Greenhouse gas emissions of livestock feeding practices

MOST POLICY INITIATIVE

Executive Summary

Different livestock feeding practices generate varying levels of greenhouse gas (GHG) emissions, specifically carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions. There are limitations and benefits associated with each feeding practice. Cows and other ruminants account for about four percent of all GHG emissions produced in the United States, and proper animal grazing management systems can help mitigate these emissions.[6]

Highlights

- Baling hay involves a series of steps that generate greenhouse gas (GHG) emissions from the fuel consumption of mowing, conditioning, raking, baling, transporting and storage operations. Baling practices that allow higher hay moisture can help decrease the miles spent on the field.
- Cover crops have beneficial effects on soil health, C sequestration, and environmental quality parameters, but may also increase CO_2 emissions compared to no cover crops and have a variable effect on N_2O emissions.
- When agricultural production and feeding management practices are combined, livestock can contribute to the reduction of carbon emissions, while helping enhance soil fertility.
- Cover crops can provide winter forage for livestock, replacing purchased or stored winter feed and can result in an average $40/acre/year in net benefit. When long-term cover crop benefits are included in the calculations the average net benefit is $135/acre/year.
- GHG emissions of the different feeding practices vary based on the cover crop species, the quality and quantity of biomass residue and how the residue is placed in the soil, but grazed and ungrazed cover crops tend to show no difference in GHG emissions.

Limitations

- The effects of baling hay and grazing vs. non-grazing cover crops on GHG emissions are unclear.
- Although cover crops can enhance soil health and environmental quality through increased carbon and nitrogen cycling, their exact effects on GHG emissions still remain unknown.
- Because of the diversity of factors that influence emissions of CO_2 and N_2O, it is difficult to identify practices that deliver overall mitigation of GHG emissions.

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Research Background

Baling hay as a feed source

Hay is a feed source for ruminant animals (e.g., cows), and may include only grass (e.g., alfalfa), legumes (e.g., clover), or a mix of the two. Ruminant animals have to eat primarily forages (such as hay) in order to stay healthy, and may eat grains, such as corn and soybean, to complement their diet.

After hay is cut and dried, it is baled with wire, twine, or plastic wrap (baleage) to be stored or easily transported. Afterwards, bales are hauled, stored in a grid pattern, and then hauled back when needed to be fed to the animals. This procedure tends to be expensive, not just due to growing, harvesting, cutting and baling, but also the hauling and storage processes.

Baling hay effects on GHG emissions

Baling hay involves a series of steps that generate greenhouse gas (GHG) emissions from the fuel consumption of mowing, conditioning, raking, baling, transporting and storage operations. A typical way to monitor how much GHG haymaking generates is by collecting data on machine capacity, fuel consumption, and dry matter yield.[5]

Generally, hay in small rectangular shapes can be baled with 22% moisture to keep molding and heating to a minimum, but because large round bales retain internal heat much longer, they need to stay out in the field for longer, until moisture is at least 18-15%. However, weather, availability of equipment and labor, and other determinants may not allow all hay to be wrapped at the same time. Letting hay sit unwrapped on the field for longer periods of time can lead to greater reductions in nutrients, thickness, oxygen levels, and overall hay quality.[5]

Wrapping hay with baleage (at least 6 layers of plastic wrap) allows the hay moisture to range to be higher from 25–70% and can reduce the delays of the hay making process. Baleage may reduce the overall trips to the field mainly because hay can be baled without waiting, resulting in fewer weather delays, less wilting time, less storage loss, and less feeding loss. Finally, because baleage eliminates the need to spray preservatives on the hay, this may further reduce the trips to the field and the related GHG emissions.

Cover crops

Cover crops are planted to cover the soil and are intended to be left in the field as green manure or a surface mulch before the next crop is planted.[8] Cover crops can help manage soil erosion, improve soil fertility, water quality, and pest and weed management, while maintaining or enhancing crop yield and reducing costs.[7,8] Moreover, cover crops may provide opportunities to use cropped land for grazing livestock or to produce a harvested feed source in the form of haylage.

