Emerging Ethanol Industry: Implications for Animal Manure Management

Summary of Heartland Water Coordination Initiative Animal Manure Management Round-Table Discussion on Distillers Grains with Solubles

John D. Lawrence, Extension Livestock Economist and Director, Iowa Beef Center, Iowa State University

Introduction

Ethanol production is increasing rapidly and the four states in EPA Region 7 — Iowa, Nebraska, Kansas, and Missouri — are at the epicenter of this growth. Actual ethanol production and plants are moving targets. In May 2007, an estimated 52 plants were producing 2.95 billion gallons of ethanol in the four states and an estimated 39 plants were expanding or under construction *(Table 1)*. Iowa and Nebraska account for most of this activity.

There are also numerous other plants under consideration across the region. DTN news service reports that there were 117 ethanol biorefineries nationwide that have a capacity to produce nearly six billion gallons annually as of May 2007. Additionally, 80 biorefineries are under construction and eight are expanding, which will add more than 6.5 billion gallons of new production capacity by early 2009.

The rapid increase in ethanol production in the Heartland region is having a profound effect on agriculture in the four states. Beyond the economics of higher corn prices and upward pressure on land values, there are significant implications for water quality. A recent report by the Council for Agricultural Science and Technology (CAST) provides a review of existing literature and identifies areas where longer-term analysis may be needed (Cassman et al., 2006). Areas that come to mind include increased fertilizer application in pursuit of higher yields and more acres of fragile land in

Table 1. Estimated ethanol plants and production (million gallons) in the Heartland region (R7), May 2007.

	IA	NE	KS	MO	R7
In Production					
Plants	28	12	8	4	52
Annual Capacity	1,881	715	215	141	2,952
Under Construction					
Plants	13	11	4	0	28
Annual Capacity	1,135	639	235	0	2,009
Expansion					
Plants	6	5	0	0	11
Annual Capacity	300	484	0	0	784
Total					
Plants	47	28	12	4	91
Annual Capacity	3,316	1,838	450	141	5,745

Table 2. Current and planned ethanol and distillers grains and solubles production compared to 2006 corn production in EPA region 7 States.

	IA	NE	KS	MO	R7
Current production					
2006 corn acreage (million acres)	12.35	7.75	3.00	2.63	25.70
2006 corn crop (million bushels)	2,050.00	1,178.00	345.00	363.00	3,936.00
Ethanol (million gallons)	1,881.00	715.00	215.00	141.00	2,952.00
Corn processed (million bushels)	672.00	255.00	77.00	50.00	1,054.00
Percent of 2006 crop	33.00	22.00	22.00	14.00	27.00
DGS production (million tons)	5.90	2.20	0.70	0.40	9.20
With construction and expansion					
Ethanol (million gallons)	3,316.00	1,838.00	450.00	141.00	5,745.00
Corn processed (million bushels)	1,184.00	656.00	161.00	50.00	2,052.00
Percent of 2006 crop	58.00	56.00	47.00	14.00	52.00
DGS production (million tons)	10.40	5.70	1.40	0.40	18.00

crop production, as crop returns outbid pasture/ CRP rates. There are also water quantity issues due to demand from the ethanol plants themselves and from potentially increased crop irrigation.

Livestock and poultry production will be impacted through higher feed prices, which may result in less livestock and poultry production. Inclusion of a co-product, distillers grains with solubles (DGS), in animal diets is being utilized as an option by several livestock and poultry producers. DGS is higher in fiber, crude protein (nitrogen), and phosphorus than corn and can affect nutrient excretion from animals if diets are changed. In general, beef feedlots and dairies will utilize more DGS in rations and are more likely to feed nitrogen (N) and phosphorus (P) in excess of the animal requirements than will swine or poultry operation owners.

Current production is estimated to use approximately one-fourth of the Heartland region's 2006 corn crop *(Table 2),* assuming a conversion of 2.8 gallons of ethanol per bushel of corn. With current construction and expansion, ethanol production is expected to nearly double and corn processing will increase by approximately one billion bushels. The total corn processed then would be the equivalent of over half of the 2006 corn production in the region.

In addition to ethanol, these plants also produce distillers grains at a rate of 17-18 pounds of dry DGS per bushel of corn processed. Once the current construction and expansion is complete, there will be approximately 18 million tons of dry distillers grains and solubles (DDGS) available.

The four states of the Heartland region are also a major livestock and poultry producing region. These states represent 43 percent of cattle on feed, 20 percent of all beef cows, 39 percent of the nation's hogs, 20 percent of layers, 11 percent of turkeys produced, and 5 percent of milk cows in the U. S. Nationally, livestock and poultry are still the largest users of corn, but ethanol is gaining fast. The region has traditionally been "grain-surplus" meaning that there is ample land to utilize the manure nutrients from animal agriculture, if properly managed. It also means that grain is exported and agronomic nutrients are imported to produce crops.

The Heartland Animal Manure Management Issue Team hosted a round-table discussion focusing on one aspect of the emerging bioeconomy: the impact of feeding ethanol co-products on manure nutrients and the resulting management implications.

