Grass Silage Management: From Packing to Inoculants

Limin Kung, Jr.
University of Delaware

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. An excellent review on the use of perennial grass silages has recently been published (Harrison et al., 2003).

Keys to Making Good Silage

The keys to making quality grass silage are to 1) harvest the crop from the field at optimum maturity for good nutritive value, 2) wilt the crop as quickly as possible to an acceptable dry matter content to preserve nutrients and promote a good fermentation, 3) chop the grass to an optimal particle size to allow for good effective fiber and silo packing, 4) use a proven silage additive to promote a more efficient fermentation, 5) rapidly exclude air from the forage mass in the silo structure by packing silage tightly, 6) seal the silo as rapidly as possible after filling and 7) prevent the penetration of air into the silage mass during storage and subsequent feed out.

One of the biggest challenges for making good 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 silages are highly prone to undergo clostridial fermentations when the dry matter is less than 30-35%. Wilting grasses above this level makes it harder for clostridia to dominate the ensiling process.

Silo Structures

Tower, bunk and bag silos are common choices for storing silage. Choosing a silage structure has recently been reviewed by Muck and Holmes (2006). Although not a common choice for larger dairies, some new tower silos have the capacity of filling at 120 tons/hour and unloading at 1000 pounds/minute. Recently 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 have a downward run three times the height. “Modified” drives over piles have steeper sides and are common on large dairies. In these piles, side packing is accomplished primarily by driving up and down the sides so there is little cross packing in these areas. Drive over piles should be made in the shape of rectangle so that there is a defined and narrow “face” to feed from and not shaped as a circle or oval. 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 face it away from most prevailing winds and rain and also minimizes exposure of the silage face to the hot afternoon sun. Be sure there is a slight grade or pitch away from the face of any bunk, pile, or bag silo. This will prevent any seepage or rain water from draining back into the silage mass.

Silo Filling and Packing

Rapid filling and adequate packing are crucial regardless of silo type. Exclusion of air limits the growth of undesirable microbes that can cause excessive heating and nutrient loss. Chopped forages should be packed in silos immediately after chopping because delayed filling can result in a clostridial fermentation that is characterized by high concentrations of butyric acid and ammonia-N and poor digestibility (Mills and Kung, 2002, Table 1). In contrast, anaerobic conditions achieved by quick filling and good packing densities encourage the ensiling process.

Air can be eliminated by fast filling (but not too fast to compromise density), even distribution of forage in the storage structure, chopping to a correct length and ensiling at recommended dry matters for specific storage structures. Bunk silos should be filled as a progressive wedge to minimize exposure of forage to air. Obtaining adequate silage density is usually not a problem for tower silos. However, insufficient weight of pack tractors and packing too much forage at once often results in less than desirable silage densities in large bunk and pile silos. The recommended optimal packing density for bunk and pile silos is about 14 –16 lbs of forage DM per cubic foot. Lower packing densities trap air in the forage mass and can result in significant losses of dry matter during storage (Ruppel et al., 1995). To obtain tightly packed silage, delivery of forage to the silo must be matched with the ability of tractors (based on weight) to pack the material. A common thumb rule is to divide tractor weight by a constant number of 800. Thus, to theoretically obtain a good silage density, a total of 30,000 lb of pack tractor could handle about 38 tons (30,000 ÷800) of forage per hour. In real world situations this target is seldom met and it is a major reason why silage densities are often less than optimal. When needing more pack tractor weight, adding small light tractors does not improve density. Holmes (2006) recommended adding more weight with tractors that weigh more than 10,800 lb in order to improve silage density. Recommendations also suggest that forage be packed in small layers (6 to 8 inches) because packing larger layers results in lower densities. Most surveys of silo density have been conducted with corn silages and alfalfa. There is little information on density of grass silages in various storage structures. However, grasses and small grain silages are probably more challenging to pack tightly at high DM because of the hollow nature of their stems.

Drive over piles should be formed to have relatively narrow faces and longer length (rectangular in shape) and should not be made in the shape of ovals or circles. The best drive over piles are obtained when pack tractors can truly “cross-over” when packing. To be able to do this, theoretical lengths (run) of drive over piles should be about 3 times the height (rise). In real world situations these dimensions are seldom seen because they result in short, flat piles that take up considerable pad space. Modified piles with steeper side angles are common. For these piles, pack tractors on the side will pack vertically (up and back down) on the sides while other tractors will pack horizontal with the length of the silo.

