SUSTAINABLE FOOD LAB

PRACTICAL FARMERS of Iowa

Greenhouse Gas Outcomes of Inclusion of Oats in Finishing Beef Rations

Sustainable Food Lab and Practical Farmers of Iowa

November 2021

Table of Contents

Background

Oats grow well in Iowa and have multiple purposes: to sell as food-grade grain, livestock feed, or cover crop seed. The state of Iowa used to be the number one oat-producing state, with over six million acres of oats grown in 1950 when oats were a common feed source for livestock. Over the last 70 years, corn has replaced oats in livestock feed, and corn acres have replaced oat acres. In 2020, only 73,000 acres of oats were grown in Iowa and today the state's row crop agricultural system is dominated by 2 crops - corn and soybeans.[1]

Because livestock feed is a primary driver of what crops are grown in the Midwest, reintroducing oats into livestock feed rations would generate demand for more oat acres. More oat acres in the Midwest would diversify the typical 2-crop corn and soybean system and provide soil health and water quality benefits. Growing oats and other small grains as part of a diversified 3-crop system helps farmers control input costs, as small grains can be grown in conjunction with nitrogen-fixing legumes that serve as a biological source of fertilizer. A diversity of crops in rotation also offers farmers biological risk management by breaking pest and weed cycles.

Many leading food and beverage companies have published regenerative agriculture goals and committed to Science Based Targets to reduce greenhouse gas (GHG) emissions in their beef and dairy supply chains. Diversification of the corn and soybean 2-crop system with a small grain is a key farm management practice that can unlock regenerative agriculture outcomes and GHG reductions.

The primary drivers of GHG emissions in beef and dairy supply chains are: 1) emissions associated with the production of feed, 2) enteric methane production from digestion in the rumen of the cow, and 3) the volume of manure solids produced and resulting emissions from storage and treatment of manure.[2] In 2020, a feeding trial was designed to address the first of these GHG drivers: incorporating low-carbon crops into livestock feed. The feeding trial was designed by Practical Farmer of Iowa and the Sustainable Food Lab and partially sponsored by McDonald's Corporation.

Couser Cattle Company Oat Inclusion Feeding Trial

The feeding trial was designed to test two things: one, the ability to feed a small grain ration (e.g. oats) to cattle and achieve the same performance as a standard corn-based ration; and two, whether incorporating a small grain could reduce GHG emissions from feed production.

The feeding trial partnered with Bill Couser in Iowa to test the inclusion of oats into cattle feed rations. Bill Couser owns and operates Couser Cattle Company in Nevada, Iowa, where he finishes 10,000 cattle and grows 5,000 acres of corn and soybeans annually. Couser understood that adding oats into a corn and soybean crop rotation could improve soil health and water quality, as well as reduce input costs, so he was interested in testing how his cattle performed on oats.

From summer 2020 to spring 2021, Couser evaluated the performance of finisher cattle fed a total mixed ration including oats (referred to as TMR-OAT) as compared to a standard, corn-dominated total mixed ration (referred to as TMR). See **Table A1 in the appendix** for ration details. As a control group, he fed 746 beef cattle the standard TMR for 230 days, from June 2020-February 2021. He fed a test group of 536 beef cattle the TMR-OAT ration for 205 days, from July 2020-March 2021. The feed intake and cattle performance data were tracked and compared between the two groups.

The main conclusions from the feeding trial were:[3]

- **Equal Performance**: Finishing beef cattle fed a TMR-OAT with a 22% oat inclusion rate gained the same as cattle fed a standard, corn-dominated total mixed ration. Meat quality, animal performance and morbidity rates were no different between rations.
- **Oat Ration More Expensive**: The feed cost to finish cattle was greater with the TMR-OAT than with the standard TMR. This was a result of two factors. One, at the time of the trial, oats cost 12 cents per pound compared to corn at 8 cents per pound.[i] Two, cows need to eat almost twice as many oats to gain at the same rate as corn.

For more details on trial conclusions regarding cattle performance and costs see the trial report; *Inclusion of Oats in Finishing Beef Rations*.

GHG Emissions at the Farmgate

The feeding trial also aimed to test whether incorporating a small grain into the diet could reduce GHG emissions from feed production. This analysis was conducted using the Cool Farm Tool (CFT)[4] to assess GHG emissions per kg of beef across the different feed rations. It examines a year one scenario that incorporates oats grown with a red clover cover crop into the ration, a year two scenario where Low-Carbon Corn follows the oats and red clover and is incorporated into the ration, and a combined two-year scenario.

