Management Guidelines During Harvest and Storage of Silage

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Abstract

Management techniques during harvest and storage can have marked effects on the quality of forages stored as silage. Wilting to correct moistures and chopping forages to recommended particle lengths will help during the silo packing process. High cutting of corn silage may be an option for some producers to consider in the future. However, no recommendations can be made until more research is completed. Mechanical processing of corn silage can help to improve its nutritive value by improving starch and fiber digestion. Rapid packing to recommended densities and excluding air from the forage mass stimulates a more optimal fermentation in the silo. To help with the ensiling process, microbial inoculation encourages a more efficient fermentation. When forages are drier than 40% DM, inoculants are more effective if applied in a liquid form. All silage additives should be added such that they are distributed evenly throughout the forage mass. Covering bunk and pile silos with plastic is a cost efficient mechanism to save nutrients during storage. Finally, good feedout and silo face management can also help to maintain silages with a high nutritive value.

Introduction

High quality forage drives milk production by stimulating dry matter intake. Therefore, insuring the availability of quality forage throughout the year is important. Assuming that forage is at the optimum stage of maturity, the next challenge is to harvest that forage and to store it so that it retains its nutritive value. 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 silage.

Preharvest Preparation

The condition of equipment to be used during harvest and silo filling should be optimized. Knives should be sharpened on the chopper. Silos and forage wagons should be cleaned before filling and moldy and spoiled silages should be removed so that they do not contaminate fresh forage. Bag, bunk and drive over pile silos should be placed in an area with good drainage and a slight pitch away from the feeding end of the bag to prevent accumulation of runoff and rain water. We preferably like to put bags and drive over piles on a poured concrete or asphalt pad. Although this can be costly, it speeds up silage removal and results in less waste, especially during rainy/muddy weather. The ground around bag silos should be kept clean and free of weed growth to deter damage to the bags by animals. When filling multiple bag silos keep them at least 4 ft apart. This will minimize damage to adjacent bags when feeding.

Chop Length

Cut forages at optimal theoretical length for the specific crop (e.g. alfalfa - 3/16 inch; unprocessed corn silage - 3/8 inch; processed corn silage - 3/4 inch). This is also a good time to measure actual particle size. 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, 5 to 10 % 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, 2 to 4% of the top screen may be sufficient. For processed corn silage, 15 to 25% of the forage should be on the top screen. Use caution as some, but not all, bagging machines can reduce particle size.

Cutting Height

Corn silage. 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. Preliminary research shows that when compared to normal-cut corn silage, high cutting (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 (Table 1). Leaving more of the stalk in the field that contains high concentrations of fiber and lignin may also help to improve soil conditioning. However, as expected, there is a small yield drag from high cutting. Ongoing research is evaluating this practice on different varieties and interactions with stage of maturity. The ultimate success of high cutting corn silage will depend on milk produced per ton of forage and milk produced per acre of forage.

Alfalfa. A recommended 1-inch cut height for alfalfa is dictated by yield and stand life. Although cutting at 3 or 4 inches may improve nutritive value, this is usually not justifiable because of the loss in yield. Belesky and Fedders[1] reported that cutting alfalfa at 1-2 inches resulted in 38% more yield than alfalfa cut at 4 inches. For healthy alfalfa, short cutting height does not reduce stand longevity. Leaving a 4-inch stubble may be justifiable under certain conditions. For example, leaving more stubble at fall cutting may allow for better snow cover to protect plants during cold winters. In addition, reserve of carbohydrate in the roots of stressed crops (excess moisture or too early of a cut) may benefit from a higher cut[7].

Mechanical Processing of Corn Silage

Mechanical processing of whole plant corn has been an accepted method to improve the quality of corn silage. 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 fiber digestion and allows for good packing in silos even with a longer length of particle chop. Rollers should be set at 1 to 3 mm (or follow manufacturer's guidelines for specific machines). 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 wear 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. In drier and more mature corn silage, clearances between rollers will usually need to be tighter. The theoretical cut of corn silage can be increased to 3/4 of an inch when corn silage is mechanically processed. This is useful because it improves effective fiber. Improvements in milk production appear to be about 1.5 to 2.0 lb/d, with larger improvements when more mature corn silage (e.g., black layer) is processed. However, always target harvest for 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. When there are reasons out of your control (inclement weather, equipment problems, scheduling problems with a contractor) that 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.

Table 1. Effect of cutting height on the composition and yield of corn silage.

Cut Height	DM %	NE_L mcal/lb	ADF %	ADL %	NDF %	Starch %	CP %	Tons per ace[1]
Normal[2]	35.3	0.72	24.6	3.58	45.3	31.5	7.50	26.5
High[3]	37.3	0.75	21.2	2.16	40.8	33.7	7.63	23.3

[1]Adjusted to 30% DM basis.
[2]Four inches of stalk left in the field.
[3]Eighteen inches of stalk left in the field.
(Jeanne Neylon, 2001. M.S. Thesis, University of Delaware,)

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. Delayed filling can result in a clostridial fermentation that is characterized by high concentrations of butyric acid and ammonia-N and poor digestibility (Table 2)[4]. Air also encourages the growth of undesirable microbes such as yeasts and molds.

