Agricultural Extension Service
The University of Tennessee
SP434-D

Corn Silage

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Corn silage is a high-quality forage crop that is used on many dairy farms and on some beef cattle farms in Tennessee. Its popularity is due to the high yield of a very digestible, high-energy crop, and the ease of adapting it to mechanized harvesting and feeding. Corn for silage fits ideally into no-till and double-cropping programs.

The object of silage making is to preserve the harvested crop by anaerobic (without oxygen) fermentation. This process uses bacteria to convert soluble carbohydrates into acetic and lactic acid, which “pickles” the crop. In a well-sealed silo, it can be stored for long periods of time without losing quality. To produce high-quality corn silage, it is important to do a good job in growing, harvesting and preserving the crop.

Growing Corn For Silage

1. **Lime and fertilize according to a soil test.** A good field of corn silage can yield 20-25 tons of wet forage per acre. A 20-ton yield will remove approximately 150 pounds of nitrogen (N), 65 pounds of phosphate (P_2O_5) and 160 pounds of potash (K_2O) per acre. In comparison, a 100-bushel corn crop will only remove 100 pounds N, 35 pounds P_2O_5 and 35 pounds K_2O. Be sure to fertilize and lime according to a current soil test. Proper pH and nutrient levels are necessary to raise a good corn crop. Without a soil test, there is an increased potential of reduced yield due to nutrient deficiencies. **When sending in soil for a soil test, be sure to indicate on the information sheet that you need a recommendation for corn silage and state the anticipated yield based on the quality of available soil resources.**

2. **Select the proper hybrid.** Research at The University of Tennessee has shown that corn hybrids that produce good grain yields also produce good quality silage. Since corn silage is used primarily as an energy feed, it is reasonable that high grain yields and good silage yields are related. Check with your local Extension office for the corn hybrid recommended list or see The University of Tennessee Agricultural Experiment Station annual bulletin *“Performance of Field Crop Varieties.”* If there is a history of specific diseases or pests on your farm, be sure to select varieties suited to those conditions.

3. **Plant at the proper time.** Plant corn for silage between April 20 and June 1. April and early May plantings will yield more than later plantings of corn.

4. **Plant at the proper population.** The University of Tennessee recommends planting

approximately 20 percent more plants when corn is grown for silage than when grown for grain. Plant populations should be based on the expected yield of silage. Table 1 is a guide for determining the plant population needed.

5. **Control weeds.** Weeds cause reductions in yield due to competition for nutrients and water. Herbicides may be used to effectively reduce this competition. Knowing the weed history in a field will be important in determining the best herbicides to use. For specific herbicide recommendations, see Extension PB 1580, *"Weed Control Manual for Tennessee,"* or check with your local Extension office.

These five steps form the basis for growing a good corn crop. For a more detailed discussion of growing corn, see Extension PB 443, *"More Corn Per Acre."*

Harvesting Corn For Silage

Corn silage that has been produced properly should have a green/yellowish color and a light, pleasant, slightly vinegar odor. If it is dark brown, or has another odor such as fruity, burnt or a rancid smell, improper fermentation or excessive heating may have occurred. Understanding the fermentation process may help explain some of the problems that can arise in silage production.

The fermentation process

When a corn plant is chopped and put into some sort of storage facility, the cells of the corn plant are still alive. The respiration of these plant cells and the microorganisms in the silage produce carbon dioxide and heat. This is called *aerobic* respiration, because oxygen is used. As the carbon dioxide level increases and the oxygen level decreases, this respiration will decrease and stop, and *anaerobic* (without oxygen) fermentation begins. In this process, desirable bacteria use the soluble carbohydrates in the cells to produce primarily lactic acid. Lactic acid causes a drop in the pH. Fermentation will occur until enough lactic acid is produced to drop the pH to approximately 4.2, at which point all bacterial action stops. This usually occurs within three weeks after a silo is filled (Figure 1). If low levels of lactic acid have been formed, then butyric acid, a foul-smelling acid, is produced and the silage spoils.

