Science Societies

Optimizing corn moisture and carbon intensity

Ethanol efficiency today, fuel credit opportunities ahead

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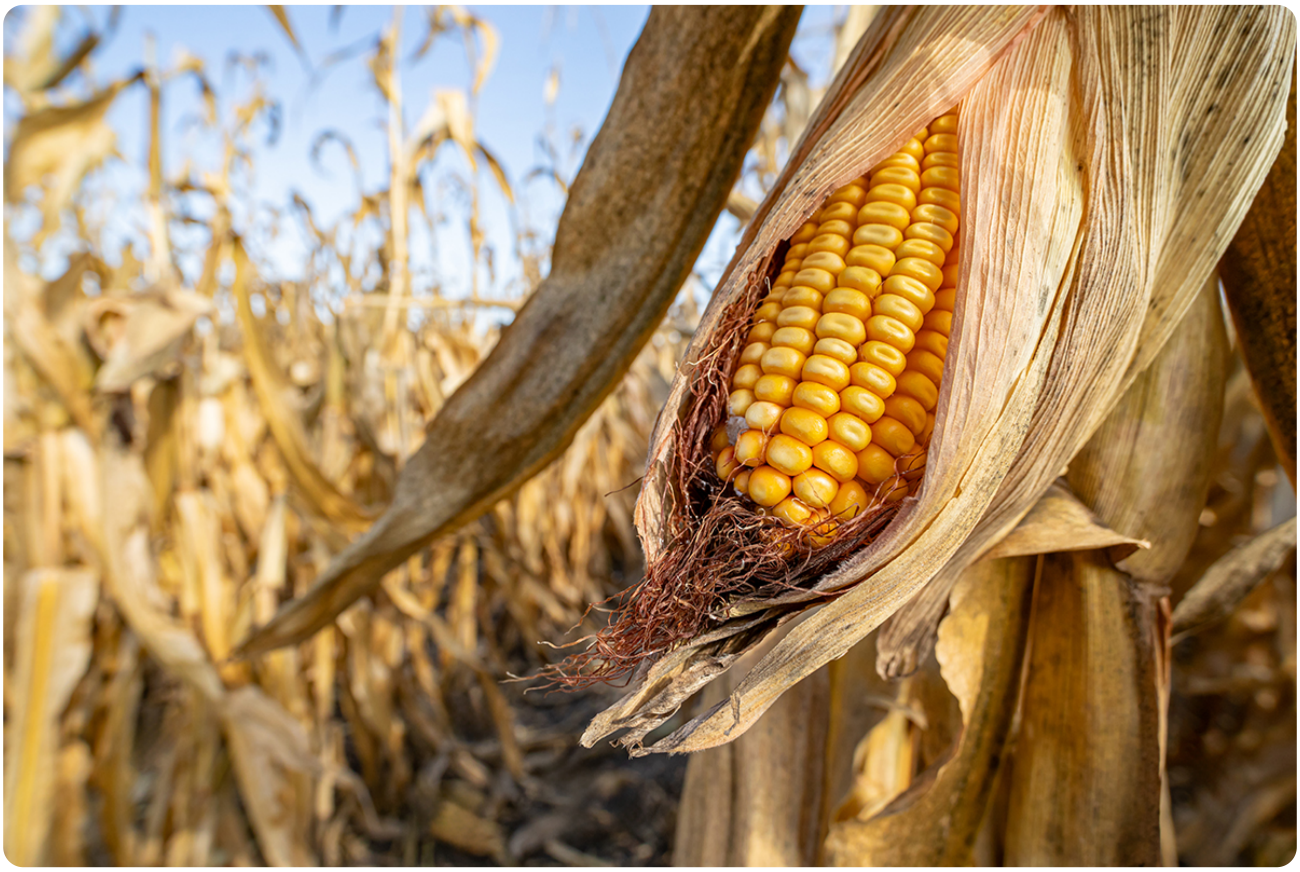

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Grain moisture plays a larger role in ethanol yield, energy use, and carbon intensity than many producers realize with real implications for profitability under emerging 45Z fuel credit programs. This article explains how moisture management, ethanol plant efficiency, and carbon intensity measurement intersect—and how CCAs can help farmers capture new value through low-CI grain strategies.

