

**Cutting, Harvest & Storage
Management for Forages
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Introduction

Harvest and storage management can have marked effects on silage quality. The objective of this paper will be to briefly discuss some recommended management practices to make high quality silages.

Evaluating Corn Forage Hybrids

Much emphasis has been placed on selection of corn hybrids for dairy cattle. There has been a significant resurgence in using brown mid rib (BMR) corn as newer hybrids now come with many stacked traits and yield drags (although still present) have been significantly reduced. A good tool that can help in on farm evaluation is the MILK2006 spreadsheet from the University of Wisconsin at http://www.uwex.edu/ces/crops/uwforage/dec_soft.htm. The MILK2006 program calculates milk/ton and milk/acre for silage hybrids. This latest version allows for input data related to kernel processing score, degree of starch access and in vitro/in situ starch digestibility. This version also allows one to enter data using either 24, 30 or 48 h in vitro NDF digestibility estimates. Depending on your specific situation, most would try to choose hybrids that give high milk/ton and milk/acre. CornPicker is another program for evaluating corn silage hybrids and is available from Michigan State University (<http://www.msu.edu/~mdr/cornpicker.html>). This program calculates partial budgets and compares net farm income between two corn silage hybrids. The program is more complicated than MILK2006 but unlike that program, CornPicker provides a monetary bottom line between hybrids. Some of the inputs that users can manipulate include the cost of SBM and corn, cost of the seed; planting densities, amount of the hybrid fed to various groups of cows and of course NDF-digestibility.

Forage Maturity and DM

Harvesting forages at optimum maturity is important because it sets the stage for the rest of the year. High forage quality drives intake and in turn, this drives milk production. Not even the best nutritionists in the world can make cows maximize their milk production if they are working with poor quality forages. Corn silage should be harvested when the whole plant is at 32 to 35% DM and the kernels are at ½ milk line. However, milk line and whole plant DM do not always match up. In all cases, whole plant DM should be the overriding factor for corn silage harvest. To monitor whole plant DM, cut representative samples of corn plants from the

field and have them chop them. Collect the chopped material and dry it down with a microwave or Koster moisture tester. Depending on the conditions, corn silage will dry down at a rate of about 0.5 percentage units per day (faster in dry and hot weather). Based on your acres and equipment you may have to start at a lower DM and you may end at a higher DM but the key is to avoid the extremes. Harvesting corn silage that is too wet (typically < 28-30% DM) results in excessive fermentations that produce high concentrations of acids and results in nutrient run off. Specifically, these wet silages are often characterized by high concentrations of acetic acid produced from “wild-type” fermentations. A common problem when feeding large quantities of wet corn silages is a reduction in DM intake because of the high acid content. In contrast, extremely dry corn silage (> 38-40% DM) should be avoided because the low moisture restricts fermentation and this material is more difficult to pack which often leads to poor aerobic stability. In addition, dry corn silage is usually very mature and thus fiber and starch digestibility are low.

One of the biggest challenges for making good alfalfa or grass silage is managing the period of wilting to result in maximum conservation of fermentable sugars and obtaining an adequate dry matter level to prevent the growth of clostridia. During prolonged wilts, sugars are metabolized by the plant in the windrow thus a quick dry down is beneficial. Wet grass and alfalfa silages are highly prone to undergo clostridial fermentations when the dry matter is less than 30-35%. Wilting these crops above this level makes it harder for clostridia to dominate the ensiling process.

Cutting Height

Corn silage is normally harvested to leave 4 to 6 inches of stalk in the field. Typically, the only time that cutting height should be higher is during drought years when the potential for nitrate accumulation in the lower third of the stalk may occur. However, some dairymen have been high-cutting their corn silage as a normal practice for years. Leaving more of the stalk in the field that contains high concentrations of fiber and lignin may also help to improve soil conditioning. Research has shown that high cut corn silage (typically leaving 18 to 20 inches of stalk) results in silage with slightly lower concentrations of fiber and lignin, but higher concentrations of starch and net energy (Wu and Roth, 2003). A small yield drag of about 5 to 10% can be expected. Disappointingly, improvements in NDF digestion have been very small. The ultimate success of high cutting corn silage will depend on milk produced per ton of forage and milk produced per acre of forage.