Year One Analysis

Traditionally, lifecycle assessments evaluate the energy, calories or GHG emissions for the production of feed and management of livestock during a growing season. If we look at the GHG emissions of the standard, corn-dominated TMR diet compared to the 22% oat inclusion rate TMR-OAT diet in a one-year period, the TMR-OAT diet had a higher emission factor (EF) by 3.6% (**Table 1**).

[i] Based on 2020 prices for Oats ($3.97/bushel) and Corn ($4.37/bushel)

TABLE 1. Year One comparison of emission factors (EF) of TMR and TMR-OAT diets.			
	TMR (kg CO_2e / kg finished beef)	**TMR-OAT (kg CO_2e / kg finished beef)**	**%CHANGE**
Feed	2.45	2.44	-0.4%
Enteric	3.97	4.11	3.4%
Manure	0.85	0.99	16.0%
Total	7.28	7.54	3.6%

This is due to three factors. Firstly, the feed EF between TMR (2.45) and TMR-OAT (2.44) is relatively comparable despite the fact that oats are a lower GHG emitting crop than corn. Growing one acre of oats requires on average 74% less N fertilizer than growing one acre of corn.[ii] However, one acre of oats produces fewer pounds per acre than corn. Oats are less energy dense than corn, resulting in more pounds of oats required to feed cattle to achieve the same rate of gain as a standard corn diet.

The second factor is that feeding cattle a TMR-OAT diet resulted in a 3.4% increase in enteric and manure emissions compared to the standard TMR. Oats contain a higher amount of fiber than corn, resulting in less soluble digestible energy and greater methane production. A greater volume of manure solids is also produced in the TMR-OAT due to the fiber content and increased volume of oats required in the diet.

The third factor is that this comparison only considers GHG emissions without accounting for GHG sequestration. When oats are incorporated into the crop rotation, it becomes possible to plant a red clover cover crop that fixes nitrogen in the soil and sequesters carbon.[5] When this sequestration benefit is considered, the analysis shows a reduced EF associated with feed in the TMR-OAT ration, ultimately resulting in a 2.3% lower total EF than the TMR diet (**Table 2**).

TABLE 2. Year One emission factor (EF) comparison of TMR + TMR-OAT diets with carbon sequestration included.			
	TMR (kg CO_2e / kg finished beef)	**TMR-OAT (kg CO_2e / kg finished beef)**	**%CHANGE**
Feed	2.45	2.01	-18.1%
Enteric	3.97	4.11	3.4%
Manure	0.85	0.99	16.1%
Total	7.28	7.11	-2.3%

Year Two Analysis

While traditional lifecycle assessments take a one-year view, many of the benefits that accrue to the landscape from incorporating small grains into the rotation can only be accounted for over a two-year time frame. As referenced above, oats planted with a legume cover crop such as red

[ii] Typical N rates from PFI farm production data (40 lb N/acre applied to oats; 155 lb N/acre applied to corn)

clover provide a source of biological nitrogen to the soil. That fixed nitrogen is then available to be taken up by a subsequent corn crop.

Figure 1 portrays a conventional 2-crop system (corn-soybean rotation) with a diversified 3-crop system (small grain-corn-soybean rotation) over a 3-year period. The planting and harvest timing of a small grain crop like oats enables the establishment of a red clover cover crop before the corn.