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Corn is the backbone of U.S. ethanol production, and the details of how that grain is harvested and delivered to ethanol plants have profound implications for both farmer profitability and downstream processing efficiency. In an ever adapting environment where 45Z fuel credits and carbon credits provide increased opportunity to farmers and processors, it becomes increasingly important that we understand where this evolution may take us.

One factor that too often goes underexplored is grain moisture. While we commonly consider moisture in relation to storage, test weight, and drying costs, moisture also materially affects ethanol yield and carbon intensity (CI) scores. As CCAs guide farmers on harvest and marketing decisions, they have an opportunity and responsibility to integrate moisture optimization into broader profitability and sustainability conversations. Moisture, however, is just one piece of a much greater puzzle in the carbon intensity of corn produced and ethanol processed. The continuation of farmer influence in carbon intensity provides immense opportunity for increased farm production profitability with the right agronomic guidance.

This analysis links grain moisture and ethanol yield to farm-level CI drivers that CCAs influence. It explains how CI is measured under 45ZCF-GREET, examines how 45Z and carbon capture and storage (CCS) or carbon-pipeline projects may shift value toward producers and ethanol plants alike, and summarizes current low-CI premium programs, turning agronomy plus documentation into practical revenue across the supply chain.

Why grain moisture matters for ethanol

Ethanol yield per bushel depends on starch content

Ethanol yield per bushel depends on starch content. Ethanol plants pay by the bushel for grain at the scale, but what actually matters in their margins is the amount of fermentable starch they receive. Water is inert weight. This being said, wetter grain contains proportionally more water and less dry matter (starch, fiber, and protein) that is usable in the production process. Studies have shown that for each 1 percentage point increase in moisture (above a reference level), ethanol yield per bushel declines roughly in proportion to the loss of dry matter. This is also based on a near universal market standard weight: 56 lb/bu for corn at a 15.5% standard corn moisture content. For example, Novozymes estimates that going from 15 to 18% moisture causes an estimated 2.16% drop in ethanol yield due only to dilution of solids (Novozymes, 2019).

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High moisture imposes extra energy burdens: the ethanol plant must dry or evaporate that excess water, consuming heat or steam energy, which increases operational energy demand and thus CI (Novozymes, 2019).

Corn quality and its effect on ethanol yield efficiency

Corn quality, closely tied to grain moisture, has a direct impact on ethanol yield, processing efficiency, and the overall economics of production. It is also another impact that farmers determine in their deliveries. Ethanol plants rely on starch conversion for yield, meaning any factor that reduces starch content or fermentation efficiency, such as mechanical damage, mold, or poor test weight, translates to real economic loss in their calculated margins in the aftermath. Research shows that ethanol yield losses due to grain quality can range from 3 to 23% in extreme cases (Singh et al., 2012; Novozymes, 2019).

Any factor that reduces starch content or fermentation efficiency, *such as mechanical damage, mold, or poor test weight of corn grain, translates to real economic loss. Photo courtesy of Adobe Stock/Metthapaul.*

The most common forms of damage affecting ethanol yield are as follows:

- **Broken kernels and foreign material** introduce dust and debris that clog equipment and reduce starch concentration per bushel.

