Choosing the Right Corn Hybrid for Silage

William P. Weiss

Department of Animal Sciences, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster, OH 44691 USA
email: weiss.6@osu.edu

Take Home Message

- Potential differences between corn silage hybrids in net dollar returns can be estimated using yield, NDF concentration, and in vitro NDF digestibility data obtained from yield trial summaries
- Higher economic value should be assigned to hybrids with increased concentrations of NDF and energy. These are important nutrients in corn silage and are likely to differ between hybrids.
- Economic value should be assigned to potential differences in dry matter intake when cows are fed silages from different hybrids. In vitro NDF digestibility might be able to estimate these differences.
- Any differences in economic value of the hybrids must be compared to potential differences in production costs
- The hybrids that provides the desired agronomic characteristics and has the greatest economic value relative to production costs should be selected for silage production.

Introduction

Corn silage is an extremely common ingredient of dairy rations in most areas of North America. The widespread use of corn silage implies that it has certain competitive advantages over other feedstuffs. This means that over the long term, diets with corn silage must result in higher income over feed costs than do diets that include less commonly used feeds. Maximizing income over feed costs should be the basis for selecting feedstuffs including the hybrid used for corn silage. Income over feed costs can be increased by increasing milk production, reducing feed costs, or both.

Hybrid can affect milk production and feed costs. When diets are formulated properly, most of the differences in milk production caused by feeding silages made from different hybrids occur via changes in dry matter intake. Hybrid effects on feed costs would largely be due to differences in production costs of the corn and nutrient composition of the resulting silage. This paper will discuss how hybrid can affect milk production and feed costs, but it will not discuss agronomic characteristics of corn hybrids. Silage growers must select hybrids that are adapted to their specific growing conditions.

▪ General Concepts for Corn Silage Evaluation

Hybrid comparisons are usually made when someone is looking at a seed catalog and trying to determine which hybrid will make the most profitable silage. Accurate comparisons at the seed selection stage are extremely difficult. Growing conditions, the nutrient composition of the silage, and the prices of other ingredients when the silage will be fed are unknowns, and all can have a drastic influence on the value of the silage.

Accurate evaluation of hybrids used for silage should be based on measured factors. Before the corn is planted, however, nothing has been measured. Therefore, one must rely on data that are available. The important factors that should be considered are production costs of the silage, nutrient content of the silage, prices of other feeds, and effects of hybrid on milk production (independent of nutrient composition). Yield trials conducted by seed companies and some universities provide data on past performance of hybrids and this data can be used to compare different hybrids. Producers, however, must be aware of all the uncertainties associated with these data.

Production Costs

Hybrid selection affects the cost of producing silage mainly through differences in yield and seed costs. Seed costs can be obtained from the seller, and expected yield differences can be compared using yield trial data. Because you are using past performance to estimate future yields, data from yield trial summaries must be evaluated statistically. If you are comparing two hybrids that have different yields but those differences are not statistically significant (this information is found in the yield trial summaries) you should assume equal yields. Yield differences will not be discussed in detail, but yield cannot be ignored when selecting a hybrid. Fixed costs and variable costs per unit of yield decrease as yield increases. Therefore total production costs of a high yielding hybrid are less than costs for a lower yielding hybrid (assuming equal seed costs). In addition to increased costs, lower yields also means that more land will have to be used to produce the same amount of silage. If land is limited, then costs will usually increase more because you must purchase feed to replace the corn silage not produced.

Economic Value

The economic value of a corn silage is dependent on its nutrient composition, the prices of other available feedstuffs, and effects on milk production that are independent of nutrient composition. Many yield trial summaries now include the concentration of neutral detergent fiber (NDF) and in vitro NDF digestibility (IVNDFD). This data, with the same statistical caveats as discussed for yield, can be used to estimate potential differences in nutrient composition and milk production between hybrids.