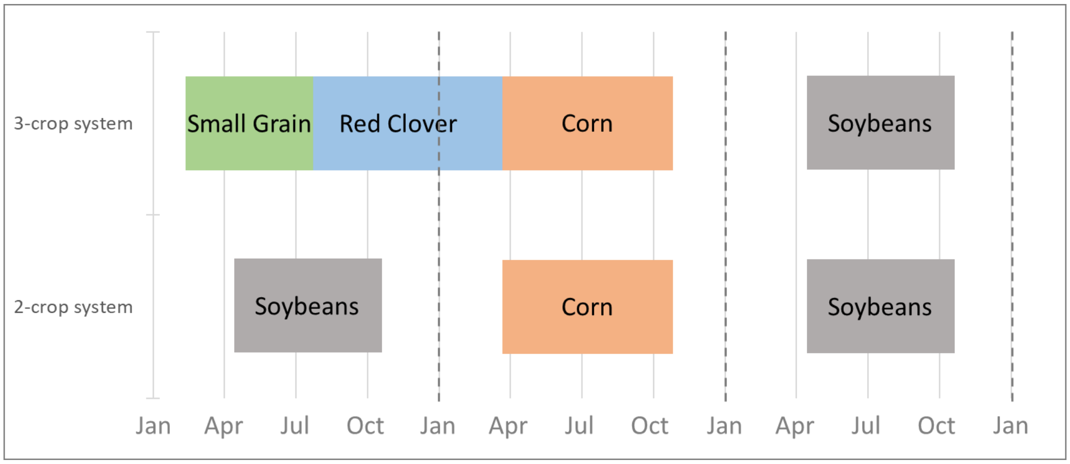

Fig 1

Figure 1. Conventional 2-crop system vs. Diversified 3-crop system.

The red clover cover crop fixes nitrogen in the soil and as a result, the subsequent corn crop can be grown with a reduced application of synthetic fertilizer. On average, growers apply 155 pounds of nitrogen per acre to corn.[iii] Synthetic nitrogen application is the biggest source of GHG emissions in corn production.[6,7] Displacing synthetic nitrogen with farmer-grown nitrogen results in a substantial decrease in GHG emissions associated with growing corn. Incorporating a nitrogen-fixing cover crop, like red clover, before corn would enable farmers to apply at least 40 pounds less nitrogen per corn acre and up to 105 pounds less nitrogen per corn acre without sacrificing yield.[8–10] This results in "Low-Carbon Corn" (LCC) when compared to conventional corn produced in a two-crop system that applies 155 pounds of nitrogen per acre. The conventional corn and two ends of the N reduction range are classified as follows:

- Conventional Corn: 155 lb N applied per acre.
- Low-Carbon Corn Conservative: 40 lb N per acre reduction from the conventional corn, decreasing corn GHG emissions by nearly 16%.
- Low-Carbon Corn Optimistic: 105 lb N per acre reduction from the conventional corn, decreasing corn GHG emissions by roughly 38.5%.

In this analysis, the assumption was made that in year two cattle would be fed the standard TMR with the low-carbon corn produced in the 3-crop system. **Tables 3 and 4** compare the GHG emissions of cows fed the TMR with conventional corn versus a TMR with low-carbon

[iii] Typical N rates from PFI farm production data

corn (TMR-LCC). The tables illustrate the conservative and optimistic nitrogen reduction scenarios discussed above and its impact on overall GHG emissions.

TABLE 3. Year Two emission factor (EF) comparison of TMR and TMR-LCC diets, conservative estimates.

	TMR (kg CO_2e / kg finished beef)	**TMR-LCC CONSERVATIVE (kg CO_2e / kg finished beef)**	**% CHANGE**
Feed	2.45	2.36	-3.7%
Enteric	3.97	3.97	0.0%
Manure	0.85	0.85	0.0%
Total	7.28	7.19	-1.3%

TABLE 4. Year Two emission factor (EF) comparison of TMR and TMR-LCC Diets, optimistic estimates.

	TMR (kg CO_2e / kg finished beef)	**TMR-LCC OPTIMISTIC (kg CO_2e / kg finished beef)**	**% CHANGE**
Feed	2.45	2.23	-9.2%
Enteric	3.97	3.97	0.0%
Manure	0.85	0.85	0.0%
Total	7.28	7.05	-3.1%

The feed ingredients and composition among the rations is unchanged. The GHG emissions reductions are driven by the emissions associated with producing the corn that is included in the ration. In the conservative scenario, cows that are fed TMR with the low carbon corn have an overall GHG emissions reduction of 1.3% compared to the standard TMR (**Table 3**). In the optimistic scenario, cows that are fed TMR with the low carbon corn have an overall GHG emissions reduction of 3.1% compared to the standard TMR (**Table 4**).

Two-Year Combined Analysis

Taking a combined two-year view enables the proper accounting of whole-farm benefits that stem from incorporating a small grain like oats into the crop rotation. **Table 5** illustrates the GHG impact of TMR with conventional corn across two years and how that compares to the GHG impact of a TMR-OAT diet in year one (accounting for sequestration of the red clover cover crop) and a Conservative Low-Carbon Corn (TMR-LCC) diet in year two.