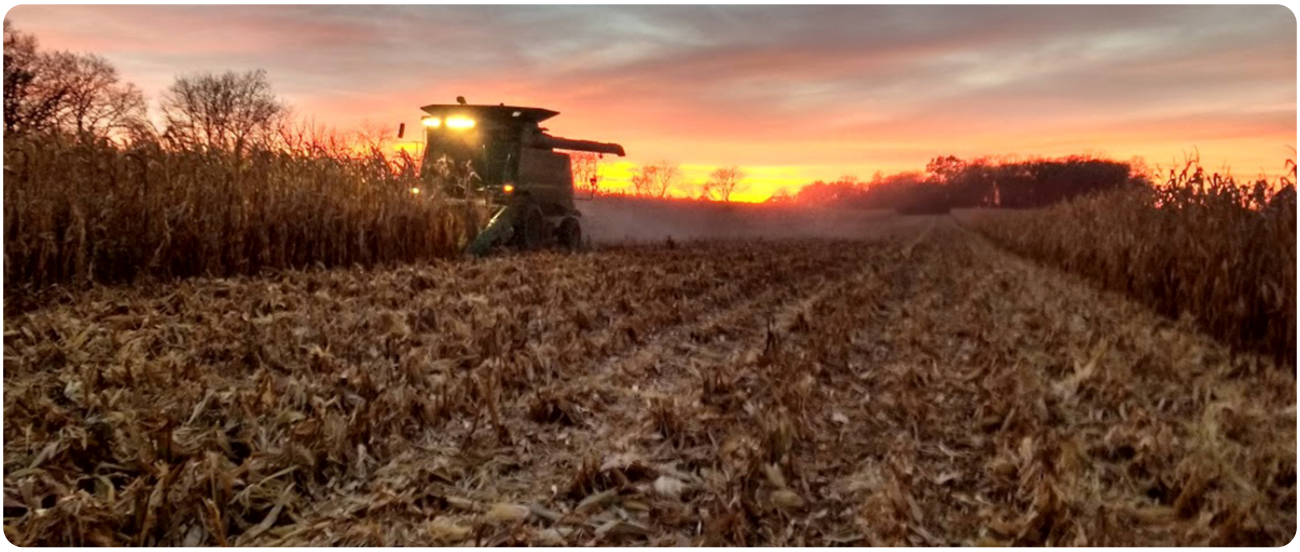
- **Stress cracks**, caused by rapid or uneven drying, lower test weight and create variable particle sizes during milling, leading to inconsistent starch-to-sugar conversion.

- **Mold growth and mycotoxins**, common in high-moisture or poorly stored grain, can inhibit yeast activity during fermentation and contaminate distillers' grains (DDGS).

- **Low test weight** often reflects poor kernel fill due to drought or early frost, meaning less starch and reduced ethanol output.

Beyond yield loss, wet or damaged corn increases plant downtime and energy use. Ethanol facilities may need to spend more on cleaning, drying, or maintenance while fermentation efficiency declines due to variable starch quality and microbial interference. Studies by the Renewable Fuels Association (2023) and Iowa State University indicate that every 1 lb drop in test weight can reduce ethanol yield by roughly 0.4–0.6%, and excessive moisture ($>15\%$) can increase greenhouse gas (GHG) emissions by 4–7 gCO_2e/MJ ethanol due to higher drying energy requirements (Wang et al., 2022).

To maintain efficiency, both farmers and ethanol plants can minimize these quality losses through timely harvest, moderate drying temperatures (<180°F), proper aeration during storage, and routine grain quality testing. Cleaner, drier corn not only ensures higher ethanol conversion rates, but also supports the industry's growing emphasis on low-CI production where quality grain reduces energy inputs and improves sustainability metrics.

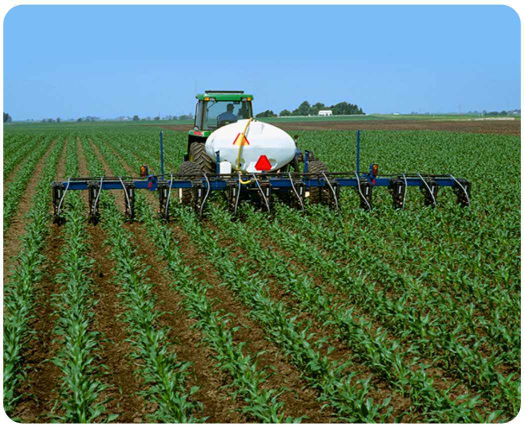


Timely corn harvest can help minimize ethanol yield losses. Photo by Jacob Kaderly.

