Ranking Corn Silage Hybrids

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Summary

Corn hybrids for silage vary in yield and several quality traits that affect farm profitability, which is the prime criterion on which hybrids should be ranked. The partial budget approach is the only way to rank corn hybrids for silage for individual farms according to their effects on farm profits. Partial budgets consider only those costs and returns that change in response to the corn hybrids being compared and ignore those that are not affected. To rank corn hybrids for silage, partial budgets must calculate for each corn hybrid the total amount of corn silage required; the cost of growing, harvesting, storing, and feeding the corn silage; supplemental feed costs; and returns from differences in milk yield. Economically important traits that must be considered include silage yield, concentrations of dry matter **(DM)**, neutral detergent fiber **(NDF)**, crude protein **(CP)**, and NDF digestibility. The partial budget approach allows the genetic variation among corn hybrids to be used to increase farm profits.

Introduction

Corn hybrids vary in forage yield as well as several quality traits, and recommendations for ranking hybrids for silage vary widely. Traditionally, hybrids with the highest grain yield have been chosen for both grain and silage purposes. However, we now know that other factors affect farm profitability and simply selecting hybrids with high grain yield will not maximize profit. For instance, selection of silage hybrids for forage yield is better than for grain yield because there is considerable variation in yield of the non-grain (stover) fraction across hybrids. Quality also varies considerably among hybrids and important quality factors are not related to grain yield. Some quality traits affect diet cost, while others also affect feed intake and milk yield. Selection indices, such as Milk per Acre, have been developed to combine yield and quality factors into one term to simplify hybrid ranking (Shaver et al., 2006). However, selection indices are unable to accurately rank hybrids for their effects on farm profits across farms and over time (Allen, 2005). The objective of this paper is to explain why this is so and to present the partial budget approach to rank corn hybrids for silage according to their effects on farm profitability.

Grain Concentration

The quality factor most often emphasized for corn silage is grain concentration, which varies widely by corn hybrid. Because grain consists mostly of starch and has little fiber and because the rest of the plant consists mostly of fiber with no starch, grain concentration of the whole plant is positively related to starch concentration and negatively related to NDF concentration. Diets are typically formulated for forage NDF and (or) energy concentration so corn silage with high NDF (low grain) concentration will be supplemented with more corn grain than corn silage with low NDF (high

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grain) concentration. The resulting diets will vary in cost depending upon the costs of corn silage and corn grain. Because properly formulated diets with corn silages varying in grain concentration will have the same forage NDF and energy concentrations, feed intake and milk yield will not be affected. Therefore, the relationship between grain (or NDF) concentration and farm profitability is related only to the cost of corn silage and corn grain. Selection indexes cannot accurately rank hybrids varying in grain concentration for their effects on farm profits because the cost of growing or purchasing corn silage and corn grain varies greatly from farm-to-farm and over time.

The recent increase in corn prices because of increased demand for ethanol production greatly changed the relative ranking of hybrids for farm profitability. Corn grain prices have more than doubled in most markets in the last year or so, while the cost of growing corn silage has increased to a much less extent. Because the price per unit of DM of corn grain was actually less than the cost of producing corn silage on some farms in previous years, it was more profitable for those farms to choose a hybrid with less grain and more fiber. However, the dramatic increase in corn grain prices has changed the situation dramatically, and few farms would find this to be the case in 2007.

Calculate the True Cost of Corn Silage

To rank corn silage hybrids accurately, it is essential to know the cost of corn silage and corn grain. While corn grain is easily transported and has well established pricing, corn silage is normally produced on the farm because it is difficult and expensive to transport. While ranking hybrids is relatively simple for the few farms that purchase both corn grain and corn silage, it is more difficult for those that grow corn silage because few producers know how much it costs to produce corn silage on their farm. The cost to grow, harvest, store, and feed corn silage varies greatly across farms. This variation, as well as the variation in the relative price of corn grain to corn silage over time, precludes the use of selection indexes from ranking corn hybrids accurately for effects on farm profitability.

