Reduced-lignin ALFALFA provides flexibility for farmers

Striking a balance between forage quality and yield has always been a challenge for alfalfa growers. Reduced-lignin varieties are helping to ease the yield-quality tradeoff and provide more flexibility to farmers. Earn 0.5 CEUs in Crop Management by reading this article and taking the quiz at www.certifiedcropadviser.org/education/classroom/classes/508.

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Striking a balance between forage quality and yield has always been a challenge for alfalfa growers. Farmers who cut alfalfa on a 28-day cycle to make dairy-quality hay end up sacrificing 20% in yield potential. Meanwhile, those who harvest later to get higher tonnage often lose feed quality and digestibility.

This trade-off exists because plants add an indigestible type of fiber, called lignin, to their tissues as they mature, and when a consortium of scientists began meeting in 2001 to “reinvent” alfalfa, they knew this was the issue to tackle. As a perennial legume that holds the soil and fixes nitrogen, alfalfa is valuable to have in rotation, says consortium member Mark McCaslin, vice president for research at Forage Genetics International (FGI). “So, part of this was: What could we do to keep alfalfa as an important part of the dairy ration?”

When improving fiber digestibility rose to the top, it didn’t take long for the researchers from FGI, the Samuel Roberts Noble Foundation, U.S. Dairy Forage Research...
Reduced-lignin Center, and DuPont Pioneer to settle on the next step. “Everyone agreed we should go after lignin,” McCaslin says.

Fast forward 16 years and the outcome of their collaboration is now available across the United States: Alfalfa varieties that are genetically modified to contain 16 to 20% less lignin than their conventional counterparts. Sold by FGI under the brand name HarvXtra, these genetically modified (GM), reduced-lignin varieties also score 4 to 5 points higher in digestible fiber than conventional alfalfa.

In studies by FGI, at universities, and now in on-farm trials, reduced-lignin alfalfa has been shown to ease the yield–quality trade-off in two primary ways, says University of Wisconsin forage agronomist Dan Undersander. Growers can cut it on a 28-day interval—the standard for dairy cattle—and obtain higher quality forage each time. Or they can purposely delay harvest to get higher yields while achieving the same quality as conventional alfalfa cut up to 10 days earlier.

Perhaps the biggest benefit, though, comes when harvest schedules fall apart, says Phil Bollman, HarvXtra support manager at FGI. Case in point: In on-farm trials with reduced-lignin alfalfa last year, bad weather forced some growers to cut later than they wanted to—not an uncommon situation. Yet they still had a positive experience, Bollman reports.

“They had a wider cutting window, and they harvested alfalfa of similar quality to what they would have [gotten] maybe a week or 10 days earlier,” he says. “So, one of the key lessons has just been the flexibility this trait offers.”

Why lignin?

To understand why the industry consortium went after lignin, it helps to know how it reduces feed quality. While people have skeletons to hold them up, plants stay upright by reinforcing their cell walls with lignin—a rigid “biopolymer” that’s the main component of wood, but is also plentiful in non-woody plants like alfalfa. The strength and stiffness lignin gives to plants is what prevents agronomic problems like lodging. But lignin also lowers fiber digestibility and, hence, feed quality.

It does this in two ways. First, lignin binds to the energy-rich, digestible components of plant fiber—cellulose and hemicellulose—blocking their digestion in the rumen. Second—and more important—because lignin itself is a bulky, indigestible type of fiber, cows that eat a lot of it can’t consume as much feed. “It’s the same with humans,” Undersander explains. “When you eat more fiber, you get
Gene flow risk low in alfalfa

One perennial worry with genetically modified (GM) crops is that their genes will mix with those of their non-GM counterparts, such as organic varieties or ones destined for export.

But the risk of this happening in alfalfa is lower than in, say, corn, which is wind-pollinated and grown for grain, says Mark McCaslin, vice president of research at Forage Genetics International. That’s because for this genetic mixing, called “gene flow,” to occur in alfalfa, several events would need to happen in sequence.

First, bees would have to transfer pollen from a GM alfalfa variety to non-GM plants. So, the GM and non-GM alfalfa fields would have to be flowering at the same time, and bees would also need to be around to carry the pollen. Next, the pollinated plants would have to produce seed, which means the farmer was harvesting much later than normal. And finally, the seed containing genes from the GM and non-GM variety would have to germinate within the alfalfa stand and grow into mature plants.

The chance of all these events happening together is remote, but the biggest argument against gene flow in alfalfa is that the crop is overwhelmingly grown for hay, not seed. In U.S. regions where alfalfa is grown for seed (roughly 200,000 ac, compared with about 18 million hay ac), farmers do need to follow strict practices to prevent gene flow between GM- and non-GM stands (for specific details, see www.TUG.monsanto.com), McCaslin says.

“But if you’re a hay producer and you’re worried about gene flow [from GM plants] into your field, the only thing you need to do is harvest your crop before seed set,” he says. “That alone helps reduce the risk significantly.”

fewer sugars and fats and all the high-energy stuff.” And when the energy cows obtain from their feed goes down, so does milk production.

