Bunkers, Piles, or Bags: Which is the most economical?

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Silage is an important feed ingredient for dairy cattle. Dairy producers must strive to deliver high quality forage in an economical manner to the cows. The "most economical manner" may not necessarily mean the lowest cost per ton of silage fed. It refers to the economics of the silage after accounting for the impact it might have on milk production (income) along with costs associated with producing, harvesting, storing, and feeding the silage. The lowest cost per ton should only be the goal if a *milk-production-per-ton-adjustment* has been made. The objective of this paper is to develop a framework for comparing the economics of three different types of silage storage structures. The framework includes procedures for evaluating bunker silos, drive-over or wall-less piles, and silage bags. A companion Excel spreadsheet (*SilageStorage$.xls)* is available at http://www.agmanager.info/livestock/budgets/production/default.asp#Dairy). This spreadsheet can be used as an aid for making decisions regarding these systems.

When evaluating the economics of silage storage alternatives it is important to recognize several factors. Silage storage costs will vary between dairies due to factors such as forage type, herd size, facilities, and management ability. Thus, dairies must evaluate the specific costs for their situation or operation. Some economic inputs required for evaluating storage alternatives may be difficult to quantify but impact the ultimate decisions. For example, labor availability for packing or covering silage piles, feed out considerations, delivery rate of silage to the storage area, etc. Even though some costs and benefits are difficult to quantify, producers should strive to realistically estimate these associated costs. After costs have been objectively estimated, other more subjective factors also may need to be considered in making the final decision. The following is a listing of some of the advantages and disadvantages of silage bunkers, piles, and bags that often dictate what is the most economical storage alternative for an individual dairy.

Concrete bunkers – Advantages of concrete bunkers include high capacity, smaller footprint, utilization of conventional farm equipment for packing, fast unloading rates, forage quality changes occur gradually if packed properly, relatively low annual "out-of-pocket" costs. Some of the disadvantages of bunkers are high initial investment, filling and packing influence dry matter losses, not cost effective for small herds, labor for sufficient packing and covering of silo is critical, and safety concerns.

Drive-over piles – Drive-over piles are advantageous since they require low capital investment relative to bunkers, flexibility in pile quantity, piles may be constructed with conventional farm equipment, and fast unloading rates. Some of the disadvantages of drive-over piles include larger amount of surface area and face area than bunkers, potentially high initial investment in the flooring or base, safety concerns, and labor availability for sufficient packing and covering.

Plastic bags – Positive benefits of bagging silage include low capital investment (assuming custom hire of bagging), flexible storage system (qualities and types), low DM loss if properly managed, small feed out face to manage, feed can be inventoried relatively easy, fewer safety

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hazards. Disadvantages of bagging silage include plastic bags are not reusable, large amounts of plastic to dispose of annually, high annual "out-of-pocket" costs, DM loss can be high if bags are ripped or torn, specialized equipment is necessary, more land area than bunkers or piles, potentially high initial investment in the flooring or base, small feed out face may be difficult to manage on large dairies feeding high volumes of silage, and preventing plastic from becoming part of the TMR.

Costs of Silage Storage

Determining the cost of delivering silage to the herd may be complex if all of the economic components such as silage production, storage, silage removal and delivery, are included. The relevant costs necessary to evaluate the possible storage alternatives differ between the systems. Some of these costs may differ but represent a small portion of total costs and may be ignored or assumed equal across systems. Therefore, it may not be economical or beneficial to perform detailed analysis due to cost of obtaining all the necessary information. For example, the equipment and costs associated with moving the silage from the pile to the TMR mixer box might vary between storage alternatives. This cost is likely to be similar and not a major concern if like equipment is used. On the other hand, differences in DM losses during handling between storage alternatives likely are important. Dairies should focus their efforts on the major cost differences and not be overly concerned about assuming minor costs that are similar across different alternatives. Costs that should be considered in a comparison include:

- costs associated with the investment in the site (including the development cost)
- cost associated with the different type of structures
- costs of packing or bagging
- costs for covering bunkers or piles
- dry matter (DM) storage and feed out losses
- costs associated with silage quality losses (loss of milk production)
- cost of silage delivered to the storage site – even though it should not vary between storage alternatives, this allows the total cost of silage to the dairy to be estimated.

