ECONOMICS OF FEEDING CORN SILAGE IN FEEDLOT DIETS

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INTRODUCTION

Cattle feeders in the upper Midwest have a great variety of forage sources for growing and finishing feedlot cattle. Of these, whole plant corn silage offers the most flexibility relative to planting, harvesting, and feeding. For instance, when farmer feeders plant regular dent hybrids in the spring, in any given year, they can choose to harvest it as corn silage, earlage, high moisture corn, or dry corn depending on corn and cattle prices. Furthermore, when harvested as corn silage, feeders can choose to vary the amount used in growing or finishing diets depending on cattle weight, cattle type, projected market weight, cattle prices, and markets. Generally speaking, feeding the whole plant should give the greatest amount of flexibility but slower gains and poorer efficiencies, while feeding the grain gives the least amount of flexibility but faster gains and better efficiencies. As producers ponder these alternatives, additional hybrids that promise greater forage, grain, oil or protein yields complicate decision-making when entertaining corn silage feeding. Therefore, objectives of this paper are to familiarize the reader with results of research evaluating use of corn silage in feedlot cattle diets, to evaluate economics of feeding corn silage in feedlot diets, and to determine simple procedures to enhance decision-making when entertaining the use of corn silage in finishing diets.

ECONOMIC CONSIDERATIONS

Before attempting to devise strategies to optimize corn silage use while maximizing profit, it is important to make a few considerations. First, the decision by farmer feeders to harvest corn fields as corn silage is usually made according to corn and cattle prices, and potential corn yield. Thus, when corn price is high, feeder prices are low, and/or fed cattle prices are expected to be high, corn grain is more likely to be harvested for sale and in-house feed grain use. In this scenario, a few acres are harvested as corn silage to meet small fiber requirement needed by feedlot cattle. Similarly, when corn price is low, but feeder prices are low and/or fed cattle prices are expected to be high, corn grain is more likely to be harvested for in-house feed grain use. In this scenario, more corn silage may be harvested to accommodate a potential greater feedlot cattle population. Corn fields are harvested mostly for corn silage when yields are expected to be low (corn fields that typically have low production potential), or when fields are stressed by drought, excess precipitation, disease, or cold weather.

Under most normal circumstances, harvesting corn fields for silage is expected to divert grain from inventories that can be sold in local markets. Because of this, most economists consider the price of corn when evaluating the cost of producing corn silage. This cost will account for the opportunity price of diverting corn grain into corn silage tonnage. Additional costs that must be accounted include: harvesting, loading, storage, unloading, and any losses that may be expected during storage or feeding. These costs vary depending on the equipment, storage type and capacity, unloading methods and delivery demand, and feeding management.

The opportunity cost of corn grain in corn silage is determined by estimating the grain yield in a ton of corn silage and corn market price. This yield is dependent on growing conditions and dry matter content of the whole plant (Table 1).

Table 1. Corn grain content of corn silage of various dry matter (DM) concentrations.

	Amount of corn in corn silage, % DM			
Plant DM, %	35	40	45	50
	------ Corn grain content, bu/ton silage ------			
30	4.4	5.0	5.7	6.3
35	5.1	5.9	6.6	7.4
40	5.9	6.7	7.6	8.4

Another method to estimate corn grain content in corn silage is based on grain yield per acre. When grain yields range between 90 and 125, 130 and 150, 160 and 180 bu/acre corn grain content in corn silage averages 5.7, 7.2, and 10 bu/ton corn silage (Wheaton and Sewell, 1978).

The cost of corn grain in corn silage is then obtained by multuplying corn grain content in bu/ton corn silage times the market price of corn. Thus, for average yields of 40% corn grain in corn silage and 40% DM content, the opportunity price of corn when the corn market is $2/bu is $13.4/ton (6.7 x 2). It is thus expected that as corn grain yield or dry matter of corn silage increase, the opportunity price of corn in corn silage also increases (Table 1).