Table 1.
Recommended plant populations for corn to be used for silage.

expected yield potential	plants/ acre
15-20 ton yield	18,000 to 24,000
20-25 ton yield	22,000 to 26,000

Harvest at the correct stage

Proper timing of harvest is one of the most critical factors that will influence the quality of the corn silage produced. The stage of maturity of the corn will influence the quality of the corn silage because of the amount of nutrients in the plants as well as the amount of moisture present.

As a corn plant matures, the plant begins to dry down, and the moisture content in the plant drops (Table 2). If the moisture content is too high when the silage is cut, there can be seepage from the silo. This seepage contains high concentrations of soluble nutrients, which are lost. The seepage can cause considerable damage to upright silos. Another problem with chopping silage with too much moisture is that a larger amount of lactic acid is needed to reduce the pH. This results in a longer period of time before the silage becomes fermented, producing a lower quality silage.

In the opposite situation, if the plant does not contain enough moisture, then it will not pack well in the silo, more oxygen will be present and it will take longer to get through the aerobic phase into the anaerobic phase of fermentation. Nutrients will be used for respiration during the aerobic phase, the temperature of the silage will increase and possibly burn. This also results in a lower quality silage.

The proper moisture content of corn chopped for silage is between 60 and 70 percent. In bunker and trench silos, where

Figure 1. The process of corn silage fermentation.

aerobic phase	anaerobic phase				stable phase
day 1	**day 2**	**day 3**	**days 4-7**	**days 8-21**	**after day 21**
Cell respiration produces CO_2, heat and water.	Fermentation begins, producing acetic acid. Heating process slows.	Lactic acid production begins. Acetic acid production continues.	Lactic acid produced. Temperature drops.	Lactic acid produced. Silage pH drops and becomes stable.	Bacterial fermentation stops. Silage preserved until re-exposed to oxygen.
temp 70 F	95 F		80 to 85 F		Silage cools to ambient temperature.
pH 6.0	5.0	4.0			4.0

Table 2. Chemical composition of corn silage as affected by maturity.

measurement	milk line 1/3 down kernel	milk 2/3 line down kernel	black line formed
moisture (%)	68.34	60.86	54.6
neutral detergent fiber (%)	46.33	43.8	44.52
acid detergent fiber (%)	26.98	25.33	25.49
total digestible nutrients (%)	66.2	68.43	68.21
net energy -lactation (Mcal/lb)	0.68	0.71	0.70
digestibility - *in situ* (%)	60.32	58.81	56.35

Hunt and co-workers. 1989. Journal of Production Agriculture. 2:357.

packing is a problem, the upper side of this range is recommended. If the silage is going into an upright silo, packing is generally not a problem, so the lower end of this range will work satisfactorily.

The kernel milk line can be used to help estimate moisture. The milk line proceeds from the top to the bottom of the kernel as the plant matures. Generally, when the milk line is $^1/_2$ to $^2/_3$ down the kernel, the moisture will be in the 60 to 70 percent range (Figure 2).

The approximate moisture level of chopped silage can be determined by means of a "grab test." Squeeze the chopped forage tightly into a ball for 20 to 30 seconds, and then release quickly. Forage chopped into $^3/_8$ to $^1/_2$-inch pieces should be used. The condition of the ball and the approximate moisture levels are found in Table 3.

Preserving Corn Silage

Chop and pack - To preserve as much of the corn silage as possible, fill the silo as quickly as possible and pack well to decrease the amount of air pockets in the silage. Cutting the silage into $^3/_8$ to $^1/_2$-inch pieces will help packing. Removing as much oxygen as possible will decrease the time needed to begin the anaerobic phase of fermentation.

Fill fast and seal tight - Fill the silo as quickly as possible, and then seal it to exclude outside oxygen. The faster the silo is filled and covered, the faster the fermentation will begin, the lower the losses will be and the better the quality of the silage. Tables 4 and 5 show the approximate capacity of upright and bunker silos. It is important to consider the size of the silo to be used. Larger silos will hold more silage and will take longer to fill.

