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Silage Management in 2006: Common Problems and Possible Solutions

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Beef and dairy producers know problems occur in all silage programs. This paper describes possible causes and solutions for eight common pitfalls, which include:

- Safety issues for bunker silos and drive-over piles
- High ‘forage in’ versus ‘silage out’ losses in bunker silos, drive-over piles, and bags
- Large variation in the DM content and/or nutritional quality of the ensiled forage
- Missing the optimum harvest window for whole-plant corn
- Clostridial, butyric acid-containing hay-crop silage
- High levels of acetic acid, particularly in wet corn silage
- Aerobically unstable corn silage during feedout
- Excessive surface-spoiled silage in sealed bunker silos and drive-over piles

Beef and dairy producers should discuss these problems and solutions with everyone on their silage team as a reminder to implement the best possible silage management practices.

Safety Issues for Bunker Silos and Drive-over Piles

Consistently protecting workers, livestock, equipment, and property at harvest, filling, and feeding does not occur without thought, preparation, and training. You have nothing to lose by practicing safety: you have everything to lose by not practicing it (Murphy and Harshman, 2006).

Major hazards and preventive measures

- Tractor roll over.
  - ✓ Roll over protective structures (**ROPS**) create a zone of protection around the tractor operator. When used with a seat belt, ROPS prevent the operator from being thrown from the protective zone and crushed by the tractor or equipment mounted on or drawn by the tractor.
  - ✓ A straight drop off a concrete retaining wall is a significant risk so never fill higher than the top of a wall.
  - ✓ Install sighting rails on above ground walls. These rails indicate the location of the wall to the pack tractor operator but are not to hold an over-turning tractor.
  - ✓ Consider adding lights to the rail if filling will occur at night.
  - ✓ Form a progressive wedge of forage when filling bunkers or piles. The wedge provides a slope for packing, and a maximum 3 to 1 slope minimizes the risk of a tractor roll-over.
  - ✓ Backing up the slope can prevent roll backs on steep slopes.
  - ✓ Use low-clearance, wide front end tractors and add weights to the front and back of the tractors to improve stability.

  - ✓ When using front-end loaders to carry feed into the silo, do not carry bucket any higher than necessary to help keep the center of gravity low.
  - ✓ Front-wheel and front wheel-assist drive tractors provide extra traction and stability.
  - ✓ When two or more pack tractors are used, establish a driving procedure to prevent collisions.
  - ✓ Dump trucks, which are used to transport chopped forage in large-scale operations, can roll over on steep forage slopes, particularly if the forage in not loaded and packed uniformly.
  - ✓ Raise the dump body only while the truck is on a rigid floor of the storage area to prevent turn overs.
- ▪ Entangled in machinery.
  - ✓ Keep machine guards and shields in place to protect the operator from an assortment of rotating shafts, chain and v-belt drives, gears and pulley wheels, and rotating knives on tractors, pull-type and self-propelled harvesters, unloading wagons, and feeding equipment.
  - ✓ "The accident happened on Saturday June 14, 1974 while making wheat silage at Kansas State University's Beef Cattle Research Unit. The blower pipe plugged for about the 10th time that afternoon. I started to dig the forage out from the 'throat' of the blower, and the PTO shaft was making one more revolution … zap! The blower blade cut off the ends off three fingers on my right hand" (Bolsen, 2006).
- ▪ Run-over by machinery.
  - ✓ Never allow people on foot (especially children) in or near a bunker or pile during the filling operation.
  - ✓ Properly adjust rear view mirrors on all tractors and trucks.
- ▪ Fall from height.
  - ✓ It is easy to slip on plastic when covering a bunker, especially in wet weather, so install guardrails on all above ground level walls.
  - ✓ Use caution when removing plastic and tires, especially near the edge of the feeding face.
  - ✓ Never stand on top of a silage overhang in bunkers and piles, as a person's weight can cause it to collapse.
- ▪ Crushed by an avalanche/collapsing silage.
  - ✓ The number one factor contributing to injuries or deaths from silage avalanches is overfilled bunkers and drive-over piles!
  - ✓ Do not fill higher than the unloading equipment can reach safely, and typically, an unloader can reach a height of 12 to 15 feet.
  - ✓ Use proper unloading technique that includes shaving silage down the feeding face and never 'dig' the bucket into the bottom of the silage. Undercutting, a situation that is quite common when the unloader bucket cannot reach the top of an over-filled bunker or pile, creates an overhang of silage that can loosen and tumble to the floor.
  - ✓ Never allow people to stand near the feeding face, and a rule-of-thumb is never be closer to the feeding face than three times its height.
  - ✓ Fence the perimeter of bunkers and piles and post a sign, "Danger: Do Not Enter. Authorized Personnel Only".
- ▪ Complacency.
  - ✓ Mac Rickels, a dairy nutritionist in Comanche, TX almost lost his life the day he took silage samples from a bunker silo with a 32-foot high feedout face (Schoonmaker, 2000). Rickels said, "Even though I was standing 20 feet from the feedout face, 12 tons of silage collapsed on me. I didn't see or hear anything. I had been in silage pits hundreds of times, and you