TABLE 5. Two-year emission factor (EF) comparison of TMR vs. TMR-OAT+TMR-LCC Diets, conservative estimates.			
Year 1	**TMR (kg CO_2e / kg finished beef)**	**TMR-OAT (kg CO_2e / kg finished beef)**	**%CHANGE**
Feed	2.45	2.01	-18.1%
Enteric	3.97	4.11	3.4%
Manure	0.85	0.99	16.1%
Total	7.28	7.11	-2.3%
Year 2	**TMR (kg CO_2e / kg finished beef)**	**TMR-LCC CONSERVATIVE (kg CO_2e / kg finished beef)**	**% CHANGE**
Feed	2.45	2.36	-3.7%
Enteric	3.97	3.97	0.0%
Manure	0.85	0.85	0.0%
Total	7.28	7.19	-1.3%
Two-Year Total Emissions Factor	**7.28**	**7.15**	**-1.8%**

In the conservative scenario, feeding TMR-OAT and a subsequent TMR-LCC has a slight GHG net reduction of 1.8%. **Table 6** similarly compares the GHG impact of a TMR diet with conventional corn across two years to the GHG impact of a TMR-OAT diet in year one (accounting for sequestration of the red clover cover crop) and an Optimistic Low-Carbon Corn (TMR-LCC) diet in year two.

TABLE 6. Two-year emission factor (EF) comparison of TMR vs. TMR-OAT+TMR-LCC Diets, optimistic estimates.			
Year 1	**TMR (kg CO_2e / kg finished beef)**	**TMR-OAT (kg CO_2e / kg finished beef)**	**%CHANGE**
Feed	2.45	2.01	-18.1%
Enteric	3.97	4.11	3.4%
Manure	0.85	0.99	16.1%
Total	7.28	7.11	-2.3%
Year 2	**TMR (kg CO_2e / kg finished beef)**	**TMR-LCC OPTIMISTIC (kg CO_2e / kg finished beef)**	**% CHANGE**
Feed	2.45	2.23	-9.2%
Enteric	3.97	3.97	0.0%
Manure	0.85	0.85	0.0%
Total	7.28	7.05	-3.1%
Two-Year Total Emissions Factor	**7.28**	**7.08**	**-2.7%**

The optimistic scenario is more favorable, showing a 2.7% net GHG reduction across the two years combined.

GHG Emissions at the Landscape Level at Scale

While the net GHG emissions reductions at the farmgate are modest, focusing only on the farmgate overlooks the benefits that would accrue on the landscape. To illustrate the potential of this intervention, we evaluate the impact of the change in feed ration at scale across cattle in the Midwest.

Across Illinois, Indiana, Iowa, Ohio, Minnesota and Wisconsin, there are approximately 6.5 million cattle[11] that are currently being fed conventional corn produced in the typical 2-crop or 1-crop (continuous corn) system produced in the region. A standard TMR ration to finish 6.5 million cows would require approximately 2.07 million acres of corn.[iv] As noted above, incorporating oats into a TMR diet is not a one-for-one swap for corn. More oats are required to finish the same number of cattle, and oats produce fewer bushels per acre than corn. Therefore, a TMR-OAT ration to finish 6.5 million cows would require 3.95 million acres of oats.

If 3.95 million acres of oats are planted followed by a red clover cover crop, then 3.95 million acres of low-carbon corn could be produced the following year. As noted above, only 2.07 million acres of corn would be needed to finish the 6.5 million cows. Therefore, even if all the cows in the Midwest were finished on the low carbon corn, there would be 1.88 million acres of low carbon corn left in the market.

In this scenario, the supply chain (Scope 3[v]) GHG emissions benefits of this surplus of low-carbon corn would likely accrue to the other major end markets for corn and not the livestock feed sector. **Figure 2** shows the breakdown of the major markets for corn.

