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Distillers Grains and Livestock are Important to Ethanol Energy and Greenhouse Gas Balance

Virgil R. Bremer
University of Nebraska - Lincoln, vbremer2@unl.edu

Adam J. Liska
University of Nebraska - Lincoln, aliska2@unl.edu

Haishun S. Yang
University of Nebraska - Lincoln

Daniel T. Walters
University of Nebraska - Lincoln, dwalters1@unl.edu

Galen E. Erickson
University of Nebraska - Lincoln, gerickson4@unl.edu

See next page for additional authors

Authors
Virgil R. Bremer, Adam J. Liska, Haishun S. Yang, Daniel T. Walters, Galen E. Erickson, Terry J. Klopfenstein, Richard K. Koelsch, and Kenneth G. Cassman

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Virgil R. Bremer
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Terry J. Klopfenstein
Rick K. Koelsch
Kenneth G. Cassman[1]

Summary

A life cycle assessment of the impact of distillers grains plus solubles (DGS) on mitigation of energy and greenhouse gas (GHG) emissions comparing corn ethanol to gasoline demonstrates the importance of feeding wet DGS (WDGS) to feedlot cattle to optimize the environmental benefit of ethanol production relative to gasoline. Ethanol produced in Nebraska has a superior environmental impact compared to ethanol produced in Iowa or Texas.

Introduction

An accurate understanding of the energy and greenhouse gas balance of ethanol production is needed to compare the environmental impact of ethanol vs. gasoline production. Utilization of distillers grains plus solubles (DGS) is an important part of this system. Biological studies have shown DGS to be an excellent livestock feed replacing corn, urea, and soybean meal in livestock diets. When DGS is fed, energy and GHG credit is given to ethanol production due to lesser need for corn, urea, and soybean meal in livestock feed.

Calculating the displacement credit requires identification of the energy efficiency of corn production for both ethanol production and cattle feeding, the amount of heat energy needed to process DGS at the ethanol plant, and the differences in livestock performance when cattle are fed DGS instead of corn. These variables indicate the related fossil fuel energy and GHG emissions savings that result from not producing the displaced feeds.

Irrigation energy input and corn yield are main factors in calculating corn production efficiency. Higher yielding Iowa rain-fed corn is less energy intense than Nebraska-grown corn. In addition, Texas corn requires more irrigation and has lower yields than Nebraska corn. Therefore, the relative corn production efficiency is greatest for Iowa, intermediate for Nebraska, and least for Texas.

A major life-cycle efficiency determinant is ethanol plant co-product energy and GHG efficiency. All plants produce wet DGS; however, some plants must dry the DGS for livestock use if livestock are not in close proximity to the ethanol plant. Producing dry DGS (DDGS; 10% moisture) requires 170% the energy to produce wet DGS (WDGS; 68% moisture). Modified DGS (MDGS; 55% moisture) production requires an intermediate amount of energy input.

Depending on the livestock class, different traditional feeds are replaced when DGS is added to the diet. Corn and urea are replaced in feedlot diets. Corn and soybean meal are replaced in swine grow-finish diets and lactating dairy cow diets. Energy requirements for corn and soybean meal are based on corn and soybean production energy from cropping inputs; urea production energy is mainly from natural gas use.

Feedlot steers have improved performance when fed DGS relative to traditional corn diets (*2008 Nebraska Beef Report*, pp. 35-36). Therefore, one unit of DGS DM will replace more than one equal unit of diet components. Feedlot steers also are fed fewer days to reach the same end point as corn fed steers. Therefore, they emit methane fewer days. The type of DGS fed influences feedlot steer performance. Because steers fed WDGS perform better than steers fed DDGS or MDGS, a unit of WDGS DM will replace more corn and urea than a similar DM unit of DDGS or MDGS. When finisher swine and dairy cattle are fed DGS, performance is similar to corn-based diets. In the swine and dairy diet, one unit of DGS replaces one equal unit of combined corn and soybean meal, but with no additional performance response like that exhibited by feedlot steers. The inability to handle wet feeds in commercial production barns prevents swine producers from utilizing WDGS.

The GHG emissions of corn produced in Nebraska and Texas are 111% and 172% of Iowa, respectively (Table 3), due to irrigation and yield differences. Iowa mainly produces DDGS, while Nebraska mainly produces wetter forms of DGS, and Texas produces only WDGS. As a result, Iowa has the highest energy input to process DDGS. The swine industry is the main DGS user in Iowa. The feedlot industry is the main user of DGS in Nebraska and Texas.

In the current study, the quantifiable differences described above were modeled as part of a corn-ethanol life cycle assessment model to evaluate the impact of feeding DGS on the energy balance and GHG emissions mitigation potential of corn ethanol compared to gasoline.

Procedure

A model was developed to evaluate the energy and GHG emissions from corn-ethanol production (www.bess.unl.edu). The Biofuel Energy Systems Simulator Model (BESS) integrated the energy and GHG emissions from corn production, ethanol plant operation, and credit due to feeding DGS to livestock. Incorporated into the BESS model were differences in energy efficiency and GHG balance of corn production for ethanol production and cattle feeding; the amount of heat energy needed to process DGS at the ethanol plant; and the differences in

Table 1. Energy and greenhouse gas (GHG) balance of Nebraska ethanol production when feeding DDGS, MDGS, or WDGS to feedlot steers[1].

