# Dairy cows and corn farming: Balancing methane and $CO_2$ sequestration

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**AT A GLANCE**

Dairy cows contribute to methane emissions, but the cultivation of corn for feed partially offsets the emissions by absorbing atmospheric $CO_2$.

Methane from agriculture, especially livestock, represents a significant portion of global methane emissions. Agriculture overall is responsible for 40%-50% of anthropogenic methane emissions, with ruminants accounting for roughly 56%-70% of methane from this figure. Other agricultural activities like manure management and rice paddies also contribute. Mitigating emissions from cattle production is one of the important aspects to reduce the environmental impact of agriculture.

### Feeding corn to cows

Lactating dairy cows consume on average 40-60 pounds of corn silage daily on an as-fed basis, and about 10-15 pounds of corn grain. As a result, over a year, a single dairy cow can consume around 15,000 pounds of corn silage and 3,600 pounds of corn grain, depending on productivity and feeding practices.

To estimate how many acres of corn a dairy cow needs in a confinement system, we can use those figures and compare them to typical corn yields. Corn silage yields vary, but a common estimate is 20-25 tons per acre. If we use a mid-range yield of 22.5 tons (45,000 pounds) of silage per acre, each cow requires about 0.33 acres of corn silage per year, as shown in **Figure 1** (page 60). Corn grain yields also vary, but let us use a conservative 150-200 bushels per acre. Taking a mid-range yield of 175 bushels per acre, it would be about 9,800 pounds of corn, resulting in about 0.37 acres of corn grain required per cow in confinement, also shown in Figure 1.

Combining both corn silage and grain, each cow requires 0.7 acres for both feedstuffs. For ease of calculation, let's say each cow requires 1 acre of corn planted yearly. This would account for both feedstuffs, allowing for some variation in yields, consumption and feed management practices.

### How much gas does the dairy cow produce?

A high-producing dairy cow consumes approximately 57 pounds of dry feed per day. To estimate her carbon dioxide ($CO_2$) and methane ($CH_4$) emissions, we need to consider emissions from enteric fermentation and from manure and other sources. On average, a dairy cow emits 220 to 330 pounds of methane per year. Cows fed high-energy diets typically fall on the lower end of the methane emission spectrum because of more efficient digestion. A cow eating 57 pounds of dry matter of an energy-dense ration could be expected to emit 220-286 pounds of methane yearly. Methane has a global warming potential (GWP) 25 times that of $CO_2$ over a 100-year period. The methane from one cow then equals approximately 5,511 to 7,165

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pounds of $CO_2$ equivalents ($CO_2E$).

As it decomposes, dairy cow manure also releases both methane and $CO_2$. Estimates for manure methane emissions for a dairy cow are approximately 44-66 pounds per year, which contributes another 1,102-1,653 pounds of $CO_2E$. Direct $CO_2$ emissions from respiration and other bodily processes are harder to quantify but are generally considered less significant.

So, the rough estimate for the total combined $CO_2E$ emissions is 220-286 pounds of methane or 5,511 to 7,165 pounds $CO_2E$ from enteric fermentation and 44-66 pounds of methane or 1,102 to 1,653 pounds $CO_2E$ from manure methane for a grand total of approximately 6,613 to 8,818 pounds of $CO_2E$ per cow yearly.

The GWP of methane compared to carbon dioxide varies with the time frame. Over a 100-year period, methane's GWP is 25 times that of carbon dioxide. However, for a 20-year period, it is often cited as 82 times more potent, reflecting its more immediate impact on global warming. The 100-year figure is used for long-term climate impacts, while the 20-year figure highlights short-term effects.

