The Development of HarvXtra™ Alfalfa

Background

As alfalfa plants mature from vegetative to bloom stage, cell wall content Neutral Detergent Fiber (NDF) increases and the digestibility of cell walls Neutral Detergent Fiber Digestibility (NDFD) decreases. The decrease in NDFD can be primarily attributed to an increase in lignin content. Lignin is indigestible per se, and cross-links with the cellulose and hemicellose decreasing the digestibility of these cell wall components (Undersander, et al., 2009)[1]. In a strategic partnership formed in 2002 between Forage Genetics International (FGI), The Samuel Roberts Noble Foundation (Noble Foundation) and the U.S. Dairy Forage Research Center, scientists from these institutions implemented a strategy to use biotech techniques to modify lignin content and composition in alfalfa. The NDFD data reported in this document is predicted by Near Infrared Spectroscopy (NIRS) using prediction equations developed from standard laboratory assays for measuring NDFD. This should not be interpreted as a direct measurement or prediction of animal performance potential, but simply as one of several forage quality metrics commonly used by the forage community.

Development of Reduced Lignin Alfalfa

There are several steps in the process of lignin synthesis in alfalfa. This lignin biosynthetic pathway involves twelve different enzymes. Each are required for a specific step in the pathway. Noble Foundation scientists identified and suppressed several "lignin genes" that code for specific pathway enzymes. FGI scientists then took the lead in generating and evaluating biotechnology-derived (biotech) plants with suppression of a specific lignin gene that was most effective in modifying alfalfa's lignin content and lignin composition, while maintaining alfalfa's important agronomic characteristics. From a single elite biotech alfalfa plant best embodying this product concept, FGI breeders developed populations designed for use in experimental field trials and also began a process of integrating the reduced lignin trait into multiple proprietary breeding lines. This reduced lignin trait will be commercially released, in conjunction with Monsanto Company, with the brand name of HarvXtra™ alfalfa.

During the HarvXtra™ trait development, FGI scientists demonstrated that plants containing the commercial event had a 10-15% decrease in lignin content and a 10-15% increase in NDFD and Relative Forage Quality (RFQ) when compared to related lines without the HarvXtra™ trait[2]. They also learned that HarvXtra™ alfalfa had a slower change in quality with advancing maturity compared with conventional alfalfa. This difference allowed more flexibility in harvest management with a broader harvest window for the production of high quality alfalfa hay/haylage. In various tests designed to better understand this phenomenon, the FGI trait development team learned that HarvXtra™ alfalfa, with harvest delayed by seven days, had about the same NDFD as conventional alfalfa harvested a week earlier. This was substantiated in cutting management trials comparing HarvXtra™ alfalfa and conventional alfalfa harvested at 28 day (~late bud) vs 35 day (~10% bloom[3]) cutting intervals (see graph).

[1] http://alfalfa.ucdavis.edu/+symposium/2009/files/talks/09WAS23_Undersander_LowLignin.pdf
[2] Mean of eighteen harvests in 2013 from data collected on ten HarvXtra™ alfalfa experimental populations and checks in forage yield trails planted in 2012 and 2013 at five locations.
[3] Stewardship requirements, similar to Genuity® Roundup Ready® alfalfa, will apply.

