SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter: 35

Grain Marketing – Understanding Corn Moisture Content, Shrinkage and Drying

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In the United States, corn is marketed in bushels, which are measured in units of mass rather than units of volume. For example, the industry standard for #1 yellow corn is 56 lbs per bushel, but may be bought and sold at many different % moisture contents (e.g., 15.5%, 13.0%). Grain drying from higher to lower moisture content shrinks as water is lost. Grain moisture shrinkage is an important concept in grain marketing as this impacts the buying price and discounts. To optimize economic returns, understanding shrinkage and drying costs calculations are critical. This chapter provides examples of how to determine the impact of variable grain moisture contents on grain mass. Key facts about grain moisture content are provided in Table 35.1.

Figure 35.1 Grain delivery to elevator, horse and wagon. Horse-drawn grain wagons at the Fullerton elevator. 1906 (Courtesy U.S. Library of Congress, http://memory.loc.gov)

Table 35.1 Key facts about grain moisture content:

1. For long-term storage, grain moisture should be 13.1% to reduce disease and insect losses.
2. Grain buyers post drying and shrink charges. Know the product delivery specifications for these two factors.
   a. Drying cost and shrink factors should be considered when deciding where to sell your corn.
   b. Handling losses > 1% may be excessive.
3. Grain moisture content is considered on a wet-weight basis, below are standard moisture contents for different grains.
   a. A bushel of corn at any moisture level weighs 56 lbs.
   i. A bushel of corn at 15.5% moisture contains 47.32 lbs of dry (0.0% moisture) corn and 8.68 lbs of water.
   ii. A bushel of corn at 13% moisture contains 48.72 lbs of dry corn and 7.28 lbs of water.
   b. A bushel of wheat at 13.5% moisture weighs 60 lbs.
   c. A bushel of soybeans at 13% moisture weighs 60 lbs.

Understanding Shrinkage

Why is the Term Shrinkage Used for Grain?

Our forefathers developed the method for buying and selling grain. Before large-scale weighing capability was available, grain was sold by volume (thus, the bushel became the basic unit of grain commerce). The inside dimensions of a grain wagon were measured to determine its width, length, and height (Fig. 35.1). A bushelUnited States dry measure equals 2150.42 cubic inches (CRC handbook). A standard bushel

of corn weighs 56 lbs at 15.5% final moisture content. However, some grain buyers want to purchase even drier grain (less water content) and have a discount based on the % difference between the seller's grain moisture content and their posted moisture content. The weight loss by drying is referred to as shrinkage. When wet corn greater than the posted moisture content is purchased by the buyer and dried, the grain loses volume as water evaporates from the grain. The grain test weight increases depending on the beginning and ending % moisture content, with a range of 0.25 to 0.50 lb/bushel-%point. Thus, the term shrinkage was used to describe the phenomena of less volume due to moisture loss in a load of corn. Today, volume (bu) is not measured and grain transactions are based upon weight. However, due to grain-selling history before scales, the word shrinkage is still associated with moisture loss.

Economic Implications of Grain Moisture

Grain discounts often consider shrinkage, handling losses, and drying costs. Shrinkage is the loss of weight (water) when grain dries. Handling losses are loss of weight due to grain respiration (carbon), loss of oils during drying, and the loss of materials when grain is transported or moved from one location to another. Drying costs result from the amount of energy needed to dry corn to a storable moisture percentage to maintain quality.

To optimize the grain selling price, the farmer must understand the buyer's delivery specifications regarding: 1) shrinkage, 2) drying charges, and 3) final moisture content based on grain sale date. In corn production, buyer discounts can substantially reduce the return. For example, the buyer may have discounts for grain that has moisture contents different than their specifications. Understanding these discounts can help farmers make sound economic decisions.

Grain moisture is measured with a sensor that usually requires, at the very least, annual calibration. There are many companies that produce moisture sensors for grain, including real-time in line sensors for combines, sensors for bulk grain, and moisture probes. When grain moisture content is measured, a sample is collected and analyzed. As with all measurements, the analysis is only as good as the sample. Accurate assessments require that a "good representative" sample be collected and that the sensor be precise and accurate. To achieve a representative moisture value for grain from the field or in an on-farm bin, read and follow the instructions provided by the sensor manufacturer regarding sample collection. Note that on-farm grain moisture sensors can be impacted by temperature of the grain. Grain moisture meter errors typically increase once the temperature is less than 40°F.