Bags silos are also commonly used for all types of silages. Silage densities in bag silos (commonly 9 to 12 lb of DM/cu ft) are usually less than in piles or bunks. However, good quality silage can be made in bag silos because there is less exposure to air in well managed bags. Keys for good packing in silo bags include 1) monitoring brake tension on the bagger to ensure a tight pack, 2) even feeding rate into the bagger, 3) installing a tunnel extension (on older baggers) for tighter packing, 4) utilizing stretch marks on bags to ensure optimum packing, and 5) maintaining the integrity of the plastic throughout storage and use. Grass and small grain silages tend to expand after packing so fill bags slightly less than recommended.

Several excellent informational tools are available from the University of Wisconsin Extension web site that help with choosing silo types, and planning and packing of pile and bunker silos (www.uwex.edu/ces/crops/uwforage/storage.htm) and bunk corers are available from several suppliers that can assist in measuring silage 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. 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.

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. pentosaceus, 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 choosing a silage inoculant, do so based on published research data that support its claims.

When compared to untreated silages, treatment with adequate numbers of viable homolactic acid bacteria results in silage with a lower pH, and lower concentrations of acetic acid, butyric acid and ammonia-N, but higher concentrations of lactic acid. A new silage microbe, *Lactobacillus 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) to silages. *Lactobacillus buchneri* was approved for use in the US in 2001 and in 2003 was able to make a claim for improved aerobic stability of silages (a claim no other silage inoculant can legally make) because anaerobic conversion of moderate amounts of lactic acid yield acetic acid. Acetic acid has good antifungal properties and thus retards the growth of yeasts and molds. *Lactobacillus buchneri* has been effective in corn silage, small grain and grass silages as well as in high moisture corn. 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 (Muck and Kung, 1997). 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 study from our lab showed that both a dry granular or liquid application of a commercially available silage inoculant were equally effective in improving the rate of fermentation of alfalfa with 30% DM (Whiter and Kung, 2001). 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. Similar results have been reported by German researchers on grass silage with a dry matter content of about 40%. Moisture in or on the crop is necessary to activate the microbes in dry-applied inoculants. In contrast, bacteria in inoculants 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 if the DM is about ≥ 40%.

The location of applying a microbial inoculant is also important because it can affect the distribution of the bacteria. 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 the inoculant should be applied at the chopper for a more even distribution. Remember that the microbes in an inoculant don't have legs, nor do they swim! If all the microbes are 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 tower or bag silo, application at the chopper or blower/bagger will probably not make a difference. Calibrating equipment for optimal rates of application is essential.

Most inoculants are stable in water for about 2 days. If for some reason, unused liquid inoculants must be stored, do so in shade and place ice packs into the liquid to lower its temperature. Tanks that store the liquid applied inoculants should be designed to reflect heat and placed so that they are away equipment that might expose them to high temperatures. Recent research from our lab showed that some bacteria in certain silage inoculants were adversely affected when exposed to high temperatures (Mulrooney et al., 2006). Any unused portion of granular or powders should be sealed tightly to protect them from moisture and stored in a cool area.

Sealing Silos and Fermentation

Bunks, pits, and drive over piles should be covered immediately with 6-8 mil plastic tarp and weighted with old tires (tires should be touching) to exclude air. Split tires are a 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 make undesirable nesting grounds for animals. Conventional cement stave silos should be leveled and sealed with a silo cap immediately after filling. The return on investment (labor and plastic) is extremely high for covering bunk and pile silos (Bolsen et al., 1993). Several alternatives to tires and a single layer of top plastic have been used with success in recent years. Plastic on the side walls has markedly reduced spoilage from water running down the sides of bunker walls into silage. Using two rather than one layer of plastic has also gained in popularity. Newer silo covering systems have utilized low oxygen permeable plastic to minimize exposure of silage to air and reusable gravel filled bags for weighting down plastic can minimize the need for using messy tires. Gravel bags can replace old tires in a ratio of 1 bag to about 4 to 5 tires (Figure 1).

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. In addition, feeding out bale silage as soon as possible will minimize potential quality loss from prolonged storage.

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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Table 1. Effect of delayed filling on composition and in vitro dry matter digestibility of barley silage.

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, log 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 in a forage wagon for 24 h prior to packing into silos.
[3]48 hour in vitro DM digestibility.

Figure 1. A research silo using gravel bags and protective tarp to cover a low oxygen permeable plastic compared to a single layer of plastic and tires.