

CORN SILAGE: WHAT ARE THE KEY HARVEST PRACTICES FOR REDUCING LOSSES?

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ABSTRACT

Corn silage is commonly fed in California dairy operations, as it provides a source of digestible fiber and readily fermentable energy for dairy cattle. Recently, California silages have been adopted into environmental regulations. This proceedings paper addresses the challenges related to setting the harvest date, packing silage properly, and monitoring harvest parameters at the silage pit.

Key Words: corn, silage quality, dairy, California

INTRODUCTION

Ideal growing conditions combined with ample fertilizer (recycled manure) and irrigation infrastructure allow forages to be a major component of California dairy cattle rations. Ensiling preserves forages and allows for storage and feed out of high quality forage crops throughout the entire year. In recent years, emphasis has been placed on homegrown, high quality silage and reducing silage losses to offset increasing commodity prices. This is particularly important for California dairy production systems, where feed is the major operating cost. In 2012, feed accounted for 65% of the total cost to produce milk in California (CDFA, 2012). Until recently, regulatory considerations were not a factor in the way dairy producers grew, harvested, stored and fed silage. Today, California dairy producers in the San Joaquin Valley comply with some of the strictest air and water quality regulations in the nation. These regulations impact decisions made on the dairy, from how much fertilizer to apply to silage crops to the feeding management of silage to animals. Any discussion on silage management in California must now include this regulatory component.

This proceedings paper will cover key areas to reducing silage losses, with a focus on silage harvest. Select results from a 2013 silage management survey conducted in the San Joaquin Valley are presented.

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Setting a Harvest Date

Deciding on a harvest date to achieve optimal yield and quality is one of the most challenging management decisions of corn silage production. Although more information is needed to understand the interaction between maturity, hybrid genetics and environment, current data suggests that the most desirable dry matter (DM) at harvest is between 30 and 36%. Corn silage harvested too early (too wet) will have lower starch content and greater seepage losses. This leachate is high in soluble nutrients and a source of pollution that should be avoided. Further, wet silages undergo a poor fermentation that results in greater production of fermentation acids and a low lactic acid: acetic acid ratio. On the other hand, corn harvested too dry undergoes a limited fermentation and is harder to pack; both factors make silage more susceptible to aerobic deterioration during feedout and in the feedbunk. Also, mature forages can have compromised fiber and starch digestibility. In the 2008 California corn silage harvest season, dry matter averaged 31%, and ranged from 25 to 46%.

The challenges to meet the targeted DM are:

- a) *Variation in whole plant moisture within and across fields and varieties.* Based on field data (Heguy et al., 2010), there is a large variation in DM of fresh chopped material delivered to the silage pit in a single field. Results from the 2013 survey, indicated dairies filled a single silage structure with forage from more than five fields, and up to five different varieties. Differences in soil type, fertilization, irrigation and variety genetics within and across fields may explain the large variation in DM observed.
- b) *Large scale farming in California.* Approximately one-third of the silage structures in the San Joaquin Valley are being filled over the course of four to eight days. During the heat of the summer, DM may increase in 0.5 to 1.0% DM units a day, making optimal DM a difficult, moving target.
- c) *Timing since last irrigation.* It may take 10 to 20 days before the harvesting equipment can enter the field after the last irrigation. The soil type, field length, and ground preparation of the field are factors that affect irrigation timing. Furthermore, those relying on scheduled water deliveries may find it more challenging to time harvest with respect to desired crop DM.
- d) *Custom harvester schedule.* A custom harvester may have various clients with the same desired harvest date.

Proposed solutions to decide when to harvest

- a) *Check DM before harvest.* Dry matter can be estimated by looking at the canopy and the kernel milk line, however, based on research from the University of Wisconsin (Laurer,

2006), dry matter estimates are poor predictors of measured dry matter ($R^2=0.63$). Determination of DM ensures that the crop will be harvested at the right moisture and this is beneficial to 1) dairy producers because they will get the most out of their investment and 2) custom harvesters because they will avoid situations where they need to back off fields when the crop is too wet. Guidelines for DM determination of the corn silage crop are described in **Appendix I**.