Table 2. Effect of delayed filling on composition and *in vitro* dry matter digestibility of barley silage.[4]

Item	Control[1]	Delayed filling[2]
DM, %	36.3	36.2
pH	3.98	4.61*
Lactic acid, %	8.57	4.96*
Acetic acid, %	2.65	1.85*
Butyric acid, %	0.00	1.65*
Ethanol, %	0.96	1.29*
Yeasts, cfu/g	3.09	5.12*
IVDMD,[3] %	71.7	64.7*

*Different from control, $P < 0.05$.
[1]Forage, chopped and immediately packed into silos.
[2]Forage, chopped and exposed to air for 24 h prior to packing into silos.
[3]48 hour *in vitro* DM digestibility.

Silo Structures

Tower, bunk and bag silos are common choices for storing silage. Recently, however, there has been considerable interest in drive over piles. As the name implies, packing of a drive over pile should be in all directions. Cross packing helps to improve pack density. Typically, drive over piles should be no more than 18 to 20 ft at the crown and have a rise over to one side run of 3:1. Form drive over piles in the shape of bunk so that there is a "face" to feed from. Drive over piles are size insensitive but should be planned for adequate daily removal of silage from the face to prevent spoilage.

Consider having the face for feed out of your bunker, bag silo, or drive over pile open to a north easterly or south-easterly direction, which will put it away from most prevailing winds and rain and also minimize exposure of the silage face to the hot afternoon soon.

Silo Packing

Rapid filling and adequate packing are crucial regardless of silo type. Exclusion of air limits heating and encourages the ensiling process. A low packing density can lead to significant losses of dry matter during storage[3]. In a recent study from our laboratory, tightly packed alfalfa forage ensiled more quickly (Figure 1) than did loosely packed forage. Loosely packed forage also had more yeasts and molds at the end of ensiling than did tightly packed silage.

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. The density of bag silos can be monitored via density gauges or by monitoring the diameter of the bag. Bunk silos should be filled as a progressive wedge to minimize exposure to air. The recommended optimal packing density for bunk silos is 14 –16 lbs of dry matter per cubic foot. 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.

The Ensiling Process

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. Undesirable fermentations from microorganisms such as Enterobacteria and Clostridia can occur if the pH does not drop rapidly. Clostridia can be eliminated by harvesting forage at less than 68 to 70% moisture (more than 30 to 32% dry matter). Lack of air prevents the growth of yeast and molds and a low pH prevents the growth of most bacteria after fermentation is done. Silage can be kept for prolonged periods of time if these conditions prevail.

Form and Location of Microbial Inoculation

Research has proven that microbial inoculants can be useful by improving silage fermentation and resulting in more dry matter and nutrient recovery and improved animal performance[5]. However, several factors can affect how well an inoculant may work.

Silage inoculants are applied in a dry or liquid form and thus a logical question is: does the form of application change the effectiveness of an inoculant? A recent study from our laboratory showed that both a dry granular or liquid application of a commercially available si-

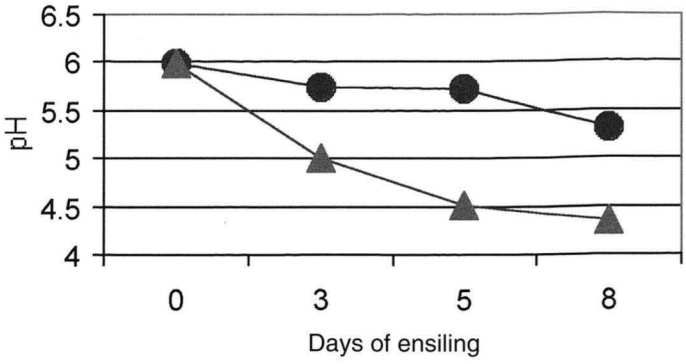

Figure 1. The effect of a tight (14-15 lb of DM/cubic ft, ▲) or loose (11-12 lb of DM/cubic ft, ●) pack on the decline in pH of alfalfa silage. (Lynch and Kung, 2001, unpublished data, University of Delaware)

lage inoculant were equally effective in improving the rate of fermentation of alfalfa with 30% DM[6]. In alfalfa from the same field, but wilted to about 54% DM, again both forms of inoculation stimulated the fermentation process when compared to untreated silage. However, the liquid-applied inoculant caused an even faster decline in pH than did the dry-applied inoculant (Figure 2). Similar results have been reported by German researchers on grass silage with a dry matter content of about 40%. Why did this happen? Inoculants applied in a dry form rely solely on moisture in or on the crop to resuscitate the organisms. In contrast, dried bacteria begin to resuscitate in the water used for a liquid application. Thus, it may take longer for the bacteria in an inoculant applied in a dry form to revive, resulting in a slower rate of fermentation than with an inoculant applied in water. We suggest that if all other things are equal, apply an inoculant that has been mixed in water to forage with ≥ 40% DM. To help with this recommendation, new high pressure/low volume liquid applicators require fewer refilling of inoculant tanks. (Do not mix an inoculant that has been designed for a dry application into water for a liquid application.) Be cautious of extremely low volume application rates (less than 8-10 oz per ton of forage) and ask for data that supports the use of such low rates.