How carbon intensity is measured today

The Clean Fuel Production Credit (45Z) pays more as a fuel's carbon intensity (CI) goes down. Carbon intensity is measured in grams of CO_2-equivalent per megajoule and, for ethanol, must be calculated with DOE/ANL's 45ZCF-GREET (hereby referred to as just GREET) model of the U.S. Department of Energy and Argonne National Laboratory. GREET totals emissions from field to fuel: crop production, hauling, plant energy, and coproduct credits, so farm practices and plant operations both move the score. Because the credit scales with CI, documenting and reducing those emissions creates headroom for value sharing with growers. The U.S. Department of Treasury has also indicated it intends to recognize climate-smart agriculture practices once rulemaking and model updates are finalized, further opening the door for farm-level improvements to count. On the plant side, GREET uses metered energy, so cutting steam and drying or switching to lower-CI fuels directly lowers CI, and adding fermenter CO_2 capture with geologic storage (CCS) can drive especially large reductions (DOE, 2025; Treasury, 2025; Xu et al., 2022).

As 45Z matures, expect more traceability and tighter contracts: field-level practice data will flow with loads and support monitoring, reporting, and verification. Premiums may be structured per CI point, in tiers (e.g., CI ≤threshold), or as fixed-plus-variable with end-of-season true-ups after verification. Enrollment may occur pre-plant or pre-harvest with delivery windows and moisture/discount policies that can amplify, or erode, premium value. Plants investing in energy efficiency or CCS can gain larger 45Z credits, which makes documented low-CI corn more valuable to them and increases the likelihood of pass-through payments.



Certified Crop Advisers can position clients to benefit by designing a yield-safe low-CI bundle (like right-rate N with timing/inhibitors, reduced till where it fits, and well-timed *covers). Photo courtesy of Alamy Stock Photo/Design Pics Inc.*

Certified Crop Advisers can position clients to benefit by establishing a CI baseline, designing a yield-safe low-CI bundle (like right-rate N with timing/inhibitors, reduced till where it fits, and well-timed covers), aligning documentation with buyer requirements for the premiums, and modeling net value after basis, moisture discounts, drying fuel, and trucking. *Keep in mind that stable or higher yields dilute fixed emissions per bushel, so the best low-CI plan is usually the one that protects yield while tightening emissions accounting* (DOE, 2025; Treasury, 2025; Xu et al., 2022).

Biorefineries vent high-purity CO_2 from fermentation; capturing and storing it cuts CI at scale. Evidence indicates large CI reductions are achievable with CCS at dry-mill ethanol plants, often dwarfing smaller, incremental process upgrades (Xu et al., 2022). Red Trail Energy in North Dakota is a real-world example of ethanol and CCS underway, illustrating how transport (pipeline or trucking), storage permits, MRV plans, and pore space access convert into bankable CI reductions (UNDEERC, 2022).

Sustainability and carbon intensity connection

As ethanol plants face pressure to lower CI, moisture management becomes more than an operational decision; it becomes a strategic one.

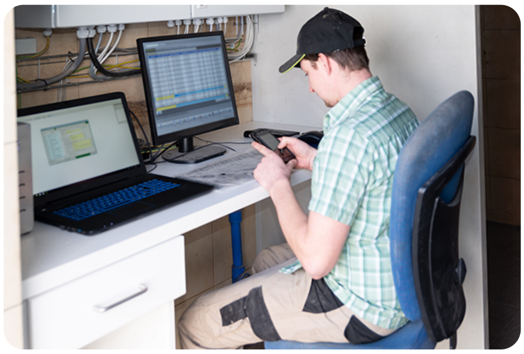
How moisture specifically affects carbon intensity

1. **Drying energy use:** More moisture means more energy to evaporate water, increasing greenhouse gas emissions per gallon of ethanol (i.e., higher potential CI score).

2. **Ethanol yield efficiency:** Drier corn yields more ethanol per bushel, lowering emissions per unit of fuel.

Research shows that ethanol's CI has declined over time, in part due to improved energy integration, co-product handling, and yield gains.

