Silage harvest moisture and proper fermentation

Key points

- Corn harvested for silage should be fermented quickly and carefully to help ensure the highest quality silage is produced.
- The production of lactic acid helps to ferment the ensiled crop efficiently by actively dropping the pH.
- Corn silage quality is more accurately determined by moisture content than corn maturity stage. However, understanding both aspects can help in determining when to begin harvest.
- Proper ensiling of a corn silage can only happen in an anaerobic (without oxygen) environment where the silage is packed to a high enough density to remove the oxygen in the forage to the point where the anaerobic bacteria can produce the organic acids needed to drop the pH.

Silage is produced to help maintain forage nutrition for feeding livestock well beyond the harvest date. To accomplish this, plant carbohydrates (sugars) are converted through fermentation into organic acids. Nutrient loss can be minimized through proper management of harvest moisture content, chop fineness, air elimination, carbohydrate content, and bacterial population.

Harvest Moisture

There are several reasons why it is critical to harvest silage at the proper moisture content and stage of maturity, including:

- Increased nutrient yield potential
- Reduced losses in the field and in storage
- Increased animal consumption and palatability
- Reduced seepage

Corn should be harvested when the whole-plant moisture is around 55 to 70 percent. Exact moisture content depends on the storage method used (Table 1).

Table 1. Recommended moisture content of corn silage by storage structure.

Horizontal silo	65-70%
Conventional upright	63-68%
Oxygen-limiting upright	55-60%
Bag	60-70%
Pile or stack	65-70%

Source: Adapted from Jones, C.M., Heinrichs, A.J., Roth, G.W., and Ishler, V.A. 2017. From harvest to feed: understanding silage management. Penn State Extension. UD016. http://extension.psu.edu/.

Corn silage quality is more accurately determined by moisture content than corn maturity stage but understanding both qualities can help when determining when to harvest. The milk line is indicated by a whitish line that divides the kernel starch and milk. At one-quarter milk line, the line will exist 25 percent of the way down from the top of the kernel (Figure 1), and all kernels will be dented. At one-half milk line, the corn crop will be around 65 percent moisture, and at three-quarter milk line and a black layer, moisture content will be around 55 to 60 percent moisture. At the corn approaches black layer, grain content increases, but starch digestibility decreases. For more digestible corn that is higher in nutrition, silage corn should be harvested around one-half milk line.[1]

Once silage corn maturity enters one-quarter milk line, whole plant moisture can be tested and used to help decide when to harvest. One-quarter milk line typically occurs when the corn crop is around 70 percent moisture content. To test whole-plant moisture the plant is chopped, weighed, completely dried, and then weighed again. Dry weight can be compared to fresh weight to determine moisture content. This can be done

Figure 1. Corn maturity stages by milk-line.

on-farm (with appropriate tools and methods not detailed here) or at a lab. For most corn hybrids in optimum growing conditions drydown rate is approximately 0.5 to 0.6 percent per day. This drydown rate coupled with the moisture content and the type of storage being used, can be used to determine the optimal day to begin silage harvest. For example, if corn moisture content is 70 percent moisture, and the ideal moisture content is 65 percent, then a total of 5 percent moisture drydown is needed. When multiplied by 0.5 to 0.6 percent drydown per day, a 5 percent drydown provides an estimate of 8 to 10 days until harvest. It is important to monitor crop maturity every couple of days to determine how rapidly the crop is drying down. Factors that could cause quicker drydown include high temperatures, moisture stress, heavy spider mite pressure, disease pressure, or corn hybrid (some hybrids may be more suited to stay green and healthy through maturity).

Fermentation

A recently harvested forage crop can be converted to silage within 21 days of ensiling.[1] The crop will move through four phases of normal fermentation converting plant sugars into organic acids, reducing the pH thereby preserving the forage. Lactic acid is the desired acid for most efficient fermentation.[2]

1. **Plant respiration** occurs once the forage is cut and can only occur when oxygen is present. Plant cells will continue to respire and plant enzymes will continue to breakdown proteins. This, coupled with the growth of naturally-occurring aerobic bacteria, will deplete readily available carbohydrates, producing carbon dioxide, water, and heat. Silage temperature may elevate to 20 °F higher than the ambient temperature.

Based on the amount of oxygen present, plant respiration may continue for three to five hours. To reduce consumption of carbohydrates, oxygen should be removed quickly and throughout storage. This can be accomplished by harvesting at the proper moisture content, chopping forage at between 3/8 to 3/4 of an inch, packing well-compacted silage evenly, and immediately sealing the storage system after ensiling.

2. **Production of acetic acid.** After packing and sealing, the absence of oxygen allows acetic acid-producing bacteria to begin multiplying. These bacteria convert carbohydrates from the forage to acetic acid. This process acidifies the plant material, which lowers the pH from around 6.0 to 5.0 over one to two days. The acetic acid-producing bacteria cannot tolerate the lower pH, and their population begins to drop. Plant enzyme activity also begins to decline in the acidic environment.

Silage harvest moisture and proper fermentation

3. **Production of lactic acid begins.** As the pH of the forage material declines during the third phase of fermentation, lactic acid-producing bacteria begin to multiply. Plant carbohydrates are converted into lactic acid, acetic acid, ethanol, mannitol, and carbon dioxide due to the presence of heterofermentative bacteria. At a pH of 5, homolactic bacteria population increases relative to the heterofermentative bacteria converting plant carbohydrates into lactic acid.[2] Again, anaerobic conditions (conditions without oxygen created by packing and sealing the forage) are required for efficient lactic acid production.

4. **Maximum production of lactic acid and storage.** The last phase of normal fermentation continues lactic acid production until the pH drops low enough that no bacterial growth occurs. For corn, the pH will range from 3.5 to 4.5. The silage material is typically stable after 21 days, and fermentation will stop as long as no outside air enters the storage area. Silage should continue to be stored without oxygen in order to help restrict the growth of yeast and mold. The acidic environment helps to prevent bacterial growth in the silage material.[1]

Improper Fermentation

Too much oxygen can lead to an accelerated conversion of carbohydrates into heat and carbon dioxide, which will lead to silage nutrient and energy loss. Heat can limit lactic acid production while allowing for the growth of undesirable bacteria, yeasts, and molds. Heat can also lower protein quality and feed digestibility.[1] Silage temperatures higher than 20 °F above ambient temperature indicates extensive respiration.[2] Oxygen supplied to silage after fermentation can also cause heating and reduction in feed quality. This can occur where silage is removed from storage but not fed the same day or where a large face on a silage pile is exposed for days.

High moisture content combined with low levels of available plant carbohydrates may allow butyric acid production to begin after the fourth phase of the fermentation process. This is most common in legume silage. The most prevalent butyric acid-producing bacteria are Clostridia species. These bacteria deplete the silage of any surplus carbohydrates, proteins, or sugars, in addition to the desirable acids produced in previous fermentation phases. The result is a silage with a sharp odor, low nutrition, low palatability, and low digestibility. Butyric acid production can occur more frequently when silage is stored at a higher moisture content (higher than 70 to 72 percent).[1]

For more information, contact your local Bayer representative.

Sources

[1] Jones, C.M., Heinrichs, A.J., Roth, G.W., and Ishler, V.A. 2017. From harvest to feed: understanding silage management. Penn State Extension. UD016. http://extension.psu.edu/.

[2] Ensiling. University of Wisconsin Extension. S005. http://corn.agronomy.wisc.edu/Silage/S005.aspx.

Web sources verified 29/07/2021

Legal Statements