Site and structures – The relevant cost associated with the site and structures is the annualized cost which is a function of the investment and structure life. Annual costs include things such as depreciation, interest, and repairs and maintenance. Depreciation should be a market-based depreciation as opposed to tax depreciation. Another cost associated with the site is the land area or foot print required. In many locations the annual costs of the land (interest times land value) will represent a small percent of total costs and thus could be excluded from the analysis. However, the physical size of the footprint (acres) is important to calculate. This parameter allows a dairy to know the area requirements of the storage system in case there are space constraints. While the land cost itself may represent a small percent of the total costs, the cost of *developing* the land (i.e., land leveling, base material, floor/surface, etc) can be significant and must be included.

Cost of silage delivered to storage – The cost of silage delivered to storage is similar to the purchase price for silage. This value reflects either the costs of production or a market value (i.e., opportunity cost) of home-grown silage.

Packing or bagging costs – The cost of packing or bagging represents the cost associated with getting the silage into storage. If this cost includes the cost of the bags, then this value reflects

the structure cost associated with bagging systems. The cost of packing can be estimated based on tractor-hours used for packing or custom rates for packing. Generally, as packing cost is reduced, packing density also is reduced resulting in higher dry matter losses. Therefore, modifying packing cost or dry matter losses should result in changing the input value of the other parameter (i.e., these two inputs are not necessarily independent of each other). Simply put, dairies that attempt to save on packing costs often "pay" in higher DM losses. Custom rates are the relevant cost to use if custom operators are used to bag silage. The relevant cost for dairies owning bagging equipment include the cost of depreciation, interest, repairs, labor, and fuel associated with the equipment or these costs may be approximated using custom rates.

Storage losses – Storage losses represent dry matter (DM) loss during storage and silage removal. The values will vary between operations due to management and operation. Holmes and Muck reported the following DM losses of corn silage harvested at 60-70% moisture:

Storage type	Filling	Seepage	Gaseous	Top surface	Feed out	Total
Bunker (uncovered)	2-6%	0-1%	9-10%	9-12%	3-15%	24-43%
Bunker (covered)	2-6%	0-1%	6-7%	3-4%	3-15%	16-31%
Stack (uncovered)	3-7%	0-1%	11-12%	19-24%	3-15%	37-58%
Stack (covered)	3-7%	0%	6-7%	4-6%	3-15%	17-34%
Bags	1-2%	0%	5%	2%	1-5%	9-14%

The data show reduction in storage losses by covering bunkers and piles. This suggests there may be a positive return when covering packed silage. Holmes and Muck show losses associated with bags were considerably less than with large bunkers or stacks, especially if those piles are not covered. One reason for the lower loss in bags is the smaller exposed face during silage removal. However, the losses in bags can be significantly higher than the values reported above if management does respond to rips or tears in the bag in a timely manner (i.e., as soon as they occur) or if an earthen base is utilized.

Quality losses (milk production adjustments) – Dry matter loss may be greater for bunkers and piles than it is with bags because some of the silage becomes spoiled and needs to be discarded. Do not minimize the amount of silage that is discarded simply to lower DM loss. This implies low nutritive quality silage is being fed which will impact milk production (Whitlock et al.; Harrison, Davison and Linder). As a general rule, management decisions that negatively impact production tend to reduce profitability. Feeding lower quality silage to minimize DM loss should be avoided. Even if producers feel they are doing a good job of discarding any spoiled silage, they still might expect differences in milk production due to silage quality varying between bunkers, piles, and bags and it is important that this is accounted for. This can be accomplished by simply looking at change in milk production relative to some base that might be expected. For example, if silage out of a bag is higher quality than silage out of a bunker or pile and this quality difference results in an extra pound of milk production per cow per day, the cost of the silage fed should be adjusted to account for this increased income.[3]

[3] The framework used in this analysis to account for varying nutritional values for silage is to adjust for milk production (income approach). Another way to account for varying nutritional values would be to adjust for increased feed costs (cost approach) associated with modifying the ration, e.g., increasing the level of corn in the ration to compensate for lost energy.