The location of applying a microbial inoculant is also important. Common sense suggests that there are preferred locations for applying an inoculant depending on the situation a producer is faced with. For example, 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

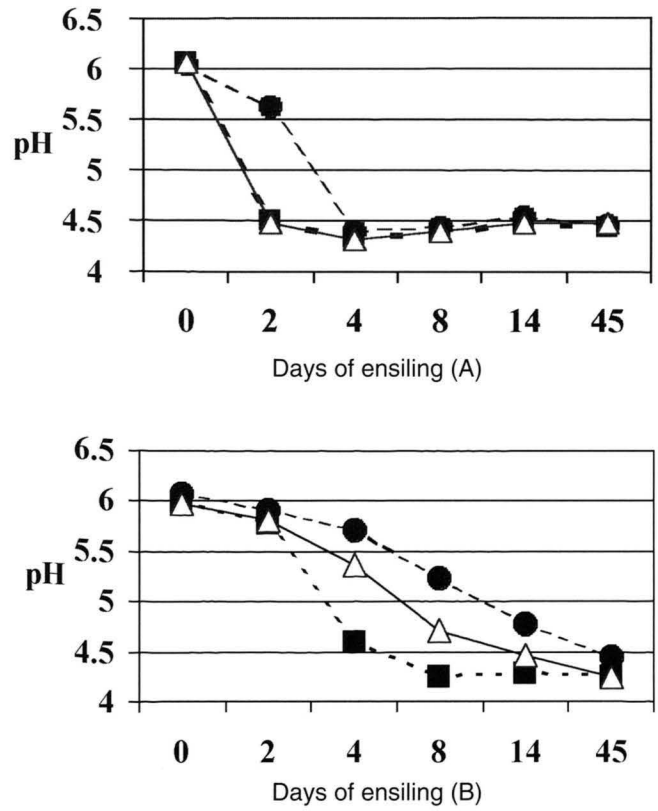

Figure 2. The effect of form of application of a microbial inoculant on the decrease in pH of low DM (A, 30% DM) and high DM (B, 54% DM) alfalfa silage. Untreated silage (●), silage treated with *Lactobacillus plantarum* MTD1(Ecosyl Products, Ltd., Stokesley, England) in a dry form (▲), silage treated with *Lactobacillus plantarum* MTD1 in a liquid form (■) (Whiter and Kung)[6]

that will be stored in a tower or bag silo, application at the chopper or blower/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!

Sealing Silos and Fermentation

Bunks, pits and drive over piles should be covered immediately with 6 mil plastic tarp and weighted with old tires (tires should be touching) to exclude air. Split tires are good alternative because they are easier to handle, do not accumulate water, and are undesirable for animals to nest in. The return on investment (labor and plastic) is extremely high for covering bunk and pile silos[2]. Conventional cement stave silos should be leveled and sealed with a silo cap immediately after filling.

When conditions allow for it, silage should ferment for about 3 to 4 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. For dairies that store silage primarily in tower or bunk silos, putting some forage into a bag silo that can be fed during silo filling (especially in the case of corn silage in the fall) is a good idea. This will allow for emptying of bunk or tower silos before filling and also allows for a uniform source of silage during this time. If possible, store bale and bag silos where they will be shaded from the hot afternoon sun. This will help to maintain silage quality for a longer period of time.

Silage Feedout

Proper management for removal of silage from silos and management at the feed bunk can help producers to maximize profits and production. Removal of about 3 to 4 inches of silage from conventional cement stave silos will help to prevent silage from heating in the silo. Because the density of pack is usually less in bunk and bag silos, it is recommended that 4 to 6 inches or more be removed form the face of silo during warm weather. 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. Cows respond best when offered fresh feed 3 to 4 times per day. Hot, moldy feeds should not be fed because it is low in nutritive value and digestibility and depresses intake. Feed bunks should be kept full but clean of decaying feed.

Summary

Good management practices during harvest and storage can help to maintain the high quality forage brought in from the field for storage. Moisture content, particle length, packing density, and covering silos eliminates air from the forage mass and encourages a good fermentation. Microbial inoculants can also help to improve the ensiling process. When forage is ≥ 40% DM, an inoculant applied in a liquid form is more effective than a dry-applied inoculant. Care must be taken to also distribute inoculant evenly through out the forage mass for maximum effectiveness.

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