Grain Moisture Calculations

Bushels of corn based on corn weight:

$$\text{Bu} = \text{Amount of corn in wagon (lb)} \times \frac{1}{56 \text{ lbs}} \quad [1]$$

This equation does not take into account the moisture content of the grain. Grain moisture equation:

$$\text{MC\%} = 100 \times \frac{\text{ww}}{\text{ww} + \text{wdc}} \quad [2]$$

Where ww = weight of water
wc = weight of wet corn
wdc = weight of dry corn
MC% = moisture content as a decimal

The amount of water in wet grain is determined by the equation:

$$\text{ww} = \text{MC\%} \times \text{wc} \quad [3]$$

The grain moisture equation can be algebraically manipulated to determine the amount of water in grain based on the grain's dry weight:

$$\text{ww} = \frac{\text{MC} \times \text{wdc}}{1\text{-MC}} \quad [4]$$

Equation [4] can be algebraically manipulated to determine the dry grain based on the wet weight of corn (wc), the % moisture of the wet corn (MC), and the % moisture of the dry corn (dry).

$$\text{grain weight at 'dry' moisture \%} = \text{wc} \times \frac{100\%\text{-MC}}{100\%\text{-dry\%}} \quad [5]$$

Dry weight of corn (grain) can also be calculated using this equation:

$$\text{WDC} = \text{WC} - \text{WW} \quad [6]$$

When grain is dried, it loses moisture to the atmosphere. The amount of loss is the shrink. Moisture shrink (%) is determined with the equation:

$$\%\text{Moisture shrink} = 100 \times \frac{\text{original moisture content \%-final moisture\%}}{\text{100-final moisture \%}}$$

This definition of shrinkage does not consider the amount of grain can also be lost at an elevator through dust and removal of foreign materials. Typically, handling losses are 0.25 to 0.5%.

Example 35.1
A farmer has delivered 16,954 lbs of 20% moisture corn to the elevator. The elevator docks for shrinkage of delivered corn to 13% moisture content. Elevator-posted prices are $3.50/bushel corn with a 1.2%/moisture point (1.2%/pt.) shrinkage discount. How many bushels of corn at 13% moisture are delivered and how much water is contained in the grain.

Method 1
An alternative technique to solve this problem is to use equation 5:

$$= 16954 \times \left(\frac{100\text{-}20}{100\text{-}13}\right) = 15{,}590$$

Finally, determine the number of bu of corn at 13% moisture, using equation [1]:

$$\text{Bushel corn}_{13\%} = \frac{15{,}590 \text{ lbs}}{56} = \mathbf{278.4\ bushels}_{13\%}$$

Based on these calculations, the amount of corn that the elevator will pay for is 278.4 bu.

Shrinkage is calculated by subtracting the initial weight from the final weight
= 16,954-15,590 = 1,364 lbs

The percent shrinkage is 100× 1364/16954 = 8.045%, and the shrinkage per percent of moisture loss is 1.01493% (8.045%/7%). See Table 35.2.

The per bushel shrinkage is 1364/302.75 bushels = 4.505 lbs/bushel, and the shrinkage per bushel per each change in moisture percent is
= 4.505 lbs/(bushel ×(20-13% moisture)
= 0.644 lbs /[bu ×point moisture].
This value is similar to Table 35.2

Method 2
This problem can also be solved by using Table 35.2. In this table, the beginning and end moisture values are determined, and the water shrink factor value is multiplied by the difference. For example, if the wet corn delivered has a % moisture content of 20% and the elevator docks for shrinkage at 13%, then 20-13 = 7% and the value for 1.149 from the table is multiplied by 7.

In this example, the elevator is using a grain moisture % of 13%. In Table 35.2, the shrinkage value to 13% moisture is 1.149.

Step 1. Determine the number of points difference from the wet grain delivered to the acceptable moisture content (points are the change in the moisture content based on percentage).

Answer:
The difference between the initial moisture content (20%) and final (13%) is 7%. This difference is the

number of moisture points.

Step 2. Percent water shrink is determined by:
(moisture points) x the water shrink factor (Table 35.2).

From Table 35.2,
1.149%/pt is the water shrink factor associated with the final moisture content of 13%.

Answer:

$$7 \text{ pts} \times \frac{1.149\%}{\text{pt}} = 8.0435 \text{ water shrinkage}$$

Step 3. The bushels lost due to water weight are calculated by multiplying the bushels at 20% moisture times the water shrink factor. The water shrink factor is converted from a percent (8.043%) to a decimal (0.08043) by dividing the percent by 100.

First, bushels delivered at 20% moisture are calculated

16,954 lbs/(56 lbs/bu) = 303 bu at 20% moisture

Answer:

$303 \text{ bu}_{20\%} \times 0.0804 = 24$ bushel shrink

Step 4. Bushels at final moisture content = 13% is:

$303 \text{ bu}_{20\%} - 24$ bu shrink = $279_{13\%}$

Table 35.2 Relationship between the final moisture content, water shrink factor, and lbs water/bu-pt.