just become kind of complacent because nothing ever happens. It just took that one time."

- ✓ Think safety first! Even the best employee can become frustrated with malfunctioning equipment and poor weather conditions and take a hazardous shortcut, or misjudge a situation and take a risky action (Murphy, 1994).
- ✓ It is always best to take steps to eliminate or control hazards ahead of time rather than to rely upon yourself or others to make the correct decision or execute the perfect action when a hazard is encountered.

High 'Forage In' vs. 'Silage Out' Losses in Bunker Silos, Drive-over Piles, and Bags

Solutions

- ▪ Select the right forage hybrid or variety.
- ▪ Harvest at the optimum DM content.
- ▪ Use the correct size of bunker or pile, and do not over-fill bunkers or piles.
- ▪ Employ well-trained, experienced people, especially those who operate the forage harvester, pack tractor, or bagging machine. Provide training as needed.
- ▪ Apply a HLAB inoculant.
- ▪ Achieve an optimum and uniform packing density in bunkers and piles (a minimum of 15 lbs of DM per ft^3).
- ▪ Provide an effective seal to the surface of bunkers and piles and consider using double polyethylene sheets or OB film.
- ▪ Follow proper face management practices during the entire feedout period.
- ▪ Start a silage quality control program and schedule regular meetings with your team.

Large Variation in the DM Content and/or Nutritional Quality of the Ensiled Forage

Causes

- ▪ Interseeded crops of different maturity.
- ▪ Multiple cuttings or multiple forages ensiled in the same silo.
- ▪ Delays in harvest activities because of a breakdown or shortage of machinery and equipment.
- ▪ Seasonal or daily weather affects crop maturing and field-wilting rates.
- ▪ Differences among corn hybrids. Hybrids with the stay-green trait tend to be wetter at a given kernel maturity than non stay-green hybrids.

Solutions

- ▪ Use multiple silos and smaller silos that improve forage inventory control.
- ▪ Ensile only one cutting and/or variety of 'hay-crop', field-wilted forage per silo.
- ▪ Minimize the number of corn and/or sorghum hybrids per silo.
- ▪ Shorten the filling-time, but do not compromise packing density.

Missing the Optimum Harvest Window for Whole-plant Corn

Causes

▪ Harvest equipment capacity is inadequate.
▪ The crop matures in a small harvest window.
▪ Warm, dry weather can speed the maturing process and dry-down rate of the crop.
▪ Wet weather can keep harvesting equipment out of the field.
▪ Sometimes it is difficult to schedule the silage contractor.

Solutions:

▪ Plant multiple corn or sorghum hybrids with different season lengths.
▪ Improve the communication between the dairy producer, crop grower, and silage contractor.
▪ Change harvest strategy, which might include kernel processing, shorter theoretical length of cut (**TLC**), or adding a pack tractor.

Clostridial, Butyric Acid-containing Hay-crop Silage

Causes

▪ The forage is ensiled too wet and undergoes a fermentation dominated by clostridia.
▪ Alfalfa and other legumes, which experience a rain event in the field after mowing, are at a higher risk because rain leaches soluble sugars from the forage.
▪ The forage is harvested too wet for the type and size of storage.