- b) *Establish communication among the silage team members.* Share pre-harvest DM results with the silage team, as each member has a specific concern to address:
- The nutritionist is concerned with harvesting at a maturity that will match the herd's needs.
 - The grower and/or farming manager is concerned with timing the last irrigation and maximizing yield.
 - The custom harvester needs to schedule the harvest.
- c) *Estimate harvest duration.* Take into account the acreage and chopper units (# choppers and size) to estimate harvest duration. If harvest spans several days, up to a week, harvest should start at 30 – 32% DM, which should result in DM of 36 – 38% at harvest end.
- d) *Segregate forage based on DM.* If obvious differences in DM are observed within or across fields, it might be beneficial to build two silage structures, or utilize silage bags, based on DM. Operations where the chopper incorporates NIR technology could easily evaluate DM allowing decisions to be made on site. Space limitation in the commodity area often excludes this practice from being a viable option. With limited space, consider mixing dryer loads with wetter loads at the silage structure.

Achieving a Desirable Silage Density

The single most critical factor affecting the efficiency of forage preservation is the rapid removal of entrapped air within the forage mass (Woolford, 1990), followed by timely covering of the material. During silage fill out, the presence of oxygen maintains the respiration of the fresh plant material and the activity of obligate and facultative aerobic microorganisms (i.e. yeasts, molds, enterobacteria, lactic acid bacteria). This results in DM losses and delays the growth of the desired lactic acid producing bacteria. Most of the aerobic spoilage takes place during storage and feedout. Air can infiltrate the top, sides and face of poorly packed silage structures resulting in important DM and nutrient losses. Nevertheless, aerobic spoilage can be minimized if the forage is well compacted and the silage structure is sealed without delay.

Researchers from Cornell University (Ruppel, 1992) studied the relationship of packing density and DM losses in alfalfa silage stored for an average of 96 days: % DM loss= 29.1 – 0.936 x DM density (lbs DM/ft³). This relationship is shown in **Table 1**.

Table 1. Dry matter loss over an average of 96-day storage as a function of storage DM density

Density (lbs DM/ft ³)	DM Loss (%)
10	10.4
12	8.0
14	7.6
16	6.2
18	4.8
20	3.4

Results from a 2010 silage survey conducted in California (Silva-del-Rio and Heiman, 2011) indicated there is still opportunity for improvement in packing density (**Figure 1**).

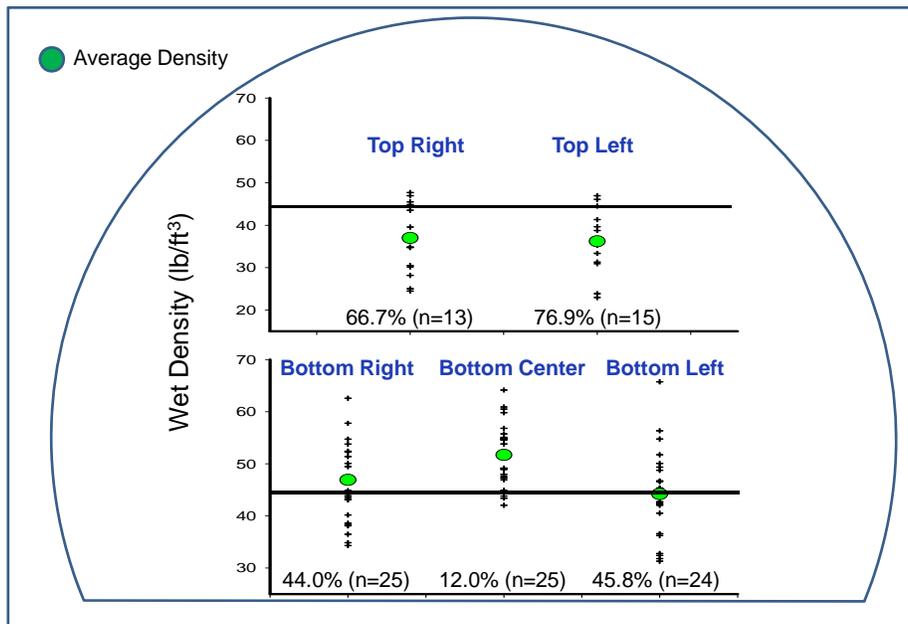


Figure 1. Percentage of wet density samples below 44lb/ft³ for each of the sample locations in twenty five corn silage structures in California.