Feeding trials are the ultimate measure of the nutritional value of a silage. The number of research trials comparing different corn silage hybrids has increased but the database is still limited. Most studies compare two or three hybrids, whereas the number of potential comparisons is almost endless. When evaluating lactation data one must ask the question, would the results be the same if a different 'control' hybrid was used? Another unknown is the repeatability of lactation data. Would the same results be found if the compared hybrids were grown in a different environment?

▪ Comparing Economic Value of Different Hybrids

Feedstuffs are simply delivery vehicles for nutrients. The feedstuff (or hybrid) that provides the lowest priced nutrients should be selected for inclusion in diets. For this approach to work, the concentrations and the economic value of the nutrients must be known, and differences in nutrient concentration must completely describe differences in animal responses. At this time none of these requirements are met completely, however, the approach of valuing a feed based on its nutrient composition with some modifications can be used to evaluate (or more correctly compare) different corn hybrids.

Concentrations of Nutrients

The nutrients that are most likely to cause differences between hybrids in economic value are net energy for lactation (NEL) and NDF. Concentrations of NEL will not be known but can be estimated. When comparing hybrids at the seed selection stage, the only information that will be available usually is NDF and IVNDFD. Two methods (NRC, 2001, Shaver and Schwab, 2001) in their must simple forms (which are adequate for hybrid comparisons), estimate NEL by summing the available energy provided by NDF (estimated using IVNDFD) and the cell soluble fraction (100% - NDF, %). The NRC system adjusts NEL for changes in DM intake but the Shaver-Schwab system does not. Increased IVNDFD is related with increased dry matter intake but as intake increases digestibility decreases (NRC, 2001). Therefore if higher IVNDFD increases intake, actual differences in NEL will be less than those estimated by the Shaver-Schwab method.

The NRC (2001) requirements for forage NDF range from 15 to 19% of the diet DM. Since forage NDF is required (assuming you use the NRC), NDF from corn silage has an economic value, i.e., if forage NDF is inadequate, it must be purchased so that a balanced diet can be formulated. Therefore, hybrids that have higher NDF concentrations may have an economic advantage over hybrids with lower NDF concentrations.

Economic Value of Nutrients

St. Pierre (2001) developed a method to determine the economic value of different nutrients. Using that method and feed prices in early December, 2001 from Wooster Ohio 1 Mcal of NEL was worth US$ 0.036, 1 kg of forage NDF (for this discussion forage NDF = effective NDF) was worth $0.05, and 1 kg of crude protein was worth $0.24 (Note: these values are not constants, they will vary based on local markets). The composition of ‘normal corn silage’ in NRC (2001) is 1.45 Mcal/kg NEL, 45% NDF, 8.8% CP (DM basis). That silage, based on the above prices, would have a maximum economic value to a buyer (or feeder) of $52.3 for NEL, $22.6 for NDF, $21.1 for protein for a total of $96/metric ton (MT) of DM. The effect of changes in NEL and NDF concentrations on nutrient value is shown in Table 1. The two main points in Table 1 are that higher NEL, if it occurs because of lower NDF, may not make the silage any more valuable, and the even a relatively large change in NEL and NDF concentrations does not greatly influence overall economic value of the silage based on nutrients.

Table 1. Hypothetical example of the effect of changes in NEL and NDF concentrations on economic value of corn silage[1].

	Average	Hybrid A	Hybrid B	Hybrid C
NEL, Mcal/kg	1.45	1.45	1.59	1.59
NDF, %	45	50	45	40
CP, %	8.8	8.8	8.8	8.8
Economic value of nutrient provided per kilogram of silage dry matter[2]				
NEL, $/kg DM	0.052	0.052	0.057	0.057
NDF, $/kg DM	0.022	0.025	0.022	0.020
CP, $/kg DM	0.021	0.021	0.021	0.021
Total, $/kg DM	0.095	0.098	0.100	0.098

All costs are in US dollars.

[1] The average hybrid is based on corn silage composition from NDC (2001), Hybrid A has 10% more NDF than average, Hybrid B has 10% more NEL than average and Hybrid C has 10% more NEL and 10% less NDF than average.