Solutions

▪ Chop and ensile all forages at the correct DM content for the type and size of silo.
▪ Proper packing to achieve a minimum density of 15 lbs of DM per ft^3 excludes oxygen and limits the loss of plant sugars during the aerobic phase (Visser, 2005; Holmes, 2006).
▪ Apply a homolactic bacterial inoculant (**HLAB**) to all forages to ensure an efficient conversion of plant sugars to lactic acid.
▪ Do not contaminate the forage with soil or manure at harvest.
▪ If it is not possible to control the DM content by wilting, the addition of soluble sugars can reduce the chance of clostridial fermentation and the problems associated with butyric acid silages.

High Levels of Acetic Acid, particularly in wet Corn Silage

Causes and symptoms

▪ When the whole-plant has a low DM content at harvest, it is predisposed to undergo a prolonged, heterolactic fermentation.
▪ This silage has a strong 'vinegar' smell, and there will be a 2 to 3 feet layer of bright yellow, sour

smelling silage near the floor of a bunker silo or drive-over pile.

Solutions

▪ Ensile all forages at the correct DM content, and especially not too wet.
▪ Use a HLAB inoculant to ensure an efficient conversion of plant sugar to lactic acid.

Aerobically Unstable Corn Silage during Feedout

Research has not explained why corn silages differ in their susceptibility to aerobic deterioration. Microbes, primarily lactate utilizing yeast, as well as forage and silage management practices contribute to aerobic stability of an individual corn silage (Uriarte-Archundia et al., 2002).

Solutions

▪ Harvest at the correct stage of kernel maturity, and especially not too mature.
▪ Ensile at the correct DM content, and especially not too dry.
▪ In normal conditions, do not chop longer than ¾-inch TLC if the crop is processed or ½-inch, if not processed.
▪ Achieve a minimum packing density of 15 lbs of DM per ft^3.
▪ Maintain a uniform and rapid progression through the silage during the entire feedout period**.** Remove a minimum of 6 to 12 inches per day in cold weather months and 12 to 18 inches per day in warm weather months.
▪ Minimize the amount of time corn silage stays in the commodity area before adding it to the ration. It might be necessary to remove silage from a bunker or drive-over pile and move it the commodity area twice daily.
▪ Do not leave corn silage rations in the feed bunk too long, especially in warm, humid weather.
▪ Add about 2 to 4 lbs of a buffered propionic acid product per ton of total mixed ration if heating does occur.
▪ Consider re-sizing a silo and subsequent feedout face for the time of year a silage will be feedout.
  ✓ Feed from ‘larger feedout faces areas’ in cold weather months.
  ✓ Feed from ‘smaller feedout faces areas’ in warm weather months.

Excessive Surface-spoiled Silage in Sealed Bunker Silos and Drive-over Piles

Solutions

▪ Achieve an optimum packing density (minimum of 15 lbs of DM per ft^3) within the top 3 feet of the silage surface.
▪ Shape all surfaces so water drains off the bunker or pile, and the back, front, and side slopes should not exceed a 3 to 1 slope.
▪ Seal the forage surface immediately after filling is finished.
▪ Two sheets of polyethylene or a single sheet of oxygen barrier (**OB**) film is preferred to a single sheet of plastic (Bolsen, 2004; Berger and Bolsen, 2006).