Cover crops for grazing

Livestock grazing of cover crops can further recycle nutrients back into the soil through manure. Systems that allow livestock and crops to complement each other in rotation, or in succession can be referred as "integrated farming (IF) systems".[9] IF systems that allow cover crop grazing enhance the health of the soil through onsite nutrient retention, and late-season grazing can provide significant cost savings to producers by minimizing the need for baled forages.[10,11,19]

<u>Bale grazing and harvesting on cover crops</u>

If directly grazing on cover crops is not an option, baling cover crops may be a good way of preserving them. Harvested cover crops for haylage can provide a nutrient-rich winter feed, and can be transported like regular hay is, or can be used for bale grazing during a cool-season as a forage option. This feeding practice, also called windrow grazing, can decrease the GHG emissions that come from the transportation of the bales to the ranches. The decrease in emissions comes only from the feedstock side, since the livestock will need to be transported to the field, if not living on the same site where cover crops grow.

Grazing cover crops effects on GHG emissions

According to research done by North Dakota University on grazing options in the Northern Plains, grazing cover crops can increase the fertility of the soil and aggregate stability of the soil particles, while improving infiltration of water. Grazing livestock can decrease emissions due to less labor and fossil fuel use associated with hauling manure and feeding cattle in regular, dry lots.[11] Studies have found that when agricultural production and feeding management practices are combined, large quantities of GHG emissions can be mitigated, while enhancing soil fertility.[1]

Another study, which collected and analyzed data between 2014-2018 from eight farms in Minnesota and Iowa, assessed the effects of grazing diverse cover crops with cattle under adaptive, high stock density management. Seven out of the eight farms showed higher total living microbial biomass in the grazing cover crops plots compared to plots without cover or grazing. The farms saw an average grazing cover crop management cost of $83/acre/year (including seed, seeding, termination, fencing, and watering expenses) and an average forage benefit of $123/ acre/year (based on estimated avoided forage purchases). Lastly, when long-term benefits associated with the use of cover crops were added to the forage benefits (for example, reduced soil erosion, improved soil fertility, and increased water storage), the average gross benefit was $216/acre/year, with a net benefit of $135/acre/year.[19]

Researchers who study integration of animal feeding operations and long-term sustainability suggest that integrating crop pasture and livestock can be mutually beneficial to each other and that the integration can play a fundamental role in mitigating negative environmental impacts. Although concrete research is lacking, researchers also indicate that the integration of the two reduces the CO_2 emissions.[12,17] The diversity of factors that influence emissions of GHGs in farming systems and feeding management practices can make it difficult to identify strategies that could deliver overall mitigation for GHG emissions.[2,18]

Additional considerations on GHG emissions

Different cover crops generate different emissions of CO_2 and N_2O based on the quality and quantity of biomass residue, the termination dates for the crops, and how the residue is placed in the soil. Because of the diversity of factors that influence GHG emissions, it is difficult to identify practices that deliver overall mitigation. However, some of the things we know about CO_2 and N_2O emissions from grazing on cover crops are: (1) CO_2 emissions are directly influenced by the quantity of carbon that is sequestered into the soil, (2) regardless of cover crop type; grazed and ungrazed cover crops tend to show similar soil CO_2 and N_2O emissions, (3) rotations of some cover crops (e.g., oats-maize) do not seem to impact GHG emissions, and (4) grazed grass cover crops may result in a higher cumulative reduction of both CO_2 and N_2O emissions than grazed legume cover crops.[3]

Generally, cover crops may not affect CO_2 emissions during the growing season in temperate climates such as Midwest, but they increase CO_2 emissions by adding organic matter.[4] Regardless of where they are grown, cover crops that are terminated early tend to not affect CO_2 emissions.

Additionally, legume cover crops, such as clover, can fix nitrogen from the atmosphere and supply nitrogen to succeeding crops reducing fertilizer needs and increasing succeeding crop yields.[13] Moreover, non-legume cover crops can increase soil carbon sequestration and reduce nitrogen leaching more than legumes or no cover crop due to their greater biomass yield.[14] Finally, the carbon and nitrogen ratio (C/N) ratio of cover crop residue is another important factor that can influence residue decomposition and GHG emissions.[15] Generally, residues with higher nitrogen concentration or lower C/N ratio decompose more rapidly and can result in higher GHG emissions.[16]

Finally, when the overall impact is accounted for a *full year*, studies indicate that there is a balance between periods when cover crops increased N_2O and periods when cover crops decreased emissions, with overall emissions being close to zero. For that reason, researchers recommend that when N_2O measurements are taken and compared to measurements of different crops or different locations, the entire year may be needed to determine the net effect of cover crops on N_2O.

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