred, that are required for a one-year P-based rate will be an obstacle to successful NMP implementation.

Summary

The following points highlight the impact of using DDGS in layers diet in relation to the field application of manure:

- The use of up to 16 percent DDGS in layers diets should not affect the NMP.
- Book value methods for estimating excretion and land requirements were not accurate for the case-study farm evaluated. Differences in feeding program and animal performance will cause NMP errors for many layer operations if you use book value approaches for estimating manure excretion.
- It is economically feasible to transition from an annual N requirement rate to a 4-year crop P requirement rate, if manure is valued at its full fertilizer replacement value.
- Manure application at a four-year P-based rate has significant economic, land requirement, and logistical advantages over a one-year P-based plan in a corn-soybean rotation in which manure is applied only to corn.

References

Benabdeljelil, K. and L.S. Jensen. 1989. *Effects of distillers dried grains with solubles and dietary magnesium, vanadium and chromium on hen performance and egg quality.* Nutrition Reports Int. 39:451-459.

Dale, N. M. 2007. *Biofuels and Poultry Production.* Extension Poultry Scientist, the University of Georgia, Cooperative Extension Service. The Poultry Web site. *http://www.thepoultrysite.com/articles/852/biofuels-and-poultry-production* accessed 09-17-07.

Iowa State University. 2007. *Iowa State University research shows poultry diets can contain high levels of ethanol by-products.* College of Agriculture and Life Science news release. Dec. 2007.

Lumpkins, B., A. Batal, and N. Dale. 2005. *Use of distillers dried grains plus solubles in laying hen diets.* Journal of Applied Poultry Research. 14:25-31.

Roberson, K.D, J.L. Kalbfleisch, W. Pan, and R.A. Charbeneau. 2004. *Dried distillers' grains with solubles changes egg yolk color without affecting egg production when included at 5 to 15 percent of a corn-soybean meal diet.* Paper presented at the 2004 Southern Poultry Science Mtg., Atlanta, GA. Jan. 2004.

Roberts, S.A., H. Xin, B. J. Karr, J.R. Russell and K. Bregendahl. 2007. *Effect of dietary fiber and reduced crude protein on ammonia emission from laying-hen manure.* Poultry Science. 86:1625-1632.

Wortmann, C. S., M. Helmers, A Mallarino, C. Barden, D. Devlin, G. Pierzynski, J. Lory, R. Massey, J. Holz, C. Shapiro, and J. Kovar. 2006. *Agricultural Phosphorus Management and Protection in the Midwest.* Heartland Regional Water Quality Initiative publication RP 187. University of Nebraska–Lincoln Extension. *www.ianrpubs.unl.edu/epublic/live/rp187/build/rp187.pdf*. 23 pages.

This publication has been peer-reviewed.

This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement No. 2004-51130-02249. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.