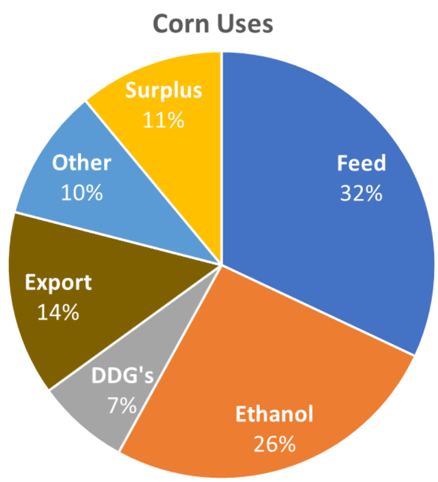

Fig 2

Figure 2. Breakdown of markets for corn.[12]

[iv] Extrapolated using the actual corn and oat cattle consumption data from the Couser feeding trial.
[v] Scope 3 emissions are the result of activities from assets not owned or controlled by the organization, but that the organization indirectly impacts in its value chain.[13]

The Scope 3 emissions benefits of this surplus low-carbon corn are sizable. **Table 7** shows the difference in GHG emissions between conventional corn grown in the typical 2-crop system and the diversified, low-carbon corn grown in the 3-crop system.

TABLE 7. Difference in GHG emissions for Conventional Corn vs. Low-Carbon Corn.

SURPLUS CORN	CONVENTIONAL CORN GHG Emissions (kg CO_2e)	LOW-CARBON CORN GHG Emissions, Conservative (kg CO_2e)	CONSERVATIVE GHG Emissions (% Change)	LOW-CARBON CORN GHG Emissions, Optimistic (kg CO_2e)	OPTIMISTIC GHG Emissions (% Change)
2,061,911 acres of corn	1,514,245,406	1,278,249,999	**-15.6%**	931,194,509	**-38.5%**

In the conservative scenario of 40 pounds of nitrogen reduction per acre, the Low-Carbon Corn realizes a 15.6% reduction in GHG emissions compared to the conventional corn. In an optimistic scenario of 105 pounds of nitrogen reduction per acre, the Low-Carbon Corn realizes a 38.5% reduction in GHG emissions compared to the conventional corn. These GHG emissions reductions are sizable (**Table 7**).

It is important to note that diversifying cropping systems would also produce benefits beyond GHG reductions. The diversified system applies several regenerative agriculture principles and would generate outcomes such as increased soil health, greater retention of water and applied chemicals, as well as farmer benefits such as reduced input costs and providing revenue buffers.

At scale, the landscape-level GHG and regenerative agriculture benefits are material. However, these benefits would not necessarily accrue to the cattle industry. If all cattle feeders were to incorporate changes to their feed rations, the cattle industry would bear the cost for the more expensive TMR-OAT diet that leads to Low-Carbon Corn on the landscape. With current GHG accounting mechanisms, the livestock industry may not be able to claim the emissions reductions of the surplus corn that is not eaten by cows. The surplus Low-Carbon Corn would be left on the landscape.

Incorporating small grains into cattle feed rations at scale is a catalyst for landscape change. Other corn buyers could benefit from reduced Scope 3 emissions, so it is reasonable to suggest that other buyers collaborate to support farmers to diversify the corn/soybean system and support producers to integrate small grains into cattle rations. If costs are shared across all industries, and not borne by the cattle industry alone, the small feeding intervention would be more commercially viable for feeders, and everyone would benefit from reduced GHG emissions.

Conclusions and Next Steps

The feeding trial successfully answered the initial question of whether cattle could achieve the same performance on an oat ration versus a standard corn ration. The TMR-OAT diet, with 22% oat inclusion, compared to a standard corn-based TMR diet resulted in no statistical difference in body weights, cattle performance or carcass quality.[3] It does cost more to finish cows on an oat ration, because oats are more expensive than corn on a pound-for-pound basis, and cows require twice as much oats to achieve the same gain as corn.

The trial also provided topline findings on the GHG emissions impact of incorporating a small grain into the feed ration to finish cattle. At the farmgate, GHG emissions are reduced when you take into account the sequestration benefits of red clover. At the landscape level across a 2-year oats-corn rotation, there is potential for at least a 16% reduction in landscape GHG emissions on the surplus low-carbon corn that is produced from this diversified system.

The Couser trial revealed that there are further areas of exploration that need to be addressed in order to activate a crop diversification strategy:

1. Understand the optimal ration that balances costs with GHG and regenerative benefits;
2. Design a market strategy and accounting methodology to account for and share costs of additional value of low carbon corn created as a result of feeding a small grain;
3. Engage the Food and Beverage, Livestock, and Ethanol industries to work together on place-based multi-user approach to investing in and sharing in the value created through this intervention.
4. Work with policymakers to incorporate this strategy into commodity programs and crop insurance.