Fiber Digestibility

Another factor that varies by corn hybrid and has a large effect on farm profitability is in vitro NDF digestibility **(IVNDFD)** of corn silage. We reported that enhanced IVNDFD significantly increased DM intake and milk yield of dairy cows in a statistical analysis of treatment means across a wide range of forages reported in the literature (Oba and Allen, 1999b). A one-unit increase in IVNDFD measured in vitro or in situ was associated with a 0.55 lb increase in 4% fat-corrected milk. Normal commercial corn hybrids vary by ~5 percentage units of IVNDFD when averaged over many growing environments, and the brown midrib mutants increase this variation by another ~5%. These relatively small differences in IVNDFD can have large effects on animal performance; a 5-unit difference in IVNDFD among corn hybrids should result in a difference in milk yield of 2.75 lb/day per cow. We recently validated this relationship using data from experiments published since that study (Oba and Allen, 2005); the relationship between IVNDFD and milk yield was similar to that previously reported.

The effects of enhanced IVNDFD of corn silage on feed intake and milk yield is dependent upon the amount of corn silage in the diet; response increases as the proportion of corn silage as a percentage of the forage NDF increases. In addition, response is greater for cows with high milk yield (Oba and Allen, 1999a); high producing cows with feed intake limited by gut fill respond much more than low producing cows with feed intake limited by metabolic mechanisms. Therefore, effects of IVNDFD on farm profits vary greatly from one farm to the next and cannot be considered by selection indexes; effects are greater for herds with high milk

yield, those that feed the silage to more lactating cows, and those that feed more corn silage as a proportion of the total forage.

Protein

The CP concentration of corn silage varies across hybrids by ~1.2 percentage units. Forages are supplemented with high protein concentrates, such as soybean meal, to increase the protein concentration of ruminant diets, and corn hybrids with high protein concentrations require less supplemental protein, lowering feed costs. Corn silages with different composition can be supplemented with corn grain and soybean meal to have nearly identical concentrations of NDF, starch, and CP. Differences in protein concentration, like differences in concentrations of NDF and starch, affect diet cost, but not animal performance, in properly formulated diets.

Starch Digestibility

Starch is located in the endosperm of corn grain, and endosperm type, floury or vitreous, affects starch digestibility; starch in vitreous endosperm is less digestible than starch in floury endosperm. The vitreous fraction of the endosperm is affected by genetics and increases with maturity at harvest and ranges from 0 to >60% for dry corn (less for corn silage that is harvested earlier). While starch digestion affects feed intake and milk yield, it is not possible to attribute this effect exclusively to corn hybrid because, although there is a genetic component, its effects are highly dependent upon management, such as maturity at harvest, kernel processing, and time since ensiling before feeding. In addition, supplementation with other grains affects production response; corn silage with highly fermentable starch should be supplemented with a less fermentable starch source than corn silage with less fermentable starch. Therefore, while starch digestion is affected by corn hybrid, it is not possible to relate starch characteristics of corn hybrids to animal performance. However, hybrids with highly vitreous endosperm should be avoided for corn silage because of their potential effects on feed costs and animal performance.

Partial Budget Approach

All economically important traits that vary by hybrid for corn silage production can be considered using a partial budget for the farm. Calculations include only those costs and returns that change in response to the corn hybrids being compared, and ignore those that are not affected. Input variables include data about the specific hybrids and the individual farm, as well as market information that varies over time, and the output is an estimate of the profitability one hybrid compared to another.

Corn Picker

CornPicker for Silage is a Microsoft Excel spreadsheet that calculates a partial budget for the effect of a change in corn hybrids for silage on farm profits by comparing one hybrid (Challenger) to another (Defender; your current favorite or a reference standard). See Allen (2006) for a more detailed description of CornPicker than appears here. Hybrid inputs include yield of DM, concentrations of NDF and CP, IVNDFD, and seed cost. The calculations are as follows:

1. Total corn silage needs from the hybrids compared for the entire farm,
2. Cost of corn silage produced from each hybrid including seed, production, harvest, storage, and land costs,
3. Adjustment for difference in cost of supplemental corn grain and soybean meal because of differences in concentrations of NDF (or starch) and CP,
4. Value of differences in milk yield and feed intake because of difference in IVNDFD,

5. The number of acres of land required for each hybrid, and
6. The total cost of corn silage plus/minus adjustments for Challenger compared to cost of corn silage for Defender.