Costs associated with corn silage production, corn silage storage and unloading are listed in Table 2. Harvesting and loading costs range from $5.5 to $7/ton dry matter (DM; Black and Schwab, 1990; Hendrix, K. personal communication; Lazarus, 1997). Storage and unloading costs range from $12.50 (bunker) to $26/ton (upright stave) DM (Benson, 1979; Holmes, 1996). Losses vary depending on storage type, DM content, packing or stave conditions, etc. but range from 7 to 30% of total DM placed in the silo (Van Fossen, 1978; Holmes, 1996).

Although some of these estimates may be difficult to obtain in production conditions, producers must be aware of these costs to effectively evaluate corn silage use. An example of adding up costs and taking into consideration losses is presented (Table 2).

Table 2. Cost of diverting corn acres to corn silage production, corn silage storage and unloading.

Cost	Range	Example	Cost[a] of corn silage @ 45% corn content ($2.30/bu), 35% DM, 15% losses in a bunker
1. Corn bu/ton corn silage (as fed)	4.4 to 8.4	6.6	$15.18
2. Harvesting and loading, $/ton DM	5.5 to 7	6.5	$2.28
3. Storage and unloading, $/ton DM	12.5 to 26	12.5	$4.38
4. Cost without losses, $/ton (as-fed)			$21.84
5. Losses, % DM	7 to 30	15	15
6. Total cost, $/ton (as fed)			$25.11

[a] Calculations are as follows:

Line 1. Choose appropriate corn content in corn silage and multiply by the market price of corn.

Line 2. Choose appropriate cost of harvesting and loading and divide by corn silage DM.

Line 3. Choose appropriate cost of storage and unloading and divide by corn silage DM.

Line 4. Tally costs not including DM losses.

Line 5. Estimate DM loss.

Line 6. Calculate total corn silage cost including DM loss by multiplying the result of line 4 by the figure resulting from the following: (1 + item in line 5/100).

When estimating storage costs and those associated with DM losses, corn silage cost can be up to 11 times the price of corn ($/bu; Table 2). A shortened equation to obtain the cost of a ton of corn silage that can include all these estimates has been suggested (Goodrich et al., 1974; Black and Schwab, 1990), and is herein modified using corn silage containing 45% corn (DM basis) at 35% whole plant DM:

$$\text{Cost, \$/ton} = [6.6 * (\text{corn price, \$/bu}) + 6.5 \text{ (bunker) or } 9 \text{ (upright)}] * [(1 + \text{DM loss, \%/100})]$$

Corn silage costs for various corn grain prices and storage losses from bunker or upright silos are listed in Table 3. Estimates of corn silage cost per ton can be derived simply by multiplying corn grain price by 10.5 or 11.5 when the storage structure is a bunker or an upright silo, respectively. Using these estimates permits a more meaningful evaluation of corn silage economics in cattle feeding enterprises.

Table 3. Corn silage price estimates for various corn grain prices and DM losses during storage.

DM losses, %	Corn price, $/bu					
Bunker	2	2.3	2.6	2.9	3.2	3.5
10	21.67	23.85	26.03	28.20	30.38	32.56
15	22.66	24.93	27.21	29.49	31.76	34.04
20	23.64	26.02	28.39	30.77	33.14	35.52
	Corn price, $/bu					
Upright	2	2.3	2.6	2.9	3.2	3.5
10	24.42	26.60	28.78	30.95	33.13	35.31
15	25.53	27.81	30.08	32.36	34.64	36.92
20	26.64	29.02	31.39	33.77	36.14	38.52

FEEDING STRATEGIES – HEAVYWEIGHT FEEDERS

As stated earlier, corn silage represents both a fiber and energy source for Midwest feeders. However, the economics of adding corn silage, beyond concentrations needed to provide adequate fiber for rumen function, to diets of heavy weight cattle presents some unique considerations. Specifically, it is well known that because of its lower energy content, both gain and efficiency of gain are reduced as corn silage content increases. Reducing gain and efficiency of gain has impacts on both feed and nonfeed costs. Additionally, because of recent changes in the grading system, heavyweight steers that finish at heavier weights or later maturity are heavily discounted. Thus, astute feeders must consider the impact of corn silage feeding on price received in addition to the impacts on feed and nonfeed costs.