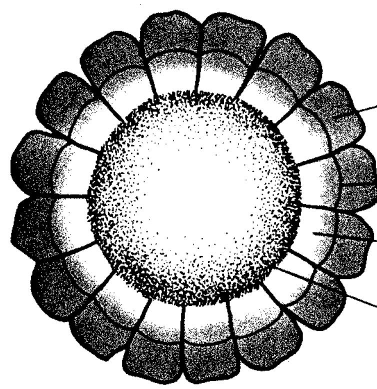

Figure 2. Cross section of the tip half of a corn cob showing milk line progression down the kernel.

After air has been thoroughly excluded from the silage by packing, cover the silo with 6 mil black polyethylene plastic to produce an air-tight structure. Preventing air and water from entering the silo is important for preserving the quality of the silage.

Upright silos - level the silage and form a trench in the silage around the wall of the silo. Place the cover over the silage with the

Table 3. Estimating moisture content of chopped forage using the "grab test."

condition of the forage ball	approximate moisture content
ball holds its shape and there is considerable free juice	over 75 percent
ball holds its shape but there is very little free juice	70 to 75 percent
ball falls apart slowly and there is no free juice	60 to 70 percent
ball falls apart rapidly	below 60 percent

Table 4. Approximate capacity of upright silos.

Size	Tons of Silage at 65% Moisture	Size	Tons of Silage at 65% Moisture	Size	Tons of Silage at 65% Moisture
12 x 30	60	20 x 40	256	24 x 50	497
12 x 40	88	20 x 50	339	24 x 60	651
12 x 50	121	20 x 60	452	24 x 70	823
14 x 30	82	20 x 65	523	24 x 80	1027
14 x 40	123	20 x 70	568	26 x 50	590
14 x 50	171	20 x 80	700	26 x 60	771
14 x 55	201	22 x 40	312	26 x 70	969
16 x 30	109	22 x 50	433	26 x 80	1226
16 x 40	161	22 x 60	549	30 x 50	771
16 x 50	218	22 x 70	690	30 x 60	1037
16 x 60	288	22 x 80	853	330 x 70	1344
18 x 40	206			30 x 80	1697
18 x 50	274				
18 x 60	365				
18 x 65	421				
18 x 70	459				

Source: National Feed Ingredients Association. 1991. Field Guide for Hay and Silage Management.

edges of the cover in the trench and up the sides of the silo. Place grain corn or wheat over the cover to seal the plastic against the silo wall and the packed silage.

Trench or bunker silos - pack to form a crown above the sides of the silo. Place the cover over the silage and extend over the walls of the silo to direct water drainage to the outside of the silo, away from the silage. Secure the cover with 3 to 4 inches of sawdust or a similar material. Old tires can be placed across the cover to help hold plastic and sawdust in place.

Silage Additives

Corn that is chopped for silage will generally ensile very efficiently. The high level of carbohydrates helps ensure that an abundance of lactic acid for preservation will be produced. If conditions for chopping or storing the silage are not ideal, fermentation may be delayed, causing a loss in forage quality. In these situations, silage additives have been recommended to improve the fermentation of the silage. It is important to remember that silage additives are not a replacement for good management. Paying attention to moisture content, chopping, packing, etc., still are the most important factors when producing corn silage.

Three types of compounds that can generally be added to corn silage when it is going into a silo are:

A. bacterial inoculants
B. acids
C. non-protein nitrogen sources

Table 5. Approximate capacity of bunker silos.

