BREEDING AND MANAGING THE IDEAL CORN SILAGE HYBRID: A RETROSPECTIVE AND DIRECTION FOR PROGRESS

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ABSTRACT

Predicting animal performance and relating it to improvements in corn silage quality whether from breeding or management is complex. In numerous studies, differences in fiber and digestibility translate into differences in animal performance. The optimum silage composition can vary depending on the type of cow it's fed to (growing heifer versus milking cow, production level, stage of lactation, etc.) and the other components of the ration. Estimates of animal performance responses can be obtained through forage analysis. The University of Wisconsin, along with many other universities, evaluates corn hybrids for silage yield and quality characteristics. Relatively small differences in corn silage fiber, starch and digestibility translate into large differences in predicted animal performance. In Wisconsin, the ranges among hybrid entries for crude protein, ADF, NDF, starch, *in vitro* digestibility and NDF digestibility are relatively narrow. However, the range among hybrids within a trial for estimated milk per acre averages 14,700 kg ha^{-1} pounds, while the range among hybrids for milk per ton is 275 kg Mg^{-1}. Consistent performance regardless of environment is important for making hybrid selection decisions for silage quality. Repeatable differences for whole plant fiber and digestibility have been observed in high and low quality checks. Fiber concentrations were lower for hybrids selected for low NDF. *In vitro* true digestibility was greater for low NDF hybrids. NDF digestibility (CWD) and crude protein content was not different between low and high NDF hybrids. This paper will provide a retrospective of our experiences developing the Wisconsin corn hybrid evaluation program for silage.

Key words: corn silage, hybrid, yield, NDF, NDFD, starch content, milk yield and quality indeces

Introduction

Wisconsin dairy farmers produce more corn (*Zea mays* L.) silage than any other state in the U.S. A University of Wisconsin corn silage research consortium evaluated corn hybrids and found that the range for NDF and digestibility among commercial hybrids is narrow, but more importantly, yield and quality differences among corn hybrids were repeatable (Coors, 1996). In 1995, an extension program was begun to evaluate commercial corn hybrids for silage yield and quality traits. Desirable corn hybrids should have traits that include high dry matter yield, high energy content (high digestibility), high intake potential (low fiber), optimum dry matter content at harvest for acceptable fermentation and storage, and high protein content (Carter et al., 1991). Predicting animal performance and relating it to corn silage quality improvements whether from

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breeding or management is complex. Differences in fiber and digestibility translate into differences in animal performance (Bal et al., 2000). Our objective is to describe the development of a corn silage evaluation program for Wisconsin producers, to highlight significant changes in the program and to provide a retrospective of trial results.

Materials and Methods

Corn hybrids are evaluated in a randomized complete block with three replications at 2 to 3 locations in a production zone. Whole-plant plots are harvested using a one-row chopper (New Holland 707) and weighed using a custom electronic system. Plot weight and moisture content are measured, and yield is adjusted to Mg dry matter ha^{-1}.

Near Infra-red (NIR) global equation:

An outcome of the corn silage consortium was the development of an NIR global equation to measure forage quality (Coors, 1996). Harvested plot sub-samples are dried, ground through a 2 mm screen, and analyzed. R^2 values between predicted and laboratory values range from 0.93 to 095 depending upon the variable measured.

Performance indices include (Milk Mg^{-1} and Milk ha^{-1}):

The Milk91 model (Undersander et al., 1993) was chosen to describe forage quality and assist farmers in making hybrid selection decisions. This model has been further adapted and released as Milk95, Milk2000 (Schwab et al., 2003), and Milk2006. The current Milk2006 silage performance indices, milk Mg^{-1} and milk ha^{-1}, are calculated using a modification of a published summative energy equation (Weiss et al., 1992) where crude protein, fat, NDF, starch, and sugar plus organic acid fractions are included along with their corresponding total tract digestibility coefficients. The sample lab measure of NDFD was used for the NDF digestibility coefficient. Digestibility coefficients used for the crude protein, fat, and sugar plus organic acid fractions were constants. Dry matter intake was estimated using NDF and NDFD content assuming a 613 kg cow consuming a 300 g kg^{-1} NDF diet. Using National Research Council (NRC, 2001) energy requirements, the intake of energy from corn silage was converted to expected milk Mg^{-1}. Milk ha^{-1} was calculated using milk Mg^{-1} and dry matter yield ha^{-1} estimates.

Repeatability estimates:

Repeatability is the ratio of variance within individuals to variance between individuals and sets an upper limit to heritability (Falconer and Mackay, 1996). Variance components were obtained using PROC MIXED (SAS, 2000). When genotypes are randomly sampled from a defined reference population, repeatability is termed broad-sense heritability and calculated by the formula:

$$r = \left[\left(V_G\right) / \left(V_G + \frac{V_{GE}}{e} + \frac{V_{error}}{re} \right) \right]$$

where V_G, V_{GE}, and V_{error} refer to variance due to genotype, genotype by environment, and error, respectively (Lorenz and Coors, 2008). Coefficients e and r refer to the number of environments and replications per environment, respectively.

Results and Discussion

Relatively small differences in corn silage fiber, starch and digestibility translate into large differences in predicted animal performance. Through 2008, a total of 5737 hybrid*location*years (n= 17,144 plots) have been evaluated in 206 trials. A significant range between the highest and lowest performing hybrid in a trial was observed for yield (7.1 Mg dry matter ha^{-1}), NDF (88 g kg^{-1}), IVD (58 g kg^{-1}), starch (138 g kg^{-1}), NDFD (89 g kg^{-1}), Milk Mg^{-1} (275 kg milk Mg^{-1}) and Milk ha^{-1} (14,700 kg milk ha^{-1}). These ranges, especially the performance indices of Milk Mg^{-1} and Milk ha^{-1} indicate that the decision for selecting corn hybrids for silage is economically important (Lauer et al., 2008).

Consistent performance regardless of environment is important for making hybrid selection decisions for silage quality. Repeatability estimates indicate that the majority of total variation observed was due to variation among hybrids (Table 1). Repeatability of yield and Milk ha^{-1} were slightly lower than the forage quality estimates of NDF, starch, NDFD, and Milk Mg^{-1}, especially in the northern production zone of Wisconsin.

Table 1. Repeatability estimates for corn silage traits in four Wisconsin production zones. Data is derived from 206 trials conducted between 1995 and 2008.

Zone	Yield	NDF	Starch	NDFD	Milk Mg^{-1}	Milk ha^{-1}
	Mg ha^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg milk Mg^{-1}	kg milk ha^{-1}
North	0.83	0.94	0.98	0.95	0.94	0.73
North central	0.97	0.98	0.99	0.99	0.98	0.96
South central	0.97	0.97	0.99	0.98	0.97	0.96
South	0.97	0.98	0.99	0.99	0.97	0.95

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