A group of scientists from the four land grant universities in the region and two representatives from the ethanol-producing sector participated, considering animal nutrition and manure excretion, storage, handling, land application, and nutrient management recommendations and regulations.

The connection of interest in these groups is the increased availability of corn co-products which could result in more livestock and poultry being fed higher levels of DGS. The impact on excreted nutrients and, therefore, land applications depends on the type of animals being fed. The round-table focused on beef feedlot and swine rations as examples of the expected implications. The following provides information on how rations and manure production may change for ruminants and monogastrics and what it implies for environmental regulations and recommendations. This report summarizes the round-table recommendations specifically to the animal nutrition, manure excretion, and land application scope of the emerging ethanol

industry. More detailed publications for each species and spreadsheet decision aids are also developed and available on the Heartland Web site: *www.heartlandwq.iastate.edu/ManureManagement*.

Feeding Ethanol Co-products

When corn is processed into ethanol, approximately one-third of the weight as starch is removed to make alcohol, one-third is released as CO_2 gas, and one-third remains as DGS. Compared to corn, DGS has a higher concentration of protein, fiber, fat and minerals. Typical DGS rations have approximately three times more nitrogen and phosphorus than the corn it originated from. While each of these nutrients is needed by animals, the availability, amounts, and ratios often do not match the needs of the animal. For some animals, it is economical to feed DGS as a replacement for certain dietary ingredients, thus resulting in excess protein and phosphorus in the diet and higher excreted levels of nutrients.

Beef feedlot cattle are the largest users of DGS in the Heartland region and when combined with dairy cattle are the largest users nationally. Cattle can effectively utilize the higher fiber content in DGS. Protein requirements of feedlot cattle can be met by feeding DGS at approximately 16 percent of the dry matter along with corn and roughage. Research data has indicated the optimum level of DGS use in feedlot cattle to range from approximately 15-35 percent of the dry matter feed intake. However, diets with 40 percent DGS or higher are currently being used as economics dictate those levels in least-cost formulation. Cattle on these diets will excrete higher levels of nitrogen and phosphorus in urine and feces. Phosphorus levels in the manure increase as higher levels are fed and are approximately twice that of diets without DGS. Nitrogen excretion is also higher, but much of the N in open feedlots will be volatized and NH_3 and N levels in manure for land application will have minimal changes. Although not common for cattle feedlots, deep pit facilities capture and retain more nitrogen that is excreted than open lots.

In summary, cattle fed economically optimal levels of DGS will excrete higher levels of N and P than they would with a conventional corn and roughage diet. The nutrient content of manure harvested for land application will have approximately twice the concentration of P, but N levels are not expected to change dramatically.

DGS serves as a partial replacement for soybean meal, corn, and supplemental phosphorus in diets for swine and poultry. In most current rations that include DGS, the inclusion level is less then 15 percent. However, level may increase to 20-30 percent in the future, as DGS becomes more available and economical to use in rations. Feeding swine DGS at 10 percent, along with the use of synthetic amino acid lysine to meet the pig's needs, would increase the dietary nitrogen 2-4 percent, thus producing a little change in N excretion.

At 30 percent DGS in swine finishing rations, the dietary nitrogen level would be raised by approximately 10-13 percent when high levels of synthetic lysine are utilized. Without synthetic lysine the levels would be two to three times higher. Thus, feeding DGS will increase N excretion, even if the best feed management practices available are utilized.

The availability of P in corn and soybean meal to non-ruminants is very low at 14 percent and 31 percent, respectively, but jumps approximately 77 percent in DGS. Producers can replace some or all of the supplemental mineral P by feeding DGS. As a result, dietary P levels will actually decrease 1-3 percent by feeding 10 percent DGS in swine diets. Higher DGS inclusion levels (30 percent) will increase dietary P levels, but only by 2-4 percent.

The take-home message is that using DGS in swine and poultry diets will increase the N content of both the diet and the excreted manure. However, intervention with the use of synthetic amino acids can help moderate the increase. Furthermore, the concentration of dietary and excreted P will decline when low levels are used, but will marginally increase at higher inclusion levels. Because most swine are raised in deep-pit facilities, more nitrogen will be captured and retained in the manure for land application.

Implications for Management, Regulations and Recommendations

Feeding DGS will affect the amount of nutrients excreted in livestock and poultry manure. Nitrogen and phosphorus excretion will be higher in cattle but have small differences in hogs and poultry. Swine manure nutrient plans will change a little. Inclusion rates are small and when diets are properly formulated, excreted nutrients change relatively little. The manure may be slightly more valuable because it will have more nitrogen relative to phosphorus and more closely match the requirements of crops. Manure nutrient plans for open lot beef and dairy cattle will require more acres if they are P-based because there is now a higher level of P in the manure. In fact, the acreage needed may double. Manure nutrient plans for confinement barn beef and dairy cattle may require more acres for N-based plans due to greater N in the manure. The value of the manure also increases because there is more total P which has value for crop production. This should

improve the opportunities for marketing manure to crop farmers who currently use commercial fertilizers. Tools exist to help producers evaluate the economics of manure management and valuing nutrients.