Challenges to meeting the desired packing density

The tons of packing weight (tractor weight and number) needed are a function of the thickness of the forage layer pushed in the silage structure, the delivery rate of fresh chopped material into the silage pit, and the forage maturity or DM at harvest.

- a) *Delivery rate of fresh chopped material to the silage pit needs to match packing capacity.* During corn harvest in California, it is common to find crews with two, eight-row choppers. In those instances, a conservative estimate will be a delivery rate of 150 tons/h. Using the “800 lbs” rule of thumb, where 800lbs of packing weight is needed for every ton of crop delivered per hour, the result would be 120,000 lbs of packing weight required to achieve proper packing density. According to our survey, approximately two-thirds of dairies are using a single packing tractor. Furthermore, it is common to see trucks delivering fresh chopped material at unequal time intervals, resulting in even greater accumulation of forage at specific times.
- b) *Layer thickness.* It is advised to spread forage in thin layers (six inches or less) to aid in compaction. To achieve a six inch layer thickness, a truck load with 20,000 lbs of fresh chopped material at 30% DM would need to be spread over an area of 2,400 ft² (Holmes, 2006).
- c) *Top vs. bottom packing.* Based on data from Muck et al. (2004), more packing is necessary on the top half of silage structures. Similar results were observed in the California silage data set (Fig 1).
- d) *Forage maturity or DM at harvest.* As DM increases, packing becomes more difficult. Furthermore, wetter forages will have decreased porosity (air space within the forage mass) and higher wet density because of the higher pressure being generated with the added moisture in the silage pile.

Proposed solutions to achieve desirable density:

- a) *Adjust delivery rate.* The number and size of choppers should match the packing capacity at the silage structure. Discuss this with your custom harvester prior to harvest, and plan accordingly.
- b) *Ensure enough packing tractor time is available.* You cannot over pack silage. If there is enough space, adding a tractor could be the difference between a silage structure reaching the desired density and not. The cost of adding an extra tractor is approximately \$100 to \$120 per hour. With a harvest rate of 300 tons per hour, for 10 hours, a total of 3,000 tons will be packed in a day. Estimating corn silage at \$50/ton, it is only necessary to reduce DM losses by less than 1% to justify the cost of the extra packing tractor.

- c) *Maximize the efficiency of the packing tractor(s).* Check to see if the packing tractor(s) is constantly driving on the pile, and not merely pushing up feed and waiting for the next load to arrive. Ensure tractor drivers compact the entire surface, and pay special attention to the top half of the structures, where packing density tends to be the lowest.
- d) *Create a constant flow of material.* Ensure trucks are delivering forage at a constant rate to avoid clusters that overwhelm the packing tractor.

Monitoring During Corn Silage Harvest

Harvesting corn silage at the correct moisture and particle length, with adequate kernel processing, is imperative to creating a high-quality feedstuff to be utilized by California's high producing dairy cows. It is difficult to improve these parameters once the feed is ensiled, so monitoring should take place throughout harvest to ensure the desired, quality end-product.

Dry Matter

As previously mentioned, whole-plant corn DM is variable, even within a single field. From the 2013 survey, two-thirds of respondents evaluated DM during harvest, using either a koster tester or sending samples to a commercial lab for analysis. However, only 11% of the dairy producers reported a sampling frequency greater than six times per day. Knowing the DM at harvest will serve to:

- Adjust settings for theoretical length of cut and roller opening for kernel processing throughout harvest.
- Estimate tonnage of DM going into a silage structure. Previous work has identified sampling DM once per hour can reduce error in yield estimations to +/- 3% of actual forage removal (Heguy, et al., 2011). Taking a single sample to estimate DM for yield determination could over- or underestimate removal by as much as 20% in a single field of corn silage.