A study of corn ethanol methods found that capturing CO_2 emissions and CCS could reduce lifecycle greenhouse gas intensity by 58% (Dees et al., 2023).



Certified Crop Advisers who pair agronomic skill with documentation and market intelligence will help producers convert practice changes into both higher net prices and lower CI. Photo courtesy of Adobe Stock/FotoSabine.

Ethanol plants are also investing in energy efficiency, including mechanical vapor recompression, heat integration, and more to reduce their thermal input needs, which further magnifies the benefit of delivering drier corn (Sapp, 2023).

Moisture management is still foundational for ethanol yield and plant energy, but the center of gravity is shifting toward measured CI under 45Z. Certified Crop Advisers who pair agronomic skill (N strategy, tillage/cover crops, and hybrid/dry-down) with documentation and market intelligence (premiums, basis, and buyer technology) will help producers convert practice changes into both higher net prices and lower CI (DOE, 2025; Treasury, 2025).

Examples of ethanol plants offering premiums or low-carbon intensity grain programs

1. Valero (Charles City, IA)

Valero's Charles City ethanol plant has announced a $.05/bu premium for grain delivered under its "CFR Sustainability Program" for deliveries between Dec. 1, 2024 and Dec. 31, 2025 (Valero Energy Corporation, 2025).

This is a clear example in the Midwest of a plant paying a moisture- or sustainability-related premium (or at least a sustainability premium tied to delivery though the program also refers to moisture discounts) rather than just docking.

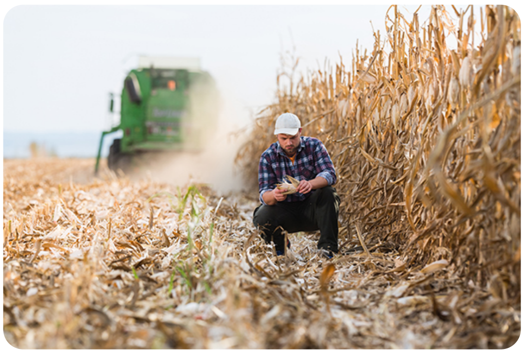
2. Red Trail Energy (North Dakota)

Red Trail is partnering with Indigo Ag to pay a premium for "low-carbon corn," i.e., corn traced to sustainable practices (reduced tillage, cover crops, etc.). The goal is to lower the overall carbon intensity of its ethanol, leverage upcoming credits (45Z), and push the premium for farmers supplying low-CI grain (Indigo Ag, 2024).

3. Landus (Iowa)—Clean Fuel Regulation Initiative (for soy/grain)

Though not exclusively for ethanol, Landus (an agribusiness firm) has created a Carbon Intensity Supply Chain Program that pays premiums to farmers for reporting sustainable practices (chain-of-custody, climate-smart farming) on their grain (Landus Cooperative, 2024).

This shows that in the broader grain supply chain, the model of premiums tied to sustainability is expanding, which could cross over more fully into ethanol feedstock premiums as incentives strengthen.



The launch of the 45Z tax credit gives plants a financial reason to pass on value to farmers who help reduce carbon intensity. Photo courtesy of Adobe Stock/Dusan Kostic.

A study highlighted in Farm Progress (2022) shows that farms closer to ethanol plants often capture implicit premiums of –$0.11 to +$0.26 per bushel (average $0.06/bu) just from reduced transportation/delivery costs and discount schedules. While this is not explicitly a “sustainability premium,” it shows that delivery conditions and logistical advantages already influence price spreads, which could be formalized as premiums in low-CI programs.

The launch of the 45Z tax credit gives plants a financial reason to pass on value to farmers who help reduce carbon intensity. The examples of Red Trail and Valero show early adoption of that concept. As carbon markets, verification systems, and low-CI programs mature, more plants may adopt premium schedules differentiated by delivered moisture, drying demand, and sustainability practices. Because moisture and drying energy influence CI scores, future premiums could be more granular, rewarding not just sustainability practices, but efficient moisture management (less drying, better quality, and lower emissions).