Particle Size

Chopping corn silage too fine and too coarse should be avoided. Finely chopped silage reduces the effective fiber and coarsely chopped silage does not pack well and often leads to sorting of the TMR. Recommendations for theoretical chop size usually run between 3/8 to 1/2 inch for unprocessed corn silage and about 3/4 inch for processed silage). In diets where corn silage makes up the majority of the forage, 15 to 20% of the particles should be greater than 1.5 inches long. If using a Pennsylvania State Forage Separator with the fourth box (now with a top, middle, low screens and bottom pan), about 8 % of the corn silage should be retained on the top screen to ensure optimum levels of effective fiber in the diet. If corn silage is not the major forage in the diet, about 3% of the top screen may be sufficient. For corn silage, the middle

screen should have 45 to 65% of the particles after shaking and there should be no more than 5% of particles on the bottom pan. If corn silage is processed, a higher proportion of particles can be targeted for the top screen. In measurements that we have taken, some baggers decrease the proportion of corn silage particles on the top screen by about 10 to 15 units so this must be taken into consideration when setting chop length. Instructions for using the new particle size separator can be found at: <http://www.das.psu.edu/TeamDairy/>. In general, if faced with drier forages, one can cut shorter to achieve a tighter pack. If feeding long hay, silages may also be cut a bit shorter.

Mechanical Processing

Mechanical processing of whole plant corn has been an accepted method to improve the quality of corn silage (Johnson et al., 1999). Whole plant processing crushes the entire plant through rollers and can be accomplished in the field during harvesting, at the silo but prior to storage, or after ensiling and just prior to feeding. Processing corn silage improves starch and allows for good packing in silos even with a longer length of particle chop. Rollers should be set to obtain adequate kernel damage. In drier and more mature corn silage, clearances between rollers will usually need to be tighter. However, care should be taken to monitor the effectiveness of the processing. When large amounts of acreage require harvesting, there may be a tendency to open the rollers more than what is recommended in order to speed up the harvest, reduce energy use and to reduce wears on equipment. As a rule of thumb, adequate processing is occurring if more than 90-95% of the kernels are crushed or cracked and cobs are more than quartered. Many labs currently provide a Corn Silage Processing Score, which is coupled to NIR analyses of corn silage. A dried corn silage sample is sifted through several screens and particles of corn that are greater than $\frac{1}{4}$ to $\frac{1}{2}$ of a kernel are retained on a screen and considered difficult to digest. The score provides feedback on processing as “optimum”, “average”, or “inadequately processed”. (One draw back is that the test takes several days for completion). An improvement in starch digestion is greater when more mature corn silage (e.g., black layer) is processed. However, always target harvest for 32-35% DM (whole plant DM). Corn should probably not be processed if harvesting forage that is less than 30% DM and especially if the corn has not dented. Improvements in fiber digestion due to mechanical processing are inconsistent. When there are reasons out of your control (inclement weather, equipment problems, and scheduling problems with a contractor) those results in corn being harvested at later stages of maturity, processing should be considered. A common observation by producers switching to processed corn silage is the reduction in cobs in the feed bunk and a reduction in kernels in the manure.

Keys to Making Good Silage

The keys to making quality silage are to 1) rapidly exclude air from the forage mass, which will result in 2) a rapid production of lactic acid and reduction in silage pH, and 3) to prevent the penetration of air into the silage mass during storage. Excessive air, due to slow silo filling or poor packing (overly dry forage or forage chopped too coarsely) allows the plant to respire for prolonged periods of time. This results in utilization of sugars and excessive degradation of plant protein. Air also encourages the growth of undesirable microbes such as yeasts and molds.

Air can be eliminated by fast filling (but not too fast), even distribution of forage in the storage structure, chopping to a correct length and ensiling at recommended dry matters (DM) for specific storage structures. Bunk and pile silos should be filled as a progressive wedge to minimize exposure to air and packed in 6 to 8 inch layers. The recommended optimal packing density for bunk silos is 14 –16 lbs. of dry matter per cubic foot (Ruppel et al., 1995). Silage corers can be obtained from several commercial sources. An Excel spreadsheet can be downloaded from the University of Wisconsin Extension web site that helps with bunker silo filling (www.uwex.edu/ces/crops/uwforage/storage.htm). Users can input silo dimensions, tractor weight, forage delivery rate, forage dry matter, and packing time to estimate packing density. In several recent surveys of bag silos, packing densities are more commonly between 9 to 12 lb of DM/cu ft. Silage in bags should be packed tightly by monitoring the stretch marks on the bags. Tunnel extensions on older units can be added to increase pack density. Silo bags should be vented for about 3 days to rid the bags of excess gas.

Under anaerobic conditions (lack of air) silage fermentation is dominated by microbial activity. Fermentation is controlled primarily by a) type of microorganisms that dominate the fermentation, b) available substrate (water soluble carbohydrates) for microbial growth, and c) moisture content of the crop. Lactic acid-producing bacteria utilize water-soluble carbohydrates to produce lactic acid; the primary acid responsible for decreasing the pH in silage. Unlike alfalfa and other grass silages, corn silage rarely undergoes clostridial fermentation. However, because of its high starch content, preventing the proliferation of yeasts that produce alcohol and cause lower DM recovery is a challenge in corn silage. Yeasts are also responsible for aerobic spoilage of silages during storage and feed out.