On-farm methods such as the microwave method or use of a koster tester can give us DM information in less than an hour. There is also the opportunity to use NIR technology, either on the chopper or with a mobile unit at the silage pit. The advantage of NIR technology is immediate feedback.

Particle Length

Particle length is especially critical when corn silage is the major, or only, source of effective fiber in the ration. If corn silage is cut too short it could affect rumen health and function in cows, whereas longer particles are easier for animals to sort out of the total-mixed ration (TMR). It is imperative to discuss harvest parameters with the dairy nutritionist to ensure adequate particle length is achieved. If particle length of corn silage is not critical in the ration, the length

of cut could be safely set to the lower settings. Achieving desirable particle length can be difficult if the crop standing in the field is lodged, or if the chopping equipment is not maintained (sharpening of knives) during harvest.

Kernel Processing

Kernel processing should result in 95% of corn kernels cracked, with at least 70% of the pieces smaller than one-quarter of a kernel. Kernel processing improves starch digestion, handling and packing of material, fiber utilization, feed intake, as well as reduces feed sorting. The most obvious consequence of improper processing will be corn kernels in feces when feeding corn silage. Samples evaluated for corn silage processing score (Mertens, 2005) between 2009 and 2011 were ranked as follows: 42% inadequately processed, 51% adequately processed, and only 7% optimally processed (Ward, 2011). Based on the 2013 survey, approximately 10% of dairies are still not processing kernels, and only half of those are considering adopting this practice in the future.

Kernel processing can be evaluated at the silage structure by:

- *Bucket method.* Kernels are separated from fodder by submerging fresh chopped material in a bucket of water (process explained in **Appendix II**).
- *Pioneer corn silage processing monitoring cup.* A 32 ounce cup is filled with fresh forage material and the content is spread out to find whole kernels. No more than two to three whole or half kernels should be found.

Suggested monitoring at the silage structure:

At least every hour, sample a truckload of forage for:

- DM determination, either on-farm (microwave, koster tester, NIR) and/or sent to a lab.
- Length of cut evaluation, either with the Penn State Shaker Box or a tape measurement.
- Kernel processing with the bucket method or the 32 ounce cup.

Results should be communicated to the dairy producer, farming operation (if a separate entity), and the custom harvester crew to make any necessary adjustments.

Custom Harvesters Evaluation

In California, 90% of dairy producers are using custom harvesting services, and most of them (70 to 80%) are satisfied with the services (2013 silage survey data). Inadequate packing was the most common complaint from dairy producers; however, only 10% of the dairies using custom harvesters considered doing their own harvesting in the future.

Future Harvest and Packing Considerations for Silage Management

In the 2013 silage survey, dairy producers were asked to rank various practices as 1) I am already doing this, 2) I would like to do this in the future, or 3) I will not do this in the future. As expected, most dairies currently kernel process corn silage, with very few dairies reporting it would not be done in the future. Increasing the silage storage area was reported as a practice to consider in the future by more than half the respondents, while about one-third of the dairies would also like to increase the number of packing tractors, plant brown mid-rib varieties, and create drive-over piles. Harvesting corn as shredlage was not a practice dairies considered for the future.

SUMMARY

Corn silage is a valuable commodity. Dairy producers should invest time and effort to coordinate growers, pest control advisors, custom harvesters and nutritionists to work towards the same goal: maximizing quality and quantity of the crop harvested and ensiled. Prior to harvest, it is very important that the silage team works together 1) to set the harvest date, 2) to explore opportunities to improve silage density (adding tractor time, building different silage structures), and 3) to decide the desired dry matter, length of chop and kernel processing at harvest. During harvest is imperative to monitor the fresh forage material for dry matter, kernel processing and chop length as well as ensure that delivery rate is adequate and packing time appropriate.