Comparison of Economic Costs – Example Dairy

The production-adjusted cost per ton of silage delivered to cows was estimated for a hypothetical 3,000 cow dairy. The following assumptions were made for the dairy:

Assumptions used in economic analysis

Herd size, cows	3,000	
Silage in ration, as-fed (AF) lbs/cow/day	45.0	
Silage moisture content, %	68.0	
Maximum feeding days per storage structure	122	(implies minimum of 3 structures)
Interest rate, %	10.0	
Land value, $/acre	$1,000	
Useful life for structures, years	30.0	
Annual repair and maintenance on structures, %	1.5	
Cost of silage delivered to storage, $/AF ton	$25.00	
Cost of plastic, $/sq ft	$0.030	
Labor cost, $/hour	$10.00	
Milk price, $/cwt	$13.50	

	Concrete bunkers	Drive-over piles	Plastic bags
Required number of storage units[a]	3.9	4.0	40.0
Size of footprint, acres[a]	2.5	3.5	4.7
Cost of floor/base, $/sq ft	$1.80	$0.90	$0.90
Estimate of DM loss (storage and feed out), %	20.0	25.0	10.0
Investment in structure, $/AF ton capacity[a]	$59.72	$23.96	$24.59
Cost of packing or bagging, $/AF ton	$1.10	$1.10	$6.00
Hours for covering silage, man-hrs/unit	50.0	50.0	0.0
Other annual storage-related costs, $/unit[b]	$500	$500	$100
Change from baseline milk production, lbs/day	0.0	0.0	+1.0

[a] based on specific assumptions not provided here and calculated in *SilageStorage$.xls*

[b] estimated costs for disposing of plastic covers and bags

Based on the input assumptions above, Table 1 shows the economic comparisons of the three methods to store silage as calculated using the *SilageStorage$.xls* spreadsheet. The annual cost of the structure is considerably higher for the bunker silo compared to the drive-over piles and plastic bags because of the initial investment in concrete. The total cost of the silage going into storage – which accounts for structure costs, cost of silage, packing, bagging, and plastic – is the highest for the plastic bags and lowest for the drive-over pile. Cost coming out of the storage accounts for dry matter (DM) losses and is higher for bunkers and lowest for bags because of lower DM loss. The cost of silage coming out of piles is only slightly higher than for bags. In this example, storing silage in bags is about $1.50/ton less than piles and $16/ton less than bunkers without any impact on milk production. If the DM loss of the piles and bunkers were equal (23%), DM cost of silage out of the piles decreased to $117.94 which was slightly less than silage out of the bags (data not shown). This reinforces how important it is for the dairy to make comparisons using their own numbers.

If the silage coming out of the bag is of higher quality and increases milk production 1.0 lb/cow/day, relative to silage out of bunkers or piles, the cost per ton on a DM basis decreases almost $17. This large change in the cost per ton reinforces why it is important to calculate a *milk-production-adjusted cost per ton* when considering the alternative storage systems if indeed there will be impacts on production.