There are two places where regulations and recommendations should be revisited due to increased DGS feeding.

- First, is the use of book values for nutrient concentrations in manure for regulations or nutrient planning appropriate? Book values for dairy and beef based on rations without DGS will underestimate the P and N in the manure compared to those with DGS. Developing additional book values for rations with DGS is impractical because there are over a dozen different corn co-products with differing levels of nutrients and producers will use a wide range of inclusion levels in their diets. For strategic nutrient planning decisions such as land requirements to utilize manure nutrients, procedures must account for dietary intake and performance of livestock following procedures established by ASABE standard on manure characteristics (ASABE, 2006).

- For annual nutrient planning decisions such as application rates, it is better to use actual manure samples specific to the feeding program utilized by the Animal Feeding Operation. Volatile swings in price of corn and DGS, availability of DGS, and new research for expanding DGS use are likely to influence DGS inclusion in diets. Manure samples and planned application rates that reflect current diets will be needed. Regulatory NMPs that "lock-in" application rates for a five-year period will result in manure nutrients being over- and under-applied when not tied to dietary decisions. NRCS and regulatory policy should promote NMP processes that encourage producers to review and possibly modify proposed application rates based upon the most recent manure and soil samples.

- Second, because manure will be higher in P, it will be technically challenging and costly to apply a one-year rate of manure with current technology. Application of a one-year P requirement for a crop versus a four-year P requirement for a crop rotation will potentially add manure application costs equivalent to the historical average cattle feeding profits. Regulatory decisions on P-based rates are likely to have a very significant impact on the overall economics of beef cattle production in the Heartland region. These costs will need to be balanced against the environmental risks of higher P-based application rates. The Heartland region 2004 round-table discussion and resulting publication on phosphorus management in cropping systems concluded that there was no likely environmental benefit to applying manure at single-year crop phosphorus removal rates (Wortmann, et al., 2005). Thus, applying a one-year rate versus multiple year rates of P at one pass should be carefully evaluated in future NRCS and regulatory policy.

While not currently regulated, the increased use of DGS may accelerate the discussion of air emission regulations for open-lot production systems. Ammonia emissions are getting a lot of attention from the public. Additional excreted N is typically released as ammonia from open cattle feedlots because of the extended storage in manure on the open lot surface. Field data from six Nebraska feedlots suggest that only about 20 percent of additional excreted N is captured as the feed ration increases in N (Kissinger et al., 2007). If volatilized N for a corn-based ration is 50 percent, it would be reasonable to estimate an approximate 80 percent increase in ammonia volatilized. Thus, higher N excretion in manure from cattle fed DGS will result in higher ammonia emissions, all else equal.

Summary

The rapid increase in corn-based ethanol production is having significant implications for agriculture. Corn prices have increased, more land is being planted to corn, and input use is intensifying. Higher corn prices have implications for livestock and poultry producers in the form of higher feed costs. While animal production is expected to decrease in light of the higher costs, the availability of DGS, particularly near ethanol plants, is expected to sustain animal agriculture in the Heartland region.

Inclusion rates of corn co-products in diets will differ with the animal type, but are expected to be relatively low for swine and poultry and higher for beef and dairy cattle. Distillers grains with solubles are higher in N and P; subsequently nutrients excreted in the manure are affected. Thus, the nutrient management plans for land application should be revisited. Beef and dairy manure nutrients will be significantly higher in P while swine manure will change relatively little.

The manure nutrient planning process that is based on manure samples or excretion models need not change when DGS is fed. However, nutrient plans based on book values for manure from livestock not fed DGS will underestimate nutrient levels in the manure.

Strategic nutrient plans that do not reflect animal diet will underestimate land access needs of a livestock operation. Annual plans not easily adjusted to the most current soil and manure samples will result in over- and under-applications of nutrients. Because of the higher concentration of phosphorus in cattle manure, single-year application may not be practical and multi-year manure application should be considered. Ammonia emissions from cattle feedlots feeding DGS will also be potentially higher than non-DGS lots and may accelerate the discussion on emission regulations.

References

ASABE, 2006. *Manure production and characteristics.* March 2005. In ASABE Standards 2006. St. Joseph, MO.

Cassman, Kenneth, Vernon Eidman, and Eugene Simpson. *Convergence of Agriculture and Energy: Implications for Research and Policy.* CAST Commentary QTA2006-3 November 2006. Council for Agricultural Science and Technology: *www.cast-science.org*

Kissinger, W. F., Koelsch, R. K., Erickson, G. E., and Klopfenstein, T. J. 2006. *Characteristics of manure harvested from beef cattle feedlots.* Applied Engineering in Agriculture.

Wortmann, Charles S, Matt Helmers, Antonio Mallarino, Charles Barden, Dan Devlin, Gary Pierzynski, John Lory, Ray Massey, John Holz, Charles Shapiro, and John Kovar. *Agricultural Phosphorus Management and Water Quality Protection in the Midwest.* Heartland Water Quality Bulletin, 2005 University of Nebraska–Lincoln Extension, RP187.

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.