- Overlap the sheets that cover the forage surface by a minimum of 3 to 4 feet.
- Arrange plastic sheets so runoff water does not contact the silage.
- Sheets should reach 4 to 6 feet off the forage surface around the perimeter of a drive-over pile.
- Put uniform weight on the sheets over the entire surface of a bunker or pile, and double the weight placed on the overlapping sheets.
  - ✓ Bias-ply truck sidewall disks, with or without a lacework of holes, are the most common alternative to full-casing tires.
  - ✓ Sandbags, filled with pea gravel, are an effective way to anchor the overlapping sheets, and sandbags provide a heavy, uniform weight at the interface of the sheets and bunker wall.
  - ✓ Sidewall disks and sandbags can be stacked, and if placed on pallets, they can be moved easily and lifted to the top of a bunker wall when the silo is being sealed and lifted to the top of the feedout face when the cover is removed.
  - ✓ A 6- to 12-inch layer of sand or soil or sandbags is an effective way to anchor sheets around the perimeter of drive-over piles.
- Prevent damage to the sheet or film during the entire storage period.
  - ✓ Mow the area surrounding a bunker or pile and put up temporary fencing as safe guards against domesticated and wild animals.
  - ✓ Develop a rodent control program for the farm.
  - ✓ Use a mesh or resistant secondary cover to exclude birds.
  - ✓ Store waste polyethylene and cover weighting materials so it does not harbor vermin.
  - ✓ Regular inspection and repair is recommended because extensive spoilage can develop quickly if air and water penetrate the silage mass.
- Discard all surface-spoiled silage because it has a significant negative effect on DM intake and nutrient digestibility (Whitlock et al., 2000; Bolsen, 2002).
- Full-casing discarded tires were the standard for many years to anchor polyethylene sheets on bunker silos. These waste tires are cumbersome to handle, messy, and standing water in full-casing tires can help spread the West Nile virus, which is another reason to avoid using full-casing tires on beef and dairy operations (Jones et al., 2004).

Achieving a Higher Silage DM Density: Case Study Dairy Operation.

A high DM density in the ensiled forage is important. Why? First, density determines the porosity of the silage, which affects the rate at which air can enter the silage mass during the feedout phase. Second, achieving a higher density increases the storage capacity of a silo. Thus, a higher DM density typically decreases the annual storage cost per ton of crop by both increasing the amount of crop entering the silo and decreasing ‘forage in’ vs. ‘silage out’ losses.

Spreadsheet calculations of the average silage density in drive-over piles of corn silage on a case study dairy are presented in **Table 1**. The actual 2003 drive-over pile of corn silage had a DM density of 11.5 lbs per ft^3 and an estimated silage DM recovery of 77.5% (i.e., a 22.5% ‘shrink’ loss). The following changes were made for the 2004 corn silage: 1) the maximum pile height was lowered from 16 to 14 feet, 2) the forage delivery rate increased from 75 to 90 tons per hour, 3) the average forage DM content increased from 32 to 34%, 4) a second tractor was added to assist in packing, and 5) the estimated forage layer thickness decreased from 8 to 5 inches. These changes resulted in a predicted silage DM density of 15.8 lbs per ft^3 and an estimated silage DM recovery of 85.0% (i.e., a 15.0% ‘shrink’ loss) for the 2004 silage.

Profitability of Sealing Bunker Silos and Drive-over Piles

A spreadsheet to calculate the profitability of sealing silage in bunker silos and drive-over piles was developed from research conducted at Kansas State University from 1990 to 1995 and equations published by Huck et al. (1997). Huck et al. noted that about 75% of the total tons of corn and sorghum silage made in Kansas from 1994 to 1996 were not sealed, and the value of silage lost to surface spoilage was 7 to 9 million dollars annually. Presented in **Table 3** are examples from the spreadsheet. The profitability of properly sealing bunkers and piles with 6-mil standard plastic or an improved OB film makes it clear that producers should pay close attention to the details of this ‘highly troublesome’ task.

Dagano (1999) introduced the OB film as an alternative to standard plastic at the XII International Silage Conference in 1999. Wilkinson and Rimini (2002) reported virtually no visible surface mold and a markedly lower percentage of inedible silage for OB film-sealed pilot silos compared to the single and double standard film-sealed silos.