[2] The value of the nutrients determined using SESAME (St Pierre, 2000) were US $ 0.036/Mcal NEL, $0.05/kg NDF, and $0.24/kg CP.

‘Non-nutrient’ Effects on Economic Value

Differences in concentrations of NEL and NDF of forages, do not account for all the differences observed in animal performance. A major determinant of animal performance is the DM intake potential of a forage. Cows consume more DM when fed a diet containing a forage with higher IVNDFD (Oba and Allen, 1999). The database used by Oba and Allen (1999) included only one study with corn silage. When two more recent studies on brown midrib silage are added to the database, the average increase in total DM intake is about 0.14 kg/ 1-unit increase in IVNDFD. In response to increased intake, milk production (4% fat-corrected) increased about 0.25 kg/1-unit increase in IVNDFD. All the data relating IVNDFD of corn silage to intake is based on comparisons of brown midrib to its isogenic control, therefore, the silages were virtually identical in major nutrients. Whether the same response will be observed for silages that differ in both NDF and IVNDFD is less certain.

Valentin et al (1999) compared two hybrids with in situ NDF disappearance of 35 and 32% and cows ate more of the diet with the silage that had the lower NDF disappearance. The silage with the lower in situ disappearance also had lower NDF concentration (41 vs. 47%). A recent study conducted at Ohio State (Weiss, unpublished) compared a hybrid with high NDF concentration (49%) and high IVNDFD (46%) to a conventional hybrid (42% NDF, 41% IVNDFD) and observed no difference in DM intake (23.9 and 23.7 kg/day). These two studies suggest that IVNDFD should not be interpreted independent of NDF concentration, i.e., a silage with high NDF concentration and high IVNDFD may not be consumed in higher amounts than a silage with lower NDF concentration and lower IVNDFD.

A Method to Compare Economic Value of Hybrids

The described method (Figure 1) to compare hybrids is based on information that is usually available from yield trial summaries. This method should be used only to compare hybrids (i.e., relative value); it should not be used to estimate absolute value of a hybrid. A set of hybrids that provide the desired agronomic characteristics is chosen. Then NDF concentration, IVNDFD, and yield data from yield trial summaries are used to calculate differences in economic value. Any differences in seed costs also need to be considered.

Step 1. Estimate differences in expected DM intake (0.14 kg/unit difference) and expected milk yield (0.25 kg/unit) caused by differences in IVNDFD. Estimated change in feed costs (caused only by changes in intake) is subtracted from change in milk income. For example, Hybrid A has an IVNDFD 5 units higher than hybrid B, therefore expected differences in intake and milk is 0.7 kg (5 x 0.14) and 1.25 kg (5 x 0.25), respectively. Multiply the change in intake by a typical feed cost (total ration) and multiply change in milk yield by a typical milk price. If feed costs are estimated at $0.15/kg of DM and milk at 0.30/kg then hybrid A would be expect to increase gross income by: (1.25 x 0.3) - (0.7 x 0.15) = $0.27/cow/day (this does not include any change in feed prices caused by differences in silage yield or seed costs which will be calculated later). To put that value on a silage basis, one must divide by kilograms of silage fed. In the studies used to obtain the effect of IVNDFD on intake, mean silage DM intake was about 10 kg. In this example a 5 unit difference in IVNDFD is worth $0.27/10 x 1000 = $27/MT of DM. If IVNDFD is not statistically different between the hybrids, no change in intake should be assumed. In addition, if expected NDF concentration differs between the hybrids, IVNDFD may not affect intake as outlined above.

Step 2. Estimate NEL of the hybrids using the NRC (2001) system. The composition of ‘Normal Corn Silage” should be used except NDF and IVNDFD of the hybrids of interest are entered. A cow (milk yield similar to herd average) and diet (similar to what is expected to be fed) is entered into the NRC model, and the model estimates DM intake and NEL concentration of the hybrid. If

IVNDFD differs between two hybrids, when the hybrid with the higher IVNDFD is evaluated, estimated DM intake should be increased based on expected change in DM intake. For example, if NRC estimated DM intake is 23 kg and the IVNDFD of a hybrid is 5 units higher than another hybrid, intake should be increased for the high digestible hybrid by 5 x 0.14 = 0.7 kg.