	DDGS	MDGS	WDGS
Corn production state	NE	NE	NE
Livestock class	Beef	Beef	Beef
Biorefinery energy use, MJ/L EtOH	8.3	6.6	4.9
DGS energy savings, MJ/L EtOH[2]	3.2	3.0	3.5
DGS GHG credit, gCO_2e/MJ EtOH[2,3]	17.7	15.7	20.9
GHG reduction, % less than gasoline[4]	47.1	50.1	60.1

[1]DDGS = dried distillers grains plus solubles; MDGS = modified distillers grains plus solubles; WDGS = wet distillers grains plus solubles; NE = Nebraska; DGS = distillers grains; EtOH = ethanol.
[2]Assumes 20% of diet DM is DGS. Improved cattle performance increases the credit.
[3]The calculation of gCO_2e is g CO_2 + (25 x g CH_4) + (298 x g N_2O).
[4]Incorporates the GHG balance of corn production, ethanol plant energy use, and DGS credit due to cattle feeding relative to gasoline GHG emissions.

Table 2. Energy and greenhouse gas (GHG) balance of Midwest ethanol production when feeding DDGS to beef, dairy, or swine[1].

	Beef	Dairy	Swine
Corn production	---------------------Midwest---------------------		
Co-product	----------------------DDGS----------------------		
DGS energy savings, MJ/L EtOH[2]	2.7	1.5	1.5
DGS GHG credit, gCO_2e/MJ EtOH[2,3]	18	11.7	11.5
GHG reduction, % less than gasoline[4]	47	41.2	40.9

[1]DDGS = dried distillers grains plus solubles; DGS = distillers grains; EtOH = ethanol.
[2]Assumes 20%, 10%, and 9% of diet DM is DDGS for beef, dairy, and swine, respectively.
[3]The calculation of gCO_2e is g CO_2 + (25 x g CH_4) + (298 x g N_2O).
[4]Incorporates the GHG balance of corn production, ethanol plant energy use, and DGS credit due to livestock feeding relative to gasoline GHG emissions.

Table 3. Energy and greenhouse gas (GHG) balance of Iowa, Nebraska, and Texas ethanol production systems when feeding DGS to beef, dairy, and swine industries within the respective state[1].

	IA	NE	TX
Corn production, gCO_2e/kg corn[2]	274	308	473
Biorefinery energy, MJ/L EtOH	7.6	5.7	4.9
Co-product type produced[3]			
DDGS, % of co-product DM	72	14	0
MDGS, % of co-product DM	14	19	0
WDGS, % of co-product DM	14	67	100
Livestock classes fed[3,4]			
Beef, % of DGS production	18	74	97
Dairy, % of DGS production	10	2	3
Swine, % of DGS production	72	24	0
DGS Energy Savings, MJ/L EtOH	1.5	3.1	5.1
DGS GHG credit, gCO_2e/MJ EtOH[2]	12	18.4	28.3
GHG reduction, % less than gasoline[5]	47.2	55.3	48.8

[1]DGS = distillers grains; EtOH = ethanol; DDGS = dried distillers grains plus solubles,.
[2]The calculation of gCO_2e is g CO_2 + (25 x g CH_4) + (298 x g N_2O).
[3]Co-product production and livestock class profiles are based on survey data, National Agricultural Statistics Service data, and personal communication with knowledgeable sources.
[4]Assumes 20%, 10%, and 9% of diet DM is DDGS for beef, dairy, and swine, respectively.
[5]Incorporates the GHG balance of corn production, ethanol plant energy use, and DGS credit due to livestock feeding relative to gasoline GHG emissions.

performance of livestock fed DGS instead of traditional feeds.

Three scenarios were evaluated to determine the energy and GHG balance of ethanol relative to gasoline: 1) the effects of feeding Nebraska WDGS, MDGS, or DDGS to feedlot steers; 2) the effects of feeding Midwest DDGS to beef, dairy, or swine; 3) the effects of Iowa, Nebraska, and Texas ethanol production systems.

Results

Table 1 summarizes the energy and GHG balance for feedlot steers. Feeding wetter forms of DGS improved the energy and GHG balance. An ethanol plant producing DDGS decreased energy use by 41% when switching to WDGS production. The benefits to the ethanol plant and the feedlot of feeding WDGS instead of DDGS represented a 28% improvement in the GHG reduction potential of ethanol relative to gasoline. The benefit of feeding MDGS was intermediate to the benefits of feeding WDGS and DDGS.

Feeding DDGS to feedlot steers instead of dairy cows or grow-finish pigs improved the energy and GHG credit associated with DGS (Table 2), which resulted in a 15% improvement in the GHG emissions reduction potential of ethanol production associated with feedlots vs. swine or dairy production operations.

The Texas, Iowa, and Nebraska production systems had differing DGS energy and GHG balances due to the different types of DGS produced and fed (Table 3). Texas had the greatest number of DGS credits because more energy-intense corn was replaced by DGS. The most important calculation was the overall GHG reduction potential of the whole corn, ethanol, and livestock system relative to gasoline. In Nebraska, GHG emissions relative to gasoline were improved by 17% and 13% relative to Iowa and Texas, respectively. The balance of moderate corn production energy requirement with WDGS feeding to feedlot steers offered the optimum energy and GHG balance of DGS fed to livestock.

[1]Virgil R. Bremer, research technician, Animal Science, University of Nebraska, Lincoln, Neb.; Adam J. Liska, assistant professor, Daniel T. Walters, professor, Agronomy & Horticulture, UNL; Galen E. Erickson, associate professor, Terry J. Klopfenstein, professor, Animal Science, UNL; Rick K. Koelsch, associate professor, Biological Systems Engineering, UNL; Kenneth G. Cassman, director, Nebraska Center for Energy Sciences Research, UNL; Haishun S. Yang, Monsanto, St. Louis, Mo.