Final moisture Content (%)	Water shrink factor (%/pt)	lbs water/ Bu-pt
16.0	1.190	0.66666
15.5	1.183	0.66272
15.0	1.176	0.65882
14.5	1.170	0.65497
14.0	1.163	0.65116
13.5	1.156	0.64739
13.0	1.149	0.64468
12.5	1.143	0.64000
12.0	1.136	0.63630

The same answer is achieved using both methods. If you have access to a table with values, the calculations may take less time. However, if the values for the water shrink factor are not available, the first method can be used.

What is the final $/bu paid to the farmer based on shrink discount?

If the corn had been delivered at 13% moisture and corn has a test weight of 56 lbs/bu, the paid amount would be: the number of bushels delivered × $/bushel. In this example:

$$303 \text{ bu}_{13\%} \times \frac{\$3.50}{\text{bu}} = \$1060.50$$

However, the corn was delivered at 20% moisture and the amount of corn delivered at 13% is only 278 bu. At $3.50/bu this is worth $973 ($278 \text{ bu}_{13\%} \times \frac{\$3.50}{\text{bu}} = \$973$).

It is important to note that this example DID NOT include drying costs, which may be an additional $0.04 - $0.06/moisture point.

Comparing Farm vs. Elevator Drying Costs

The elevator often charges for drying costs for grain that is delivered too wet to the elevator. These charges are often expressed as a $ amount per point of moisture content between the wet (delivered) and dry (acceptable). The farmer must decide whether the drying cost is reasonable. To calculate the on-farm drying costs, the fuel, capital, and labor costs must be considered.

Capital costs to own the dryer

In this example, a 20 ft. axial plenum grain dryer system costs approximately $77,000. This system can dry corn up to about 750 bu/hour at full heat from 20% to 15% moisture. The interest rate at the bank is 5% and depreciation is 8%. The farm averages 750 acres of corn. The average yield is 170 bu/acre. The producer starts to harvest grain at 21% moisture desires a final dry moisture content of 15.5%.

Example 35.2 One thousand (1000) lbs of grain at 22% moisture content are delivered to an elevator. If the buyer's final moisture content is 13% moisture, determine shrinkage and the amount of grain at 13% moisture.

Method 1

Using equation 5, grain weight at 'dry' moisture % = WC x $\frac{100\%\text{-MC}}{100\%\text{-dry\%}}$

$= 1000 \times \frac{100\text{-}22}{100\text{-}13} = 897$ lbs

Shrinkage was 1000-897= 103 lbs.

The load contains 16 bushels.

Method 2

An alternative method of calculation is to use Table 35.2 to estimate water shrinkage. Using Table 35.2 when the final moisture content = 13%, the corresponding shrink factor is 1.149%/pt. The points change in this example from wet to dry is: 22% - 13% = 9 pts.

$9 \text{ pts} \times \frac{1.149\%}{\text{pt}} = 10.341\%$ shrink

There were 17.86 bu corn at 22% moisture:

Therefore:

17.86 bu × 0.101341 = 1.85 bu shrink

17.86 bu - 1.85 bu = 16 $\text{bu}_{13\%}$

Example 35.3 An elevator's posted cash price and final moisture is $3.29/bu at 15.5%. The corn delivered by the farmer is 13% moisture, less than the posted moisture. If the farmer sells the corn to this elevator, what is the value of the grain?

Step 1. First, the shrink value associated with the final moisture content of 15.5% must be determined. Using Table 35.2:

Final moisture Content (%)	Water shrink factor (%/pt)	Lbs water/ Bu-pt
15.5	1.183	0.66272

If the base price is $3.29 and the grain is aerated with high humidity air, the corn moisture content may potentially increase from 13% to 15.5%.

Water weight has been added to the grain to increase the moisture. The resulting increase in grain price will be:

$(15.5\text{-}13.0 \text{ pts}) \times \frac{0.01183}{\text{pt}} \times \frac{\$3.29}{\text{bu}} = \frac{\$0.097}{\text{bu}}$

An additional $0.097 or ~ $0.10/bu is added to the selling price, $3.29/bu, to increase the price to $3.39/bu.

Example 35.4 The elevator will dry each bushel of the 22% moisture corn to 13% moisture. At delivery the corn had a moisture content of 22%. For each bu of 56 lbs/bu 22% moisture corn dried, calculate is the lbs of dry corn at 13%.

Equation [5] is used to calculate the dry grain at the lower moisture content:

$$\text{Dry grain weight=wet grain weight} \times \frac{(100\%\text{-wet\%})}{(100\text{-dry\%})}$$

Substituting in the delivery moisture content (22%) and the moisture content desired by the elevator (13%), the dry grain weight is calculated:

$\text{Grain weight at 13\%} = 56 \frac{100\text{-}22}{100\text{-}13} = 50.21$ dry corn

The elevator's actual shrinkage was from 56 lbs to 50.21 lbs, which is a loss of: 56-50.21 = 5.79 lbs water.