On the other hand, one could argue that feeders can evaluate the economics of using increasing amounts of corn silage in yearling cattle diets on the basis of beef produced per acre, or net income from beef production per acre. This is especially true when feeders feed only one lot of cattle a year and produce their own crops.

Research conducted over the last two years at the Southern Experiment Station (MN Cattle Feeder Reports B-442 and B-451) was undertaken to assess the impact of corn silage feeding on performance and profitability in yearling steers. In one study (B-451) yearling steers were fed increasing amounts of corn silage from two distinct hybrids (regular dent vs leafy). Another study (B-442) evaluated response of yearling steers to increasing amounts of corn silage from a leafy hybrid. In both studies, steers were slaughtered when half of the cattle in each treatment were visually assessed to have reached Choice grade. The number of cattle reaching Choice grade, or having been discounted for heavy weights, dark cutters, or mature (greater than A maturity) were similar across dietary treatments or hybrids. However, results from the first study indicated that short-term feeding (less than 80 days) after implanting with Revalor-S resulted in more carcasses discounted for dark cutter beef (DiCostanzo et al., 1997). In our most recent

study (DiCostanzo et al., 1998), steers were implanted with Revalor-S at least 87 days before slaughter. This resulted in only one dark cutter carcass from a total of 96. Therefore, producers are encouraged to administer the second implant in steers weighing more than 850 lb (on-weight), especially if using a trenbolone acetate-based implant at least 85 days before projected slaughter date.

Steers responded to either hybrid of corn silage similarly (DiCostanzo et al., 1998). Thus, the only differences in performance were due to feeding increasing amounts of corn silage (DiCostanzo et al., 1997; 1998). Daily gain decreased 2% and feed DM required/100 lb gain increased 5% for each 12 percentage point increase in diet corn silage DM when cattle were fed between 12 and 36% corn silage DM (DiCostanzo et al., 1997). In our second study, daily gain decreased 14% and feed DM required/100 lb gain increased 16% when dietary content of corn silage increased from 12% to 24% (DiCostanzo et al., 1998). There were no differences in performance between steers fed 24% or 36% corn silage DM.

Results from these experiments were used to generate data in Tables 4 and 5 in an attempt to determine economic impact of increasing corn silage content in diets of yearling steers under various corn and steer price scenarios. Dry matter intakes and gains from DiCostanzo et al. (1997) were used to determine profitability. Dry matter content of corn grain, corn silage and supplements were fixed at 87%, 35% and 92%, respectively. Profitability was expressed as net return (considering yardage at $.35/head, veterinary, medicine and transportation costs at $20/head) per head per year (3.3, 2.9, 2.5, or 2.2 lots on feed/year for steers consuming diets containing 12%, 24%, 36%, or 48% corn silage DM) or per acre assuming corn grain and corn silage yield of 150 bu/acre and 18 ton/acre.

When corn silage price is based on corn price, increasing corn silage content reduced annualized net return per head (Table 4). Increasing corn silage content, for diets containing between 12% and 36% corn silage DM, decreased annualized profit $.45/head for every percentage DM point increase in corn silage content. Increasing corn silage content beyond 36% of the diet DM decreased annualized profit $1.62/head for every percentage DM point increase beyond 36%.

When corn silage is priced at cost of production and storage (no allotment is made to cover opportunity price of corn in corn silage), increasing corn silage, under $3/bu corn grain price scenario, content actually increased profit (Table 4). Increasing corn silage content between 12% and 36% of the diet DM increased annualized profit $.79/head for every percentage DM point increase in corn silage content. Increasing corn silage content beyond 36% reduced profit slightly.

Positive profit response to increasing corn silage content in diet is only observed when corn silage is priced lower than its feed value relative to corn (Goodrich et al., 1974). This value can be approached by multiplying the price of corn grain by 10.5 (DiCostanzo, 1997). This also happens to be the factor used to obtain the cost estimate for corn silage. Thus, when comparing the scenario with corn silage priced at cost ($21/ton) vs that of corn silage priced based on corn grain at $3/bu corn grain ($31/ton) the apparent greater profit obtained when increasing corn silage results from shifting profit source from corn grain to corn silage.