Step 3. Using SESAME (St. Pierre, 2001) and local market ingredient prices, estimate the price of effective NDF ($/kg) and NEL ($/Mcal) and determine relative (not absolute) differences in nutrient value. For example, SESAME calculates a value of $0.05/kg of NDF and $0.04/Mcal of NEL and hybrid A has 40% NDF and 1.50 Mcal NEL/kg and hybrid B has 46% NDF and 1.45 Mcal/kg. Per MT of DM, hybrid A will provide 60 kg less NDF [1000 x (0.40 - 0.46)] and 50 more Mcal of NEL [1000 x (1.50 - 1.45)]. The value caused by nutrient differences is the sum of NDF and NEL difference = (0.05 $/kg x -60) + (0.04 x 50) = -1$ (Hybrid A is worth $1 less per MT of DM than hybrid B).

Step 4. Calculate total change in gross value by adding value obtained from Step 1 to that obtained in Step 3.

Step 5. The difference in seed cost per DM yield (based on yield trial data) and production costs caused by differences in yield are used to estimate difference in production costs. An equation derived from Ohio State University Extension Budgets (OSU, 2001) was developed to estimate effect of yield on production costs: Production costs ($/MT of DM) = 75.4 – 1.85 x yield (MT of DM/ha). That equation assumes all differences are caused by hybrid; this equation is not appropriate if you are comparing hybrids that may have different variable costs, e.g., a non-bt-hybrid may require insecticides not required by a bt-hybrid. For example hybrid A expected DM yield is 17 MT/ha and seed cost is $9.4/MT of expected DM yield; hybrid B expected yield is 19 MT of DM/ha and seed cost is $4.5/MT of DM. Estimated production cost of hybrid A is $44/MT of DM and $40/MT DM for hybrid B (a difference of $4/MT). Hybrid A would be expected to cost $4.9 (difference in seed costs) + 4 = $8.9.4/MT of DM. If the difference in total gross value (Hybrid A - Hybrid B) is less than the difference in total cost, hybrid B would be the better buy.

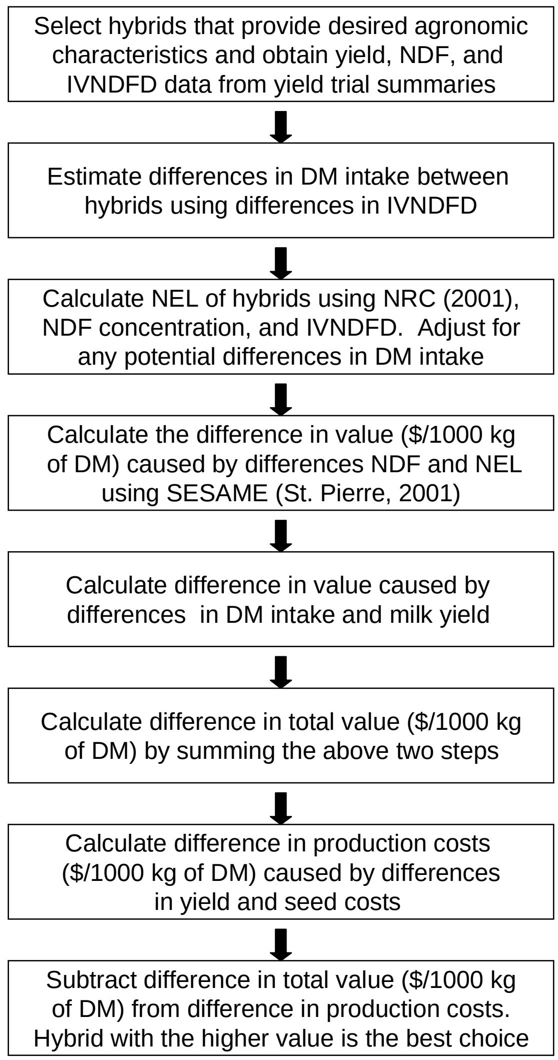

Figure 1. Flow chart outlining how two hybrids should be compared when making planting decisions.