Corn grain moisture is far more than a number on a harvest ticket; it’s a critical junction among agronomy, economics, and sustainability. For farmers, optimizing moisture decisions can reduce drying cost, yield losses, and discount penalties. For ethanol plants, drier deliveries improve processing efficiency, ethanol yield per bushel, and carbon intensity. In a shifting market landscape where CI programs, carbon credits, and regulatory pressures are increasing, CCAs are uniquely positioned to guide farmers toward strategies that align profitability with sustainability in an industry that values it more and more each day.

In a shifting market landscape where CI programs, carbon credits (including 45Z), and regulatory expectations are expanding, CCAs are uniquely positioned to guide producers toward integrated, profitability-first decisions that also lower risk and emissions. By helping growers align agronomy with CI measurement, contract requirements, and evolving premium opportunities, CCAs not only strengthen farm economics today, but also contribute to a more carbon-efficient and resilient biofuels supply chain for years to come.

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1. **Why does corn grain moisture directly impact ethanol yield at the plant?**

a. Wetter corn contains less usable starch per bushel.

b. Higher moisture reduces test weight and efficiency.

c. Additional drying energy increases processing costs.

d. All of the above.

2. **As ethanol plants adopt low-carbon-intensity grain sourcing programs, what proactive step should advisers take to position farmers for potential premiums?**

   a. Suggest reducing fertilizer rates below agronomic recommendations.

   b. Encourage documentation of sustainable practices and efficient grain drying methods.

   c. Focus solely on achieving maximum test weight.

   d. Delay harvest until late fall to minimize drying costs.

3. **Certified Crop Advisers can help farmers identify current economic opportunities for lower-carbon-intensity (CI) grain production by**

   a. comparing local ethanol plants' sustainability programs and carbon-related incentives available to farmers.

   b. recommending that all farmers dry grain to below 12% moisture regardless of cost.

   c. ignoring local ethanol market differences and focusing on national average prices.

   d. advising farmers to avoid sustainability programs until premiums are guaranteed.

4. **Why is it important for CCAs to evaluate local ethanol plants' CI-related opportunities now?**

   a. Because some plants already offer sustainability or traceability premiums that may expand under 45Z and impact how a farmer needs to operate their farm.

   b. Because federal CI programs have no regional variability.

   c. Because low-CI grain has lower starch content and less ethanol potential.

   d. Because only large-scale farms qualify for CI-based payments.

5. **Which practice gives farmers the most flexibility in deciding when to harvest corn at higher moisture levels?**

   a. Using longer maturity hybrids.

   b. Selling grain directly at harvest.

   c. Having on-farm drying capacity.

   d. Planting cover crops after harvest.

6. **Delivering wetter corn always results in higher revenue for the farmer.**

   a. True.

   b. False.

7. **How does grain moisture affect carbon intensity (CI) scores?**

   a. Higher moisture reduces CI scores.

   b. Higher moisture increases drying energy use, raising CI scores.

   c. Grain moisture has no impact on CI.

   d. Drier grain reduces ethanol yield and increases CI.

8. **What emerging opportunity may reward farmers for delivering corn produced at a better CI performance?**

   a. Government subsidies for propane.

   b. Sustainability premiums from ethanol plants.

   c. Higher seed discounts at co-ops.

   d. Crop insurance rebates.

9. **Certified Crop Advisers can best help farmers prepare for future ethanol plant premiums under programs such as 45Z by**

   a. Encouraging farmers to delay harvest until moisture is below 10% regardless of weather conditions.

   b. Recommending only high-yield hybrids without considering sustainability metrics.

   c. Focusing exclusively on marketing grain through elevators instead of ethanol plants.

   d. Advising farmers on practices that reduce on-farm energy use and fertilizer emissions to lower carbon intensity.

10. **How does grain moisture most directly affect a farmer's profitability when marketing to an ethanol plant or elevator?**

    a. Wetter grain increases the total sale weight and revenue per bushel.

    b. Drier grain is always rejected due to low test weight.

    c. Wetter grain leads to dockage and drying costs that reduce the final settlement price.

    d. Moisture content does not influence grain price.

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