Appendix

TABLE A1. Makeup of feeding trial rations, expressed as percent dry matter (DM).

INGREDIENTS, %	TMR	TMR-OAT
Couser Liquid	3.70	3.79
Dried Distillers Grain	34.56	33.21
Grass Hay	0.87	1.02
MOG	2.75	3.70
Oats	0.00	21.97
Optaflexx	0.04	0.05
Rolled Corn	25.10	8.08
Screenings	13.69	11.99
Water	10.08	9.99
Whole corn	9.21	6.19

Source: Inclusion of Oats in Finishing Beef Rations.[3]

References

1. US Department of Agriculture-National Agricultural Statistics Service. Quick stats. USDA-National Agricultural Statistics Service. https://quickstats.nass.usda.gov/ (accessed October 2021).
2. Rotz, C.A., S. Asem-Hiablie, S. Place and G. Thoma. 2019. Environmental footprints of beef cattle production in the United States. Agricultural Systems. 169:1–13. https://doi.org/10.1016/j.agsy.2018.11.005 (accessed October 2021).
3. Filbert, M., S. Carlson and B. Couser. 2021. Inclusion of Oats in Finishing Beef Rations. Practical Farmers of Iowa Cooperators' Program. https://practicalfarmers.org/research/inclusion-of-oats-in-finishing-beef-rations/ (accessed October 2021).
4. Cool Farm Alliance. Cool Farm Tool. https://coolfarmtool.org/ (accessed October 2021).
5. McClelland, S.C., K. Paustian and M.E. Schipanski. 2020. Management of cover crops in temperate climates influences soil organic carbon stocks: a meta-analysis. Ecological Applications. https://doi.org/10.1002/eap.2278 (accessed October 2021).
6. Camargo, G.G.T., M.R. Ryan and T.L. Richard. 2013. Energy use and greenhouse gas emissions from crop production using the farm energy analysis tool. BioScience. 63:263–273. https://academic.oup.com/bioscience/article/63/4/263/253267 (accessed April 2021).
7. Hunt, N.D., M. Liebman, S.K. Thakrar and J.D. Hill. 2020. Fossil Energy Use, Climate Change Impacts, and Air Quality-Related Human Health Damages of Conventional and Diversified Cropping Systems in Iowa, USA. Environmental Science & Technology. acs.est.9b06929. https://pubs.acs.org/doi/10.1021/acs.est.9b06929 (accessed April 2021).
8. Gaudin, A., S. Westra, C. Loucks, K. Janovicek, R. Martin and W. Deen. 2013. Improving Resilience of Northern Field Crop Systems Using Inter-Seeded Red Clover: A Review. Agronomy. 3:148–180. https://www.mdpi.com/2073-4395/3/1/148 (accessed July 2021).
9. Gailans, S. and T. Sieren. 2014. Nitrogen Replacement Value of Red Clover. Practical Farmers of Iowa Cooperators' Program. https://practicalfarmers.org/research/nitrogen-replacement-value-of-red-clover/ (accessed July 2021).
10. Sustainable Food Lab. 2020. On-Farm Data Continues to Reveal Benefits of Diverse Rotations. https://sustainablefoodlab.org/on-farm-data-continues-to-reveal-benefits-of-diverse-rotations-ghg-reductions-roots-in-the-ground-year-round-and-yield-improvements/ (accessed October 2021).
11. US Department of Agriculture-National Agricultural Statistics Service. 2019. 2017 Census of Agriculture. https://www.nass.usda.gov/Publications/AgCensus/2017/ (accessed October 2021).
12. US Department of Agriculture-Economic Research Service. 2021. Feed Grains Database. https://data.ers.usda.gov/FEED-GRAINS-custom-query.aspx (accessed October 2021).
13. US Environmental Protection Agency. 2021. Scope 3 Inventory Guidance. https://www.epa.gov/climateleadership/scope-3-inventory-guidance (accessed November 2021).

Acknowledgements

We gratefully acknowledge funding from the following organizations:

McDonald's Corporation
McKnight Foundation
USDA NRCS
Walton Family Foundation

This report was published by the Sustainable Food Lab in partnership with Practical Farmers of Iowa

For more information contact:

Carol Healy
Sustainable Food Lab
chealy@sustainablefood.org
www.sustainablefood.org

Learn more about our work to diversify the Corn Belt:
https://sustainablefoodlab.org/initiatives/smallgrains/