Application of the Evaluation Method

The approach outlined above was applied to a few 'specialty' hybrids that have peer-reviewed lactation data available. An important caveat is that the lactation trials usually involve a comparison between two specific hybrids and do not necessarily mean that those differences would be observed if a different control (i.e., conventional) hybrid was used. The calculations below are based on average values, actual data from yield trials should be used.

Brown Midrib Hybrids

Nutrient Composition. Brown midrib (bmr) corn silage and typical hybrids have similar protein and NDF concentrations. At equal DM intakes, bmr silage is more digestible than its isogenic control (Tine et al., 2001). Cows fed bmr silage eat more DM and digestibility decreases as DM intake increases. Tine et al. (2001) measured the NEL content of diets with 60% corn silage (bmr or isogenic control) and both diets contained 1.61 Mcal NEL/kg of DM.

Cow Responses. On average, cows fed bmr silage produced about 1.4 kg/day more milk and ate about 1.6 kg/day more DM than cows fed other hybrids (review by Eastridge, 1999; Ballard et al., 2001; Moreira et al., 2000; Oba and Allen, 2000; Tine et al., 2001). The available data strongly suggests that increased milk production observed when bmr silage replaces an equal amount of conventional silage is caused by increased intake, not by changes in NEL or NDF concentrations.

Economic Value. Based on nutrient composition (NDF, CP, and NEL concentrations) the economic value of bmr corn silage is similar to conventional hybrids; however, bmr silage clearly has a higher intake potential which results in higher milk production. Assuming a 7% unit higher IVNDFD (Oba and Allen, 2000), DM intake would be about 1 kg higher and milk production about 1.75 kg higher for bmr silage. Using feed and milk prices described above, this should result in a $0.37/day advantage for bmr or a $37/MT of DM. This $37/MT advantage compared to expected lower yields and higher seed costs of about $8.9/MT means that bmr silage (assuming 7% increase in IVNDFD) is a wise choice. The lower yield (approximately 10%) and higher intake of diets with bmr silage increases the land needed to produce corn silage.

Leafy Hybrids

Nutrient Composition. In three studies (Bal et al., 2000; Ballard et al., 2001; Kuehn et al., 1999) no differences were reported in crude protein, but NDF concentration tended to be 1 to 3 percentage units higher than control hybrids. The NEL concentration of leafy hybrids has not been measured. In vivo DM digestibility data are inconsistent but differences have been small between leafy silages and the control silages (Kuehn et al., 1999; Bal et al., 2000). This implies that the NEL of leafy hybrids is probably similar to that of the control hybrids. Published IVNDFD data for leafy hybrids are extremely limited, and no statistical differences have been reported (Kuehn et al., 1999; Ballard et al., 2001).

Cow Responses. Four studies (Bal et al., 2000; Ballard et al., 2001; Kuehn et al., 1999; Moreira et al., 2000) have been published comparing leafy hybrids to different control hybrids, and no statistical differences in milk yield or DMI have been found. The lack of an intake response fits the small differences reported in IVNDFD.

Economic Value. The concentrations of CP and NEL in leafy hybrids appear similar to that of the control hybrids used in the studies. Data from lactation trials show no difference in DM intake potential for leafy hybrid. Leafy hybrids tend to have higher NDF concentrations (approximately 2 percentage units). Assuming a 2 percentage unit increase in NDF concentration, 1 MT of DM of leafy corn silage will have about 20 kg more NDF than conventional hybrids. The approximate value of the additional NDF is $0.05/kg x 20 lbs = $1/MT of DM compared to the control silages used in the studies. This value must be compared to expected differences in yield and seed costs.