Corn silage required

A partial budget analysis for corn hybrid selection needs to account for all corn silage consumed by different groups of animals on the farm. CornPicker calculates corn silage intake for up to three lactating cow groups (e.g. fresh, higher producing, and lower producing), up to two dry cow groups (e.g. far-off, and close-up), and up to two heifer groups (e.g. < 12 months, and > 12 months). Within a group, corn silage intake depends on the number of animals in the group and corn silage intake per animal. CornPicker calculates corn silage intake per animal considering farm-specific inputs, such as DM intake, forage NDF concentration of the diet, the fraction of forage NDF from corn silage, and the NDF concentration of the corn hybrids being compared. Forage NDF concentration is used to calculate the corn silage concentration in diets because forage NDF limits feed intake, and diets are normally formulated to the same or similar forage NDF concentrations.

Cost of corn silage

Some of the costs of producing corn silage, such as those for seed, fertilizer, lime, insecticide, herbicide, irrigation, fuel, labor, insurance, interest, etc., are more obvious than others. These costs are actually a minor fraction of the total costs of producing corn silage. Machinery (fixed costs and repairs) must be included as well as harvest and storage costs. Storage costs vary widely and include the cost of the structure, as well as filling, packing, covering, and removing the silage. Horizontal silos generally cost less per unit of silage than vertical silos, and large silos cost less per unit of silage than small silos. Corn silage is more acidic than other silages which decreases the life of concrete silos, and storage is costly for corn silage because silos are often filled only once per year. The opportunity cost of the land must also be included: if the land isn't used to produce corn silage, what could it be rented for? Lastly, shrinkage and spoilage must be included which also vary widely and have a large effect on the price of corn silage fed.

Adjustments

Once the total costs of producing corn silage from the Defender and Challenger hybrids have been calculated, cost adjustments must be made for differences in supplemental feed and milk yield. Differences in concentrations of NDF and CP between hybrids affect the amount of corn grain and soybean meal fed per year, and differences in IVNDFD affect annual milk yield and feed intake of lactating cows. CornPicker accounts for these differences by adjusting (credit or debit) the cost per year of the Challenger hybrid relative to the Defender hybrid.

Supplementation

Annual amounts of CP supplied from each hybrid are calculated as total corn silage DM fed multiplied by the CP percentage of each hybrid. Differences in amounts of CP supplied per year for the two hybrids are converted to soybean meal equivalents and then multiplied by the price of soybean meal (48% CP, user input) to get the value of the protein adjustment for the Challenger hybrid. This might be a positive or negative amount, depending upon the differences in yield and CP concentrations of the two hybrids. Difference in the amount of corn grain fed per year between hybrids is calculated as the difference in corn silage DM fed per year minus the difference in soybean meal required (because soybean meal replaces some corn grain). The financial value of this difference is then calculated by multiplying by the price of dry ground corn delivered to the farm.

Milk yield

CornPicker adjusts the cost of the Challenger hybrid for changes in expected milk yield and feed intake of lactating cows based on differences in IVNDFD between the two hybrids. The percentage unit difference in IVNDFD between hybrids is multiplied by 0.55 (user input by cow group) to get the expected difference in 4% fat-corrected milk yield per cow per day for the two hybrids. This value is adjusted linearly for the corn silage NDF as a proportion of the total forage NDF and multiplied by the number of lactating cows and 365 days per year to get the difference in milk yield per year, which in turn, is multiplied by the adjusted milk price (user input) to adjust the cost of the Challenger hybrid. When the Challenger has higher IVNDFD than the Defender, this amount is subtracted from the cost and vice versa. Greater milk yield with enhanced IVNDFD is because of greater feed intake, so the partial budget must account for increased feed costs. The marginal increase in feed intake per lb of 4% fat-corrected milk is ~0.4 lb of DM. This is multiplied by the cost of the diet (user input by cow group) to adjust for the difference in feed intake to support the milk yield difference.

Land required

The amount of land required for corn silage production per year is calculated as the amount of corn silage DM required as described above, which is adjusted for shrink, spoilage, and feed refusals (user inputs) and divided by the DM yield of the corn hybrids. Differences in the amount of land required between hybrids is dependent upon DM yields and NDF concentrations.

Partial budget cost

CornPicker compares the adjusted annual cost of corn silage from the Challenger hybrid per year to the annual cost of production of corn silage from the Defender hybrid. The cost for the Challenger hybrid is the cost of production of the required amount of corn silage, which is adjusted (credit or debit) for the difference in feed costs and milk yield.

