2010

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 Yang  
*University of Nebraska-Lincoln*, hyang2@unl.edu

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*

Follow this and additional works at: [https://digitalcommons.unl.edu/animalscinbcr](https://digitalcommons.unl.edu/animalscinbcr)

Part of the Animal Sciences Commons

[https://digitalcommons.unl.edu/animalscinbcr/551](https://digitalcommons.unl.edu/animalscinbcr/551)

This Article is brought to you for free and open access by the Animal Science Department at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Nebraska Beef Cattle Reports by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.
Authors
Distillers Grains and Livestock are Important  
to Ethanol Energy and Greenhouse Gas Balance

Virgil R. Bremer  
Adam J. Liska  
Haishun S. Yang  
Daniel T. Walters  
Galen E. Erickson  
Terry J. Klopfenstein  
Rick K. Koelsch  
Kenneth G. Cassman1

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% of 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...
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.

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

<table>
<thead>
<tr>
<th></th>
<th>DDGS</th>
<th>MDGS</th>
<th>WDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Corn production</strong></td>
<td>NE</td>
<td>NE</td>
<td>NE</td>
</tr>
<tr>
<td><strong>Livestock class</strong></td>
<td>Beef</td>
<td>Beef</td>
<td>Beef</td>
</tr>
<tr>
<td><strong>Biorefinery energy use, MJ/L EtOH</strong></td>
<td>8.3</td>
<td>6.6</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>DGS energy savings, MJ/L EtOH</strong></td>
<td>3.2</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>DGS GHG credit, gCO₂e/MJ EtOH</strong></td>
<td>17.7</td>
<td>15.7</td>
<td>20.9</td>
</tr>
<tr>
<td><strong>GHG reduction, % less than gasoline</strong></td>
<td>47.1</td>
<td>50.1</td>
<td>60.1</td>
</tr>
</tbody>
</table>

1DDGS = dried distillers grains plus solubles; MDGS = modified distillers grains plus solubles; WDGS = wet distillers grains plus solubles; NE = Nebraska; DGS = distillers grains; EtOH = ethanol.
2Assumes 20% of diet DM is DGS. Improved cattle performance increases the credit.
3The calculation of gCO₂e is g CO₂ + (25 x g CH₄) + (298 x g N₂O).
4Incorporates 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.

<table>
<thead>
<tr>
<th></th>
<th>Beef</th>
<th>Dairy</th>
<th>Swine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Corn production</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Co-product</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DGS energy savings, MJ/L EtOH</strong></td>
<td>2.7</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>DGS GHG credit, gCO₂e/MJ EtOH</strong></td>
<td>18</td>
<td>11.7</td>
<td>11.5</td>
</tr>
<tr>
<td><strong>GHG reduction, % less than gasoline</strong></td>
<td>47</td>
<td>41.2</td>
<td>40.9</td>
</tr>
</tbody>
</table>

1DDGS = dried distillers grains plus solubles; DGS = distillers grains; EtOH = ethanol.
2Assumes 20%, 10%, and 9% of diet DM is DDGS for beef, dairy, and swine, respectively.
3The calculation of gCO₂e is g CO₂ + (25 x g CH₄) + (298 x g N₂O).
4Incorporates 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.

<table>
<thead>
<tr>
<th></th>
<th>IA</th>
<th>NE</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Corn production, gCO₂e/kg corn</strong></td>
<td></td>
<td></td>
<td>274</td>
</tr>
<tr>
<td><strong>Biorefinery energy, MJ/L EtOH</strong></td>
<td>7.6</td>
<td>5.7</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Co-product type produced</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDGS, % of co-product DM</td>
<td>72</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>MDGS, % of co-product DM</td>
<td>14</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>WDGS, % of co-product DM</td>
<td>14</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td><strong>Livestock classes fed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef, % of DGS production</td>
<td>18</td>
<td>74</td>
<td>97</td>
</tr>
<tr>
<td>Dairy, % of DGS production</td>
<td>10</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Swine, % of DGS production</td>
<td>72</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td><strong>DGS Energy Savings, MJ/L EtOH</strong></td>
<td>1.5</td>
<td>3.1</td>
<td>5.1</td>
</tr>
<tr>
<td><strong>DGS GHG credit, gCO₂e/MJ EtOH</strong></td>
<td>3.5</td>
<td>18.4</td>
<td>28.3</td>
</tr>
<tr>
<td><strong>GHG reduction, % less than gasoline</strong></td>
<td>47.2</td>
<td>55.3</td>
<td>48.8</td>
</tr>
</tbody>
</table>

1DDGS = distillers grains; EtOH = ethanol; DGS = dried distillers grains plus solubles.
2Assumes 20%, 10%, and 9% of diet DM is DGS for beef, dairy, and swine, respectively.
3The calculation of gCO₂e is g CO₂ + (25 x g CH₄) + (298 x g N₂O).
4Co-product production and livestock class profiles are based on survey data, National Agricultural Statistics Service data, and personal communication with knowledgeable sources.
5Assumes 20%, 10%, and 9% of diet DM is DGS for beef, dairy, and swine, respectively.
6Incorporates the GHG balance of corn production, ethanol plant energy use, and DGS credit due to livestock feeding relative to gasoline GHG emissions.

© The Board of Regents of the University of Nebraska. All rights reserved.