Microbial Inoculation

Because forage often naturally contains many detrimental types of bacteria, the concept of adding a microbial inoculant to silage was to add fast growing homofermentative lactic acid bacteria in order to dominate the fermentation resulting in higher quality silage. Some of the more common homolactic acid bacteria used in silage inoculants include *Lactobacillus plantarum*, *L. acidophilus*, *Pediococcus acidilactici*, *P. pentocaceus*, and *Enterococcus faecium*. Microbial inoculants contain one or more of these bacteria which have been selected for their ability to dominate the fermentation. The rationale for multiple organisms comes from potential synergistic actions. For example, growth rate is faster in *Enterococcus* > *Pediococcus* > *Lactobacillus*. Some *Pediococcus* strains are more tolerant of high DM conditions than are *Lactobacilli* and have a wider range of optimal temperature and pH for growth (they grow better in cool conditions found in late Fall and early Spring). When compared to untreated silages, silages treated homolactic acid bacteria are often lower in pH, acetic acid, butyric acid and ammonia-N but higher in lactic acid content and have better DM recovery (Muck and Kung, 1997).

Lactobacillus buchneri has been proven to improve the aerobic stability of silages. In the silo, *L. buchneri* results in a “controlled” fermentation that produces moderate amounts of acetic acid which limits the growth of spoilage yeasts. Production of moderate amounts of acetic acid by this organism is not detrimental to intake nor does it lead to excessive amounts of DM loss during ensiling (Kleinschmit and Kung, 2006). Recently, *L. buchneri* has been combined with traditional homolactic acid bacteria to form “combination” inoculants that are specifically

designed to speed up the fermentation process and to improve the aerobic stability (shelf life) of silages.

The location of applying a microbial inoculant is important. If silage is to be stored in a bunk, pile or pit silo I would recommend that the inoculant be applied at the chopper for a more even distribution. Remember that these bugs don't have legs, nor do they swim! If all the inoculant gets put on in one spot, it will probably stay there. (Some distribution will occur during tractor movement and packing, but this is not efficient.) For silage that will be stored in a bag silo, application at the chopper or bagger will probably not make a difference. (In a few instances, forage is chopped and harvested far away from where it is ensiled. Under these circumstances, I would prefer to have the inoculant applied at the chopper so that the microorganisms can begin their work right away.) Don't forget to properly calibrate your applicators to match forage delivery and don't increase the dilution or reduce the application rate! Also, remember that inoculants in water are stable for about 2 to 3 days but maybe less under very hot temperatures. If for some reason, unused liquid inoculants must be stored, do so in shade and place a few ice packs into the liquid to lower the temperature of the liquid. Do not allow the temperature of water in the applicator tanks to rise above about 100°F as this may decrease the viability of the bacteria (Mulrooney and Kung, 2008). Seal any unused portion of powders tightly to protect from moisture and stored in a cool area.

Sealing Silos and Fermentation

After filling silage should be covered with plastic as soon as possible and weighted down with tires (tires should be touching) or gravel bags to exclude air. Split tires are good alternative because they are easier to handle, do not accumulate water (thus less breeding grounds for mosquitoes that could carry the West Nile Virus), and are undesirable for animals to nest in. The return on investment (labor and plastic) is extremely high for covering bunk and pile silos (Bolsen et al., 1993). Oxygen barrier plastics are also now available for use (Borreani et al., 2007).

When conditions allow for it, silage should ferment for a minimum of 6 to 8 weeks before feeding. A gradual transition over a 10 to 14 day period from old silage to new silage is also recommended. Unfermented feed is the equivalent of feeding green-chop that is high in fermentable sugars and can cause cows to go off feed and have loose manure.

Silage Feedout

Proper management for removal of silage from silos and management at the feed bunk can help producers to maximize profits and production. Enough silage should be removed between facing to minimize aerobic spoilage. Lesser amounts may be removed in areas of the country where ambient temperatures remain cool during the winter months. Removal of silage should be such to minimize loose silage on the ground between feedings. Hot, moldy feeds should not be fed because they are low in nutritive value and digestibility and depress intakes. Feed bunks should be kept full but clean of decaying feed. Face shavers are becoming popular (W. C. Stone: <http://www.ansci.cornell.edu/prodairy/health/reducingpap.pdf>) but research is needed on their benefit. Extreme care should be taken to prevent air from penetrating between

the plastic and reaching the silage mass. Examples of putting more weight on the plastic at the leading face are shown (Figure 1).

Conclusions

Great care should be taken to preserve and maintain the nutritive value of forage crops. Management starts in the field with harvesting crops at the optimum maturity and then following this with a quick wilt (for grasses and alfalfa), by chopping to an adequate particle size, treating with a good microbial inoculant, processing the plant (for corn silage), filling silos quickly and packing them tightly and finally managing the silage in the silo with plastic and weights to minimize exposure to air.

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Figure 1. Placing more weight on the leading face of silos minimizes air from penetrating into the silage mass.