Table 4. Annualized return per head when feeding increasing amounts of corn silage at various grain and cattle market scenarios.

			Price, $/cwt live:	58.00	62.00	66.00
			Price, $/cwt carcass:	93.54	100.00	106.45
Scenarios	Corn silage, % diet DM	Feed DM/100 lb gain, lb				
Corn at $2/bu, corn silage at $21/ton[a]	12	670		122.54	170.57	218.60
	24	710		118.22	165.38	212.54
	36	750		113.03	159.16	205.30
	48	790		95.27	139.80	184.33
Corn at $3/bu, corn silage at $21/ton[b]	12	670		-9.17	38.87	86.90
	24	710		.27	47.43	94.59
	36	750		11.30	57.44	103.57
	48	790		9.84	54.37	39.27
Corn at $3/bu, corn silage at $31.5/ton[a]	12	670		-24.11	23.92	71.96
	24	710		-28.58	18.58	65.73
	36	750		-32.12	14.02	60.15
	48	790		-49.79	-5.26	39.27

[a] Corn silage price based on corn grain price ($/bu * 10.5).
[b] Corn silage price based on cost of production and storage.

When corn silage price is based on corn price, increasing corn silage content reduced net return per acre (Table 5). However, the rate of decrease in return is much lower than for return per head. Increasing corn silage content, for diets containing between 12% and 36% corn silage DM, decreased profit $.25/acre for every percentage DM point increase in corn silage content. In contrast, increasing corn silage content beyond 36% had the same impact on net return per acre as on per head (Table 5). Increasing corn silage content beyond 36% of the diet DM decreased profit $1.60/acre for every percentage DM point increase beyond 36%.

Under price conditions of $2/bu corn and $21/ton corn silage, feeding cattle less than 36% corn silage in the diet DM increased the value of these crops by $1/bu and $9/ton, respectively. Under price conditions of $3/bu and $31.50/ton corn silage, feeding cattle less than 36% corn silage in the diet DM in a $62/cwt live market increased the value of these crops $.13/bu and $1.11/ton, respectively.

When corn silage is priced at cost of production and storage (no allotment is made to cover opportunity price of corn in corn silage), increasing corn silage content, under $3/bu corn grain

price scenario, actually increased profit (Table 5). Increasing corn silage content between 12% and 36% of the diet DM increased profit $.93/acre for every percentage DM point increase in corn silage content. Increasing corn silage content beyond 36% reduced profit slightly. Under this scenario, feeding cattle results in added value to corn and corn silage of $.34/bu and 2.83/ton, respectively.

Table 5. Net return per acre when feeding increasing amounts of corn silage at various grain and cattle market scenarios.

			Price, $/cwt live:	58.00	62.00	66.00
			Price, $/cwt carcass:	93.54	100.00	106.45
Scenarios	Corn silage, % diet DM	Feed DM/100 lb gain, lb				
Corn at $2/bu, corn silage at $21/ton[a]	12	670		126.88	176.61	226.35
	24	710		124.74	174.50	224.26
	36	750		123.30	173.63	223.96
	48	790		106.59	156.41	206.23
Corn at $3/bu, corn silage at $21/ton[b]	12	670		-9.49	40.24	89.98
	24	710		.29	50.05	99.81
	36	750		12.33	62.66	112.99
	48	790		11.01	60.83	110.65
Corn at $3/bu, corn silage at $31.5/ton[a]	12	670		-24.97	24.77	74.50
	24	710		-30.16	19.60	69.36
	36	750		-35.04	15.29	65.62
	48	790		-55.70	-5.88	43.94

[a] Corn silage price based on corn grain price ($/bu * 10.5).
[b] Corn silage price based on cost of production and storage.