Table 1. Economic Comparisons of Alternative Silage Storage Systems

	Silage Storage System		
Storage-type-specific inputs	Bunker silo	Drive over pile	Plastic bags
Tons of silage stored, AF	31,997	32,850	27,683
Plastic required for covering bunkers and piles, sq ft	25,261	37,345	na
Structure investment per ton of storage capacity, $/ton AF	$59.72	$23.96	$24.59
Annual cost of structure and land, $/ton AF	$7.24	$2.91	$2.99
Total cost of silage into storage, $/ton AF	$33.46	$29.13	$34.14
Total cost of silage into storage, $/ton DM	$104.55	$91.03	$106.68
Estimate of storage DM loss, %	18.0%	20.0%	8.0%
Estimate of feedout DM loss, %	5.0%	5.0%	3.0%
Total DM loss, %	23.0%	25.0%	11.0%
Total cost of silage out of storage, $/ton AF	$43.45	$38.84	$38.36
Total cost of silage out of storage, $/ton DM	$135.78	$121.37	$119.87
Silage cost adjustments due to quality			
Milk production adjusted cost of silage out of storage, $/ton AF	$43.45	$38.84	$33.02
Milk production adjusted cost of silage out of storage, $/ton DM	$135.78	$121.37	$103.18

Given that a dairy might already have built a bunker and thus this "structure cost" is fixed, how does this impact the analysis? In this case, the appropriate thing to do for comparing bags to bunkers would be to zero out the annual cost of the structure and land and focus only on the variable costs. Table 2 shows the cost comparisons assuming the annual costs associated with the structures and land for the bunkers are $0 and drive-over piles and plastic bags still have costs of $2.91 and $2.99/ton, respectively (assumes you still need to develop an area for piles or bags). In this case, the cost per ton of DM silage out of the bunker is less than that out of the piles or bags ($106.40 vs. $121.37 and $119.87). Thus, in this scenario the extra milk production is needed if bags are going to be lower costing than bunkers. It should be pointed out that this scenario is not sustainable in the long run because eventually the bunkers would have to be replaced.

Summary

There have been many papers written and decision aids developed to help dairy managers make sound decisions concerning silage storage. The reason for all of this attention is because the forage component of the dairy cow ration is critical. Dairy producers need to recognize that many factors will influence which silage storage system is best for their operation. It is important for each dairy manager to evaluate their own unique situation. The costs per ton of milk-production-adjusted silage were compared for silage stored in concrete bunkers, drive-over piles, and plastic bags for an example dairy. The cost per ton was lowest for silage stored in bags if all costs were included for the bunkers. The cost per ton of silage stored in piles was similar to silage stored in bags. If the fixed costs of concrete bunkers were ignored, the cost of storing silage in bags was only lower than silage stored in bunkers if milk production increased

slightly compared to silage stored in a bunker. One of the most important points to take home from this analysis is how much costs per ton will vary depending on the assumptions. To aid dairy managers with evaluating their silage storage alternatives an Excel computer spreadsheet (*SilageStorage$.xls*) has been developed that can make this process much easier.

Table 2. Economic Comparisons of Alternative Silage Storage Systems

	Silage Storage System		
Storage-type-specific inputs	Bunker silo	Drive over pile	Plastic bags
Tons of silage stored, AF	31,997	32,850	27,683
Plastic required for covering bunkers and piles, sq ft	25,261	37,345	na
Structure investment per ton of storage capacity, $/ton AF	fixed	$23.96	$24.59
Annual cost of structure and land, $/ton AF	$0.00	$2.91	$2.99
Total cost of silage into storage, $/ton AF	$26.22	$29.13	$34.14
Total cost of silage into storage, $/ton DM	$81.93	$91.03	$106.68
Estimate of storage DM loss, %	18.0%	20.0%	8.0%
Estimate of feedout DM loss, %	5.0%	5.0%	3.0%
Total DM loss, %	23.0%	25.0%	11.0%
Total cost of silage out of storage, $/ton AF	$34.05	$38.84	$38.36
Total cost of silage out of storage, $/ton DM	$106.40	$121.37	$119.87
Silage cost adjustments due to quality			
Milk production adjusted cost of silage out of storage, $/ton AF	$34.05	$38.84	$33.02
Milk production adjusted cost of silage out of storage, $/ton DM	$106.40	$121.37	$103.18

References

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