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### Corn as a $CO_2$ sink

Plants used in agriculture are classified as C3 or C4 based on their

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**FIGURE 1** Calculations of required acreage for corn silage and grain corn needs of a typical dairy cow in confinement

$$\frac{\text{15,000 lbs of silage per cow per year}}{\text{45,000 lbs of silage per acre}} \approx \text{0.33 acres} \qquad \frac{\text{3,600 lbs of grain per cow per year}}{\text{9,800 lbs of grain per acre}} \approx \text{0.37 acres}$$

Figure provided by Alvaro Garcia

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**FIGURE 2** Comparing emissions for silage and corn production

Silage: Land Preparation + Planting + Fertilizing + Harvesting = 487-597 lbs $CO_2E$ per acre

Grain: Land Preparation + Planting + Fertilizing + Harvesting = 465-575 lbs $CO_2E$ per acre

Figure provided by Alvaro Garcia

carbon-fixation pathways. Wheat and rice are considered C3s since they fix CO2 directly into a three-carbon compound via the Calvin cycle, making them efficient in cooler, moist environments. Corn, on the other hand, is considered a C4. It fixes CO2 into a four-carbon compound, reducing photorespiration and maintaining high photosynthesis rates, conserving water and achieving high yields even under intense heat.

Corn is thus among the top CO2 utilizers among agricultural plants using significant amounts of atmospheric CO2 for photosynthesis, making it effective in carbon sequestration and biomass production. Research suggests one acre of corn removes around 6.6 to 9 metric tons (MT) of CO2 per growing season, depending on conditions like crop management, soil type and climate.

The yearly carbon sequestration from the acre of corn the dairy cow uses yearly offsets the cow's total CO2E emissions of 3-4 MT per year. This, however, will depend on other factors such as feed management and composition, agricultural practices, and manure management on the specific farm.

To make the comparison even more precise, we should consider the emissions from machinery used during corn production. Research estimates that plowing requires about 5-6 gallons of diesel per acre, with diesel combustion producing roughly 22 pounds of CO2E per gallon. Plowing an acre will thus emit 110-132 pounds of CO2E. Planting will add around 1-2 gallons of diesel per acre, adding 22-44 pounds of CO2E. Fertilizer production and application also contribute, with nitrogen fertilizers emitting about 286-330 pounds of CO2E per acre. Finally, during harvesting, corn silage requires 3-4 gallons of diesel per acre, emitting 66-88 pounds of CO2E. Harvesting corn for grain consumes about 2-3 gallons of diesel per acre, resulting in 44-66 pounds of CO2E. Total CO2E emissions from machinery use would then be 487-597 pounds of CO2E per acre for silage and 465-575 pounds of CO2E per acre for grain, as shown in **Figure 2**.

These CO2E should be added to the cow's emissions and the total deducted from the CO2E sequestered by corn. However, since the difference between sequestration and emission sources was more than double, (9 MT versus 4 MT of CO2E) the net will still favor CO2E removal.

### Future directions: Mitigating gases and particulate matter

Emissions from dairy cows should be viewed within the broader agricultural system, incorporating the carbon sequestration potential of corn farming.

While dairy cows contribute significantly to methane emissions, a potent greenhouse gas (GHG), the cultivation of corn for their feed partially offsets these emissions by absorbing atmospheric CO2. With effective management, one acre of corn can sequester more CO2 than the emissions generated by a dairy cow, including methane from enteric fermentation and manure, even when factoring in the emissions from machinery used in corn farming.

Beyond GHGs, particulate matter 2.5 (PM2.5) from agricultural activities is a present critical environmental concern. These tiny particles can remain airborne for long periods and penetrate deep into the lungs, causing serious health risks like respiratory and cardiovascular diseases. PM2.5 pollution, originating from soil disturbance, diesel combustion and nitrogen-based fertilizers, accounts for about 16% of human-made emissions. Sustainable practices like no-till farming and manure incorporation can help reduce soil disruption, lower diesel use and minimize harmful nitrogen emissions, offering effective solutions to this issue.

In 2020, manure was applied to less than 8% of the 238 million acres of major U.S. field crops, with only 16.3% of corn fields receiving manure. No-till farming, favored for its soil conservation benefits, is used on about 30% of U.S. corn acreage. Adoption varies by region, with higher rates in states like Iowa, Ohio and Pennsylvania due to their emphasis on conservation. Overall, no-till farming is gaining traction as farmers increasingly value its benefits for soil health and sustainability.

Ultimately, reducing agriculture's environmental footprint requires a comprehensive approach that addresses not only methane and CO2 emissions but also particulate pollution. By adopting sustainable farming methods, we can mitigate the harmful effects of livestock production and crop cultivation, ensuring that agriculture contributes positively to both climate goals and public health.