When only one lot is fed per year, producers are encouraged to consider results from the latter analysis in detail. Profit per acre was not greatly affected by extreme changes in corn silage content of the diet as long as corn silage was kept within 36% of diet DM. This suggests that feeders who are also actively farming or conducting other activities besides feeding may rely on finishing diets for yearlings containing higher proportions of corn silage, especially when corn prices are high. This strategy prevents producers from formulating and managing high-energy diets that demand close monitoring of the bunk and animal. Certain consideration need to be made before establishing a finishing program with high corn silage diets:

- Start with the appropriate cattle type
- Formulate diets containing 36% corn silage DM or less
- Provide supplemental protein (50% protein supplement or better), vitamins and minerals
- Feed an ionophore
- Maintain urea diet DM below 1% (52% supplemental protein from urea or less)

- Use a low potency implant for the first 50 to 60 days
- If using a high potency finish implant, administer at least 85 days before marketing

In contrast, cattle feeders who feed more than one lot per year may only consider feeding high corn silage diets when cattle prices are less than $62/cwt live and corn grain prices are $3/bu or higher. Kesteloot (1996) suggested a similar strategy. Similarly, when considering the total cost of corn silage and equating this cost to the equation suggested by Goodrich et al. (1974) for the value of corn silage, corn silage becomes an attractive alternative to cattle feeders when corn price rises over $3.27/bu. This is especially true if feeders grow their own corn.

Similar considerations apply to feeders who feed more than one lot per year with a few exceptions:

- Start with the appropriate cattle type
- Formulate diets containing less than 24% corn silage DM
- Provide supplemental protein (40 to 50% protein supplement), vitamins and minerals
- Feed an ionophore
- Maintain urea diet DM below 1% (50% supplemental protein from urea or less)
- Use a low potency implant for the first 35 to 50 days
- If using a high potency finish implant, administer at least 85 days before marketing

EVALUATING ALTERNATIVE HYBRIDS FOR SILAGE

The preceding discussion was based on results from evaluations of leafy and regular dent hybrids available commercially. A recent review (Kuehn et al., 1998) of results from corn silage feeding trials in beef and dairy cattle indicated a lack of trials evaluating alternative hybrids in both beef and dairy cattle. As more results become available, it is important to consider the relationship between corn silage yield and potential changes in digestibility (Kuehn et al., 1998). A simulation was prepared to study this relationship. Utilizing data obtained with corn silage diets in feedlot cattle and potential differences in yield and feed DM required/100 lb gain Table 6 was generated to study their impact on net return per acre. Cost of corn ($2.30/bu) and corn silage ($24.15/ton) are typical for conditions in Minnesota. Cattle price was held at $62/cwt live.

Data in Table 6 reveal that changes in yield with no change in feed DM required/100 lb gain (overall diet DM digestibility) resulted in small changes in net return per acre. The magnitude of this change was between $.72 and $3.70/acre for every 2 ton change in yield. In contrast, changing feed DM required/100 lb gain (diet DM digestibility) resulted in changes of $40 to $51/acre for every 50 lb feed DM/100 lb gain.

Table 6. Net return[a] per acre when feeding corn silage hybrids at various digestibilities and forage yields.

Feed[b] DM/100 lb gain	Forage yield, ton/acre			
	16	18	20	22
650	183.90	187.60	190.68	193.26
700	134.87	137.58	139.84	141.73
750	90.39	92.21	93.72	94.99
800	51.45	52.49	53.35	54.07

[a] Corn price at 2.30/bu and corn silage at $24.15/ton. Cattle price at $62/cwt live.
[b] Diets containing 24% corn silage DM.

Therefore, when evaluating alternative hybrids, producers are encouraged to preview results of animal feeding trials where silage is fed at concentrations similar to those found under practical conditions. Particular attention must be paid when complete diet DM digestibility or, more importantly, feed DM/100 lb gain is expected to be affected by choice of hybrid.

In the preceding analysis corn silage was priced based on corn grain, thus credit for corn grain content in corn silage is given. However, if the hybrid used is expected to yield corn grain of higher value, or additional costs are incurred by planting or cultivating an alternative hybrid this cost is not considered. Therefore, data used in generating Table 6 were set to equalize net return per acre by changing corn silage price when feed DM required/100 lb gain was different. The resulting analysis indicated that $15/ton additional costs offset advantages of using an alternative high digestibility hybrid (50 lb feed DM/100 lb gain).

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