Bolsen (2004) compared the OB film to 6-mil standard black plastic in two field trials conducted from September 2003 to May 2004. The first trial was with whole-plant corn at a commercial feedyard near Dimmit, TX; the second trial, with high moisture (**HM**) corn at a feedyard near Garden City, KS. In Trial 1 the OB film and standard plastic were applied to side-by-side, 40 ft wide x 60 ft long areas of the bunker surface; in Trial 2, the OB film and standard plastic were applied to side-by-side, 130 ft wide x 60 ft long areas. The standard plastic and OB film was weighted with either full-casing, discarded car tires (Trial 1) or truck sidewall disks (Trial 2). A thin tarpaulin was put on the film ahead of the tires or sidewalls because the OB film did not have protection from ultraviolet light. The sealing materials were removed about 240 day post-filling and samples taken at 0 to 6, 6 to 12, and 12 to 18 inches from the surface at four locations across the width of each test area.

There was virtually no visible discoloration or surface spoilage in the OB film-sealed bunkers, however there was visible mold and aerobic spoilage in the standard plastic-sealed bunkers, particularly in the top 12 inches of corn silage. The corn silage and HM corn in the top 0 to 18 inches under the OB film had better fermentation profiles and lower estimated additional spoilage losses of OM compared to the corn silage and HM corn under the standard plastic (**Table 2**).

When compared to standard plastic in a 1,152-ton capacity bunker silo, OB film would result in the net saving of $490 of corn silage in the original top three feet (**Table 3**). In a 180 x 280 drive-over pile of corn silage, OB film would produce a net savings of $6,140 of silage in the original top three feet compared to standard plastic (**Table 3**). In a 100 x 150 drive-over pile of alfalfa haylage, OB film would produce a net savings of $18,600 of haylage in the original top three feet. Additional information about the OB film is located at www.silostop.com.

Profitability of HLAB-treated Corn Silage for Growing Cattle

Many dairy producers, nutritionists, and custom silage operators are concerned about whether it is economical to use a HLAB when making corn silage. Presented in **Table 4** is an example from a spreadsheet, which show the profitability of inoculating whole-plant corn silage with HLAB for growing cattle.

The cattle in this example had an average weight of 650 lbs, a DM intake of 2.62% of body wt, a ration DM intake to gain ratio of 7.1, and an average daily gain of 2.39 lbs. The cattle performance responses to HLAB-treated corn silage were a 0.05 lb increase in DM intake (17.0 vs. 17.05 lbs per day) and an improved ration DM to gain ratio of 0.15 (6.95 vs. 7.1). The DM recovery response was 1.3 percentage units for HLAB -treated silage compared to the untreated silage (83.8 vs. 82.5). The gain per ton of 'as-fed' whole-plant corn ensiled was 91.78 lbs for the HLAB-treated vs. 88.45 lbs for untreated corn silage, which was an increase of 3.33 lbs. With a cattle price of $1.20 per lb and a HLAB cost of $0.75 per ton of crop ensiled, the net benefit per ton of crop ensiled was **$3.25.**

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Table 1. Spreadsheet calculations of the average silage densities in drive-over piles of corn silage on a case study dairy operation.[1, 2]

Component	Actual: 2003 corn silage	Predicted: 2004 corn silage
Bunker silo wall height, ft (0 for silage pile)	**0**	**0**
Bunker silo maximum silage height, ft	**16**	**14**
Forage delivery rate to bunker, fresh tons / hr	**75**	**90**
Forage DM content, % (note: decimal)	**0.32**	**0.34**
Estimated forage packing layer thickness, inches	**8**	**5**
Tractor # 1	**35,000 (80)** [3]	**35,000 (80)** [3]
Tractor # 2	**0**	**35,000 (95)** [3]
Estimated average DM density, lbs / ft^3	11.5[4]	15.8[4]
Maximum achievable DM density, lbs / ft^3	23.2[4]	24.8[4]

[1] Adapted from B. Holmes[a] and R. Muck[b]; [a]Biological Systems Engineering Dept. and [b]U.S. Dairy Forage Res. Center, UW-Madison and available at: ***www.uwex.edu/ces/crops/uwforage/storage.htm***

[2] Values in **bold** are user changeable.

[3] Estimated packing time as a percent of filling time is shown in parenthesis.

[4] Values are result of calculations. Note: intermediate calculations are not shown.