REFERENCES

1. Heguy, J.M., Karle, B.M., Price, P.P., Meyer, D. 2010. Calculating field nutrient removal rates to comply with General Order for existing Milk Cow Dairies from California's Central Valley Regional Water Quality Control Board. In:Proceedings of the American Dairy Science Association Annual Meeting, Denver, CO.
2. Heguy, J.M., Karle, B.M., Price, P.P., Meyer, D. 2011. Variability in dry matter content of harvested corn for silage. In:Proceedings of the American Society of Agronomy, California Chapter, Fresno, CA.
3. Holmes, B.J. 2006. Density in silage storage. Pages 214 – 238. In: Proc. Silage for Dairy Farms: Growing, Harvesting, Storing and Feeding Conf, Harrisburg, PA.
4. Laurer, J. 2006. Methods and targets for determining harvest. Pages 58-64 In: Proc. Silage for Dairy Farms: Growing, Harvesting, Storing and Feeding Conf, Harrisburg, PA.

5. Mertens, D.R. 2005. Particle size, fragmentation index, and effective fiber: Tools for evaluating the physical attributes of corn silages. 4-State Dairy Nutrition and Management Conference, Dubuque, IA. Midwest Plan Service, Iowa State, Univ., Ames. Pages 211-220.
6. Muck, R.E., B.J. Holmes, and P. Savoie. 2004. Packing practice effects on density in bunker silos. ASAE Paper No. 041137, Amer. Soc. Agric. Engineers, St Joseph, MI.
7. Ruppel, K.A. 1992. Effect of bunker silo management on hay crop nutrient management. M.S. Thesis, Cornell University, Ithaca, NY.
8. Silva-del-Río, N. and C. Heiman. 2011. Chop length, dry matter and density of wheat and corn silage structures in California. In:Proceedings of the American Dairy Science Association Annual Meeting, New Orleans, LA.
9. Ward, R. 2011. Analyzing silage crops for quality: what is most important? Alfalfa and forage symposium, Las Vegas, NV.
10. Woolford, M.K. 1990. The detrimental effects of air on silage. J. Appl. Bacteriol. 68:101-116.

APPENDIX I.

Dry Matter Determination of the Corn Crop Prior to Harvest

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The dry matter of the crop standing in the field can be estimated by evaluating the greenery of the canopy, breaking down the stalk and examining the kernel milk line. But, how well does that relate to actual dry matter? We suggest you to take a new approach that may help you to more accurately determine the dry matter of the crop standing in the field.



Step 1. Take a representative sample of the field. **Select 10-20 plants** at different locations away from the head or tail of the field. Enter the field several rows from the edge. You can use a machete or pruning shears.



Step 2. Hand feed the plant to a **chopper** (you can use a chipper shredder).

Place a bag to collect the chopped material.



Step 3. Take a **representative sample**:
Method 1 (more accurate): divide your sample in quarters and discard two opposite quarters. Mix the other two quarters and repeat until you get a 1lb sample, or volume of 5-7 cups.
Method 2: Mix the pile well and collect 5-7 cups of forage throughout the pile.



Step 4. Place your sample in a plastic bag and keep on ice. Take the sample quickly to a lab or to your dairy for dry matter determination. It is important to get the wet weight as soon as possible.



Step 5. Use approximately 100 g for microwave method or 200 g for Koster Tester (1lb = 454 g). You may also find a nearby lab where you can get timely results.

APPENDIX II.

Evaluating Kernel Processing During Harvest

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Kernel processing breaks up corn kernels, allowing the starch to be digested. If whole kernels pass through the animal, the starch is lost in feces rather than used as energy for milk production. By evaluating kernel processing at the time of harvest, adjustments can be made to ensure kernel processing is effective. Following are 6 easy steps to evaluate kernel processing:



- 1) Items needed: 5-gallon bucket filled with water and your silage sample.
- 2) Add silage sample to the water bucket.
- 3) Mix for several seconds.
- 4) Let the contents of the bucket settle.
- 5) Carefully pour off the water and floating material.
- 6) Kernels (and other dense material) sink to the bottom of the bucket; examine the kernels to ensure the majority are broken or crushed.