Sensitivity Analysis

The sensitivity of farm profit response to changes in hybrid inputs varies depending upon inputs, such as the price of corn and soybean meal (Table 1). With the default response in milk yield of 0.55 lb/cow/day per unit of IVNDFD for all lactating cows, profitability is much more sensitive to IVNDFD than all other inputs, including yield, which is the next most sensitive input. Sensitivity to increased NDF concentration is highly dependent upon the price of corn, ranging from increased profits if the price is low (as it has been the last several years) to decreased profits if the price is high (as it is currently). Although corn silage contains low CP concentration, differences in protein affect profitability and must be considered. Seed price is the least sensitive of the corn hybrid inputs but also the most variable, varying over 100%.

Quality of Data

Environmental conditions change from year to year and affect rankings for yield and quality traits; therefore, it is very important to use data for hybrids grown across different environments. Don't use data from just one location (such as your farm or a neighbor's farm) for this very important economic decision. Corn hybrid yield and quality information can be obtained from seed companies to compare within their product lines and from university corn hybrid testing programs such as the Michigan Corn Performance Trials (Thelen et al., 2006) to compare hybrids across companies. Although hybrid yield must be entered on a DM basis to account for differences in moisture that have no value, harvest moisture should also be similar for a fair comparison because maturity at harvest affects both yield and quality.

Conclusion

The partial budget approach employed by CornPicker accounts for economically important information related to corn hybrid selection that varies from farm to farm and over time. Selection indices that rank corn hybrids fail to consider many important differences among farms and should not be used because they may provide the wrong ranking for specific farms.

Download CornPicker Excel spreadsheet at:
www.msu.edu/~mdr/cornpicker.html

References

Allen, M. 2005. Milk per acre: right for few, wrong for many. Michigan Dairy Review 10(3):1-4. July, 2005, Department of Animal Science, Michigan State University, East Lansing.
www.msu.edu/user/mdr/reprints/July05/MDR_reprint_july05_milkperacre.pdf

Allen, M. 2006. CornPicker for silage: a partial budget approach. Michigan Dairy Review 11(1):1-6. January, 2006, Department of Animal Science, Michigan State University, East Lansing. www.msu.edu/user/mdr/reprints/Jan06/MDR_reprint_january06_cornpicker.pdf

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. 2005. In vitro digestibility of forages. pp. 81-91 Proc. Tri-State Dairy Nutrition Conference, The Ohio State University, Columbus.
www.tristatedairy.osu.edu/Oba%20paper.pdf

Shaver, R., J. Lauer, J. Coors, and P. Hoffman. 2006. Milk2006 Excel spreadsheet.
www.uwex.edu/ces/crops/uwforage/dec_soft.htm

Thelen, K., K. Dysinger, and W. Widdecombe. 2006 Michigan Corn Hybrids Compared. Extension Bulletin E-431, Cooperative Extension Service, Michigan State University, East Lansing.
www.css.msu.edu/varietytrials/corn/2006%20PDF/New%202006%20Corn%20Bulletin.pdf

Table 1. Change in output for a 20% increase in various hybrid inputs for a 500-cow dairy farm feeding corn silage as 2/3 of total forage. Base values for inputs are as follows: $100 /bag for seed, 26.5 ton/acre yield as fed (8 ton/acre DM yield), 40% NDF, 50% IVNDFD, and 7% CP. Results are shown for 2 scenarios of corn grain and SBM input cost. Response in milk yield per unit of IVNDF was 0.55 lb/cow/day for all lactating cows.[1]

		Corn: $85/ton; SBM: $200/ton		Corn: $140/ton; SBM:$230/ton	
Input	20% increase	Partial budget, $	Land, acres	Partial budget, $	Land, acres
Seed cost	20 $/bag	($2,580)	0	($2,857)	0
Yield	5.3 ton/acre	$18,790	(57)	$27,454	(64)
NDF	8 units	$1,970	(57)	($12,588)	(64)
IVNDFD	10 units	$62,145	10	$62, 145	10
CP	1.4 units	$10,460	0	$8,018	0

[1]DM = dry matter, NDF = neutral detergent fiber, IVNDFD = in vitro NDF digestibility, CP = crude protein, and SBM = soybean meal.