Size* width x height x length (ft)	Tons of Silage at 65% Moisture	Size width x height x length (ft)	Tons of Silage at 65% Moisture
20 x 8 x 40	114	40 x 20 x 80	1123
20 x 8 x 80	243	40 x 20 x 120	1763
20 x 12 x 40	163	40 x 20 x 160	2403
20 x 12 x 80	354	60 x 16 x 120	2154
40 x 12 x 80	711	60 x 16 x 160	2923
40 x 12 x 120	1097	60 x 16 x 200	3691
40 x 16 x 80	923	60 x 20 x 120	2643
40 x 16 x 120	1434	60 x 20 x 160	3606
40 x 16 x 160	1949	60 x 20 x 200	4566

Source: National Feed Ingredients Association. 1991. Field Guide for Hay and Silage Management.
** Excessive height of silage in a bunker or trench silo can be dangerous. Silage heights over 12 feet require care when extracting silage.*

A. Bacterial inoculants

Bacterial inoculants contain large numbers of the bacteria responsible for producing lactic acid. When these are added to corn silage, the increased concentration of the "good" bacteria results in the levels of lactic acid increasing at a faster rate, which results in a quicker drop in the pH. These inoculants do not generally help the fermentation of corn silage, due to the high levels of the bacteria occurring naturally on the corn plants, and high concentration of soluble carbohydrates in corn silage. If fermentation conditions are less than desirable, adding bacterial inoculants can be helpful.

B. Acids

The preserving acids help prevent a buildup of molds and bacteria that result in improper fermentation. This should allow more time for the lactic acid-producing bacteria to start producing lactic acid. As with the bacterial inoculants, corn silage does not normally benefit from these acids. Acids can be beneficial, however, on the upper surface of the silo, in particular with bunker or trench silos. Since packing is not as good in these silos, excess oxygen is present in the upper layers of the silage. Adding an acid before sealing this portion of the silo will help decrease the amount of spoilage. Buffered acids can be used for silage preservation with minimal corrosion of machinery.

C. Non-protein nitrogen sources

Corn silage is not considered to be high in protein. Adding a non-protein nitrogen (NPN) source such as urea as the silage goes into the silo can improve the crude protein content of the silage. Energy is required to utilize urea as a feed source. The high energy content of corn silage makes it an ideal feed to use with NPN. Research in Tennessee has shown that adding 10 pounds of urea per ton of silage is the most efficient rate to use NPN.

Conclusion

Corn silage is a high-quality feed that contains a high concentration of energy. It yields a high tonnage per acre, is easy to mechanically mix and feed, and can be preserved for long periods of time. Paying attention to the details listed above on growing, harvesting and storing silage will help ensure a valuable, high-quality crop.

Table 6. Corn silage evaluation form.

	Possible Score	Score Given
I. GRAIN CONTENT (Total 40)		
1. High - 35% and above	36-40	
2. Medium - 15 to 35%	28-35	
3. Low - 1 to 14%	16-27	
4. None (either no ears developed or ears removed)	0-15	
II. COLOR (Total 12)		
1. Desirable - green to yellowish-green	9-12	
2. Acceptable - Yellow to brownish	5-8	
3. Undesirable - Deep brown or black indicating excessive heating or putrefaction. Predominantly white or gray excessive mold development	0-4	
III. ODOR (Total 28)		
1. Desirable - Light, pleasant odor with no indication of putrefaction	24-28	
2. Acceptable - Fruity, yeasty, musty, which indicates a slightly improper fermentation. Slight burnt odor. Sharp vinegar odor.	11-23	
3. Undesirable - Strong burnt odor indicating excessive heating. Putrid, indicating improper fermentation. A very musty odor indicating excessive mold which is readily visible throughout silage.	0-10	
IV. MOISTURE (Total 10)		
1. No free water when squeezed in hand. Well preserved silage.	9-10	
2. Some moisture can be squeezed from silage or silage dry and musty.	5-8	
3. Silage wet, slimy or soggy, water easily squeezed from sample. Silage too dry with a strong burnt odor.	0-4	
V. CHOP (Total 10)		
1. Small, uniform, sharp angled pieces of silage.	9-10	
2. Silage uniform in cut, but slightly stringy, some large pieces of shucks, cobs, and stalks.	5-8	
3. Silage stringy, puffy or large variable sized pieces.	0-4	
	TOTAL	

Scoring:		
	90 and above	Excellent silage
	80-89	Good silage
	65-79	Fair silage
	Below 65	Poor silage

References

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