Example 35.5 Determine the costs for an on-farm system with the following specifications. The dryer energy efficiency for heat is 3000 BTU/lb-water and for electricity is 0.03 kWh/lb-water. Propane is $1.45/gal and the electric rate is $0.09/kWh.

In this example the final corn moisture % is 15.5%. At 15.5% final moisture content, a bushel point is 0.6627 pounds of water (0.67 lbs water/bu-pt) (see Table 35.2):

Final moisture Content (%)	Water shrink factor (%/pt)	Lbs water/ Bu-pt
15.5	1.183	0.6627

1. Propane cost, amount needed per % point

$$\frac{0.6627 \text{ lbs water}}{\text{bu-pt}} \times \frac{3000 \text{ BTU}}{\text{lb-water}} \times \frac{1 \text{ gal propane}}{92{,}000 \text{ BTU}} \times \frac{\$1.45}{1 \text{ gal propane}} = \frac{\$0.0315}{\text{bu-pt}}$$

2. Electricity cost for drying system and fans, amount needed per % point

$$\frac{0.6627 \text{ lbs water}}{\text{bu-pt}} \times \frac{0.03 \text{ kWh}}{\text{lb-water}} \times \frac{\$0.09}{\text{kWh}} = \frac{\$0.0018}{\text{bu-pt}}$$

3. Total cost on farm drying cost, energy

$$\frac{\$0.0315_{\text{propane}}}{\text{bu-pt}} + \frac{\$0.0018\text{h}_{\text{electricity}}}{\text{bu-pt}} = \frac{\$0.0333}{\text{bu-pt}}$$

a. Cost to own dryer per year (does not consider capital investment to purchase the dryer)

$$\frac{(5\%+8\%)}{100} \times \$77{,}000 = \$10{,}010$$

b. Bushel points to dry:

$$750 \text{ a} \times \frac{170 \text{ bu}}{\text{a}} \times (21\text{-}15.5 \text{ pts}) = 701{,}250 \text{ bu-pts}$$

c. Cost to own on-farm dryer system

$$\frac{\$10{,}010}{701{,}250 \text{ bu-pts}} = \frac{\$0.01427}{\text{bu-pt}}$$

The total cost to dry grain on the farm considering energy, and interest and depreciation to own the systems is:

$$\frac{\$0.0333}{\text{bu-pt}} + \frac{\$0.01427}{\text{bu-pt}} = \frac{\$0.04757}{\text{bu-pt}}$$

Labor costs to operate the on-farm drying system were not included. If hired labor is used, this must be considered into the on-farm drying costs as well. Therefore, if the cost of drying at the elevator is $0.03/bu-pt then it is cheaper to use the elevator.

Important Related Information

How fast does corn dry?

Typically in South Dakota it takes 15 to 30 growing-degree days (base 50°F) to reduce the corn moisture content from 30% to 29% (1 percentage point). After November 1, very little in-field drying occurs.

How efficient is your dryer?

Dryer efficiencies can range from as low as 0.005 gal/bu-pt to as high as 0.03 gal/bu-pt or more. At $1.60/gal for propane, this translates to $0.008/bu-pt to $0.048/bu- pt. For drying corn from 24% to 15% moisture, this calculates to a cost of between $0.072/bu to $0.432/bu. In addition, capital costs (the cost of owning a dryer) can amount to an additional cost of $0.06/bu-pt.

Compare drying system costs of using (1) air and heat vs. (2) air only to dry crops. Air-only drying will require a shorter bin fill (usually less than 20 ft) and a significantly greater amount of air (usually more than 1.00 to 1.25 cubic ft per min/bu). Drying with air will require bins that are dedicated only to drying single load for most of the fall drying season. The air-drying systems typically will use no propane and require an electric energy input range of from 0.1 to 0.6 kWh/bu-pt. At $0.07/(k Wh), this translates to a cost of between $0.007 to $0.042/bu-pt. Capital costs must also be considered. Note that the lowest cost will typically occur early in the drying season when ambient air temperature is the highest. Unfortunately, this normally is when the highest moisture percentage may be observed in corn.

Harvest Corn or Leave in the Field?

The cost of field drying is frequently viewed as being free; however, field drying has risks. The longer corn is left in the field, the greater the potential for ear drop caused by wind, precipitation, or wildlife. Drier corn (15%) has been shown to exhibit greater combine harvest loss (both ear drop and kernel shelling) than wetter corn (24% moisture).

To make the best decision for your operation, evaluate the costs of (1) on-farm drying vs. (2) local elevator drying charges. The local elevator may be using natural gas rather than propane and this may result in both profit for the elevator and cost savings for the producer.

References and Additional Information

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