Hybrids with Different NDF Concentrations

Nutrient Composition. Bal et al. (2000) conducted a study with a corn silage with low NDF and a more typical hybrid. The NDF content of the two hybrids was 33 and 39%. Weiss (unpublished) conducted a study with a conventional hybrid and a high NDF hybrid. The NDF content of the two hybrids was 42 and 49%. Crude protein did not differ between hybrids within experiment. Dry matter digestibility was similar between hybrids (within experiments) suggesting that the NEL content of the low and high NDF silages were similar to the control hybrids.

Cow Response. Bal et al. (2000) compared a corn silage with about 33% NDF to one with 39% NDF, and found no effect on intake (27 kg) or milk production (44 kg) when equal amounts of corn silage were included in the ration. In an unpublished study (Weiss) compared a corn silage with 42% NDF to one with 49% NDF and found no difference in intake (24 kg) or milk production (34 kg) when cows were fed diets with 45% corn silage.

Economic Value. In the two available studies, protein did not differ between hybrids with significantly different NDF concentrations. Based on in vivo digestibility, NEL concentrations did not differ, and no differences were reported in DM intake. The difference in NDF, however, has economic value. In both studies, NDF concentration differed by about 6 percentage units. Assuming the prices presented earlier, the high NDF silages in both studies would be worth about $3/MT of DM more than the low NDF silages.

References

Bal, M. A., R. D. Shaver, H. Al-Jobeile, J. G. Coors, and J. G. Lauer. 2000. Corn silage hybrid effects on intake, digestion, and milk production by dairy cows. J. Dairy Sci. 83:2849-2858.

Ballard, C. S., E. D. Thomas, D. S. Tsang, P. Mandebvu, C. J. Sniffen, M. I. Endres, and M. P. Carter. 2001. Effect of corn silage hybrid on dry matter yield, nutrient composition, in vitro digestion, intake by dairy heifers, and milk production by dairy cows. J. Dairy Sci. 84:442-452.

Eastridge, M. L. 1999. Brown midrib corn silage. 179-190 *in* Tri-State Dairy Nutr. Conf. Ft. Wayne, IN

Kuehn, C. S., J. G. Linn, D. G. Johnson, H. G. Jung, and M. I. Endres. 1999. Effect of feeding silages from corn hybrids selected for leafiness or grain to lactating dairy cattle. J. Dairy Sci. 82:2746-2755.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle. Natl. Acad. Press, Washington DC.

Oba, M., and M. S. Allen. 1999a. Effects of brown midrib 3 mutation in corn silage on dry matter intake and productivity of high yielding dairy cows. J. Dairy Sci. 82:135-142.

Oba, M., and M. S. Allen. 1999b. Evaluation of the importance of the digestibility of neutral detergent fiber from forage: Effects on dry matter intake and milk yield of dairy cows. J. Dairy Sci. 82:589-596.

Oba, M., and M. S. Allen. 2000. Effects of brown midrib 3 mutation in corn silage on productivity of dairy cows fed two concentrations of dietary neutral detergent fiber: 1. Feeding behavior and nutrient utilization. J. Dairy Sci. 83:1333-1341.

Ohio State University. 2001. Ohio Enterprise Crop Budgets. http://aede.ag.ohio-state.edu/people/moore.301/crops-2001/index.htm.

Shaver, R.D., and E. Schwab. 2001. Development and application of an integrated approach for estimating the nutritive value of corn silage. In: Proc. Four-State Applied Nutrition and Management Conf. LaCrosse, WI. pp 123-126.

St-Pierre, N.R. 2001. Pricing feed ingredients on the basis of their nutritional value. Proc. of the Western Canadian Dairy Seminar, Vol 13, 127-139.

Tine, M. A., K. R. McLeod, R. A. Erdman, and R. L. Baldwin VI. 2001. Effects of brown midrib corn silage on the energy balance of dairy cattle. J. Dairy Sci. 84:885-895.

Valentin, S. F., J. M. Forbes, and P. Lescoat. 1999. Comparison of the voluntary intake by lactating cows of two maize silages with different in situ dry matter degradability. Ann Zootech 48:211-218.