Table 2. **Effects of standard plastic and OB film on pH, fermentation profile, estimated additional spoilage loss of OM, and ash content in corn silage and high moisture (HM) corn at 0 to 18 inches from the surface at 240 days post-filling.**

	---------- Corn silage ---------		------------ HM corn ---------	
Item	std plastic	OB film	std plastic	OB film
DM content, %	29.2	31.6	72.3	73.2
pH	4.28	3.78	4.70	4.09
Estimated OM loss[1,2]	27.3	8.4	12.6	7.2
	------------------------ % of the silage DM -----------------------			
Lactic acid	2.7	6.8	0.86	1.08
Acetic acid	2.6	2.2	0.25	0.31
Ash	11.2	9.1	2.10	1.98

[1] Values are estimated additional spoilage loss of OM, calculated from ash content using the equations described by Dickerson et al. (1992).

[2] Ash content of the face samples was 8.4% for the corn silage and 1.85% for HM corn

Table 3. Profitability of sealing corn silage and alfalfa haylage in bunker silos and drive-over piles with standard plastic and OB film.[1]

Inputs and calculations	Bunker 1 corn std plastic	Bunker 2 corn OB film	Pile 1 corn std plastic	Pile 2 corn OB film	Pile 3 alfalfa OB film
Silage value, $ per ton	**32.50**	**32.50**	**32.50**	**32.50**	**60.00**
Silage density, lbs per ft^3 as-fed basis	**48**	**48**	**48**	**48**	**40**
Silo width, ft	**40**	**40**	**180**	**180**	**100**
Silo length, ft	**100**	**100**	**280**	**280**	**150**
Silage lost in the original top 3 feet:					
unsealed, % of the crop ensiled	**50**	**50**	**50**	**50**	**50**
sealed, % of the crop ensiled	**20**[a]	**12**[a]	**20**[a]	**12**[a]	**10**
Cost of covering sheet, ¢ per sq. ft	**3.5**	**10.0**	**3.5**	**10.0**	**10.0**
Silage in the original top 3 ft, tons	288	288	3,630	3,630	900
Value of silage in original top 3 ft, $	9,360	9,360	117,975	117,975	54,000
Silage lost if unsealed, $ per silo	4,680	4,680	58,970	58,970	27,000
Silage lost if sealed, $ per silo	1,870	1,120	23,590	14,150	5,400
Sealing cost, $ per silo	560	800	6,800	10,100	3,000
Silage saved by sealing, $ per silo	2,270	2,760	28,580	34,720	18,600

[1] Numbers in **bold** are inputs by the producer and changeable.

[a] Unpublished field trial data comparing standard plastic and OB film on bunker silos of corn silage and high moisture corn (Bolsen, 2004).

Table 4. Profitability of HLAB-treated corn silage for growing cattle.[1]

Ration ingredients	DM basis	Untreated ration	HLAB ration	Untreated ration	HLAB Response[2]	HLAB ration
	%	DM, %	DM, %	lb per day		lb per day
Corn silage	**87.5**	**0.333**	**0.333**	14.88		14.92
Other silage or hay	**0**	**0.90**	**0.90**	0		0
Grain or supplement	**12.5**	**0.90**	**0.90**	2.12		2.13
Total	100			17.0		17.05
Avg. cattle wt, lb	**650**					
Cattle price, $ per lb	**1.20**					
Avg daily gain, lb				2.39		2.45
DM intake, lb per day				**17.0**	**+ 0.05**	17.05
Ration DM per lb of gain, lbs				**7.1**	**- 0.15**	6.95
Silage per lb of gain, lb of DM				6.21		6.08
Silage per lb of gain, lb as-fed				18.7		18.3
DM recovery, % of the ensiled crop				**82.5**	**+ 1.3**	83.8
Gain per ton of as-fed crop ensiled, lb				88.45		91.78
Value of the extra gain per ton of crop ensiled, $				---		4.00
Cost of HLAB per ton of crop ensiled, $				---		**0.75**
Net benefit per ton of HLAB-treated crop ensiled, $				---		3.25

[1] Numbers in bold are user inputs and changeable

[2] Response is a 19-trial average across all HLAB products (Bolsen et al., 1992).