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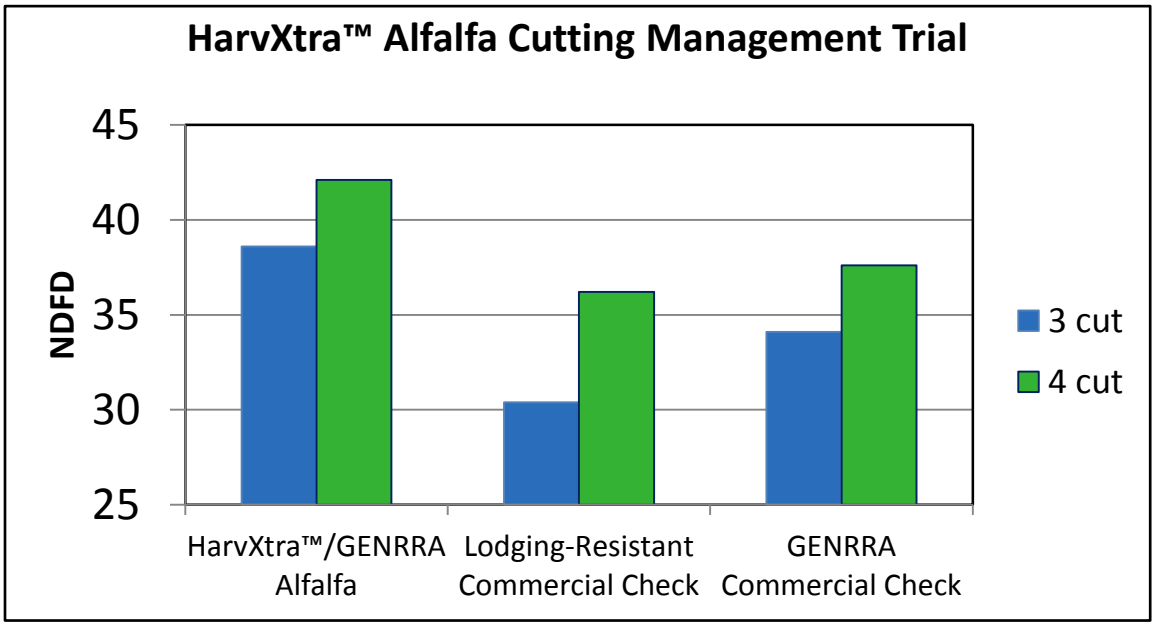

A comparison of three cut (35 day cutting interval) vs four cut (28 day cutting interval) harvest management on forage quality of HarvXtra™ alfalfa vs commercial checks. GENRRA=Genuity® Roundup Ready® Alfalfa

Multiple university-conducted cutting management trials with conventional alfalfa have consistently demonstrated that while early and more frequent harvest is often required for the production of high-quality hay suitable for feeding to high-producing dairy cows, forage yield and stand persistence is improved when harvest is delayed until the 10% bloom stage[4]. For example, multiple trials conducted at the University of Wisconsin (UW) have shown a 15-20% forage yield advantage for a three cut verse four cut management system over a four year rotation. However, forage quality of conventional alfalfa in the UW three-cut treatment was significantly lower than in the four-cut treatment. This "forage yield vs. forage quality tradeoff" defines the dilemma for most alfalfa forage producers in managing their cutting strategy. The potential for delayed harvest of HarvXtra™ alfalfa without sacrificing forage quality provides alfalfa growers the flexibility at forage harvest a potential "high yield/high quality" solution to this historic dilemma and a potential for fewer cuts/season with the associated lower harvest costs.

Preliminary trials of experimental varieties of HarvXtra™ alfalfa are showing a 10-15% increase in NDFD and RFQ compared with conventional commercial checks harvested at the same time. This can translate into an approximate 20 point RFQ advantage and a $15-20/T price premium based on current Midwest hay pricing standards.

The product concept for HarvXtra™ alfalfa is[5]

1) a ≥12% increase in RFQ compared to conventional varieties harvested at the same time; or
2) a ≥ 7 day delay in harvest with the same or better RFQ as a conventional commercial check harvested without the delay.

Furthermore, we expect that forage yield potential per se, persistence, multiple pest resistance, and lodging tolerance will be similar to commercial varieties harvested on the same cutting schedule.

[4] http://alfalfa.ucdavis.edu/+symposium/proceedings/2001/01-031.pdf and http://hayandforage.com/hay/striking_balance_wisconsin_1108

[5] All HarvXtra™ alfalfa varieties will have met these minimum requirements in tests conducted at multi-year, multiple location variety trials; however, on farm results may vary depending on local conditions and management practices.

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