As they began studying ways to bring down alfalfa’s lignin content, the consortium members knew from their decades of collective breeding experience that conventional breeding couldn’t deliver the reductions they were looking for. So, they opted for a genetic engineering approach. First, they systematically suppressed the activity of each of 12 genes that work together in alfalfa to make lignin. They then examined the impact of each genetic change on lignin content, fiber digestibility, and agronomic attributes. Once they identified a gene whose suppression produced the effects they wanted, they made non-functioning copies of this natural gene and inserted them into alfalfa.

What happens, then, is that the non-functioning copies interfere with the function of the real gene, resulting in less lignin production in the plant. In some ways, “it’s not unlike brown-midrib (BMR) corn or BMR sorghum,” McCaslin says. “Those plants also have mutations in one of the genes in the lignin synthesis pathway.” The difference is that in BMR plants, the affected gene is completely turned off—it doesn’t work at all—whereas with HarvXtra alfalfa, it’s suppressed rather than shut down. And suppression, McCaslin says, offers more control. “You can fine-tune in such a way that you get improved forage quality without sacrificing agronomic performance.”

Regarding performance, Bollman says a top concern of farmers is that reduced-lignin alfalfa will lodge more. But so far, the growers participating in FGI’s on-farm demonstrations in South Dakota, Wisconsin, New York, and three other states are reporting no issues. “We’ve seen no difference in lodging between HarvXtra and conventional alfalfa,” Bollman says.

Many farmers also ask about yield, he adds, and here, too, reduced-lignin varieties differ little from conventional alfalfa when the two are cut on the same schedule. However, because HarvXtra alfalfa’s quality remains higher as it matures, farmers who wait to harvest will see a benefit. “What we say is that alfalfa with the HarvXtra trait will yield no better or worse than conventional,” Bollman says. “But what it will allow you to do is change your agronomic processes to delay harvest and take advantage of yield.”

How large is the advantage? Yield curves for alfalfa show an increase of roughly 100 to 150 lb dry matter/ ac/day, Undersander says. “So, if you wait seven days to harvest, that’s 700 to 1,000 more lb/ac. That’s a big deal.”

Digestibility and harvest advantages

For his part, Undersander has been fielding questions about reduced-lignin alfalfa’s impact on relative feed value (RFV) and relative forage quality (RFQ), two indices of energy intake potential—or how digestible a feed is and how much cows will consume. The bottom line is that the index to watch with HarvXtra alfalfa is RFQ, Undersander says, because of how it’s calculated compared to RFV.

To estimate feed intake and digestibility, RFV uses only the fiber content of the feed [neutral detergent fiber (NDF) and acid detergent fiber (ADF)], he explains. On the other hand, RFQ estimates feed digestibility both from NDF and actual measurements of digestible fiber (NDF digestibility, or NDFd), obtained by incubating the feed with rumen microbes. Not only does this make RFQ the more accurate predictor of feed digestibility, but HarvXtra alfalfa also consistently scores higher in NDFd than conventional alfalfa.

“So, because RFV [uses] only fiber content, it isn’t going to be much different between GM and conventional

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alfalfa,” Undersander says. But because RFQ is based on digestible fiber, “it will show the improved fiber digestibility of a feed, if it exists,” he adds. “And with reduced-lignin alfalfa, it does.”

Data on reduced-lignin alfalfa’s digestibility come from FGI’s own studies and from field trials established in spring 2015 at six universities across the country, which were supported by FGI. Led by Ohio State University crop science professor Mark Sulc, the university study compared the feed value and yield of HarvXtra alfalfa and several conventionally bred, commercial varieties under various cutting schedules. Two sites in California and Pennsylvania also included Alforex Seeds’ Hi-Gest, a non-GM, low-lignin alfalfa that was developed through conventional breeding.

Across all six states in 2015, HarvXtra forage scored 4.5 to 5.5 points higher in digestible fiber (NDFd) at each sampling point than conventionally bred varieties, including Alforex Seeds’ low-lignin, Hi-Gest alfalfa. And what these higher NDFd scores translate into is a roughly 10-day harvest advantage. When cut on a 38-day interval, for example, HarvXtra alfalfa’s forage quality was the same or greater than any conventionally bred variety cut on a 28- or 33-day schedule—i.e., 7 to 10 days earlier.

In addition to flexibility, being able to extend the cutting interval offers several other benefits. For one, it lets alfalfa growers in northern states exploit more of the growing season. Wisconsin farmers, for example, typically harvest alfalfa for the first time around May 20, and then three more times, every 20 days or so, after that, Undersander says. This means the fourth and final cutting typically happens in early to mid-August even though alfalfa can grow for a month longer. “So, if we can stretch out those cuttings, then we can get more tonnage because we’re using the full growing season,” he says.

A bit further south, longer intervals may allow farmers to reduce their cuttings from five per season to four while still achieving the same yield. This represents a significant savings in labor and money, when it costs an estimated $50 per acre to harvest the crop, Undersander says.

That said, he advises against delaying the very first harvest of HarvXtra alfalfa; instead, farmers should take their first cutting at the normal time and then extend the interval between subsequent harvests if they want more yield. “One of the problems with forage in the spring is the first cutting is very high tonnage and plants tend to get tall,” he says. “So, if you don’t get to it in time, it lodges, whether it’s GM or conventional.”

Management considerations

Yet another benefit of lengthening the cutting interval is that it may result in healthier alfalfa. “When we’re cutting at the bud stage every time, we’re putting a lot of stress on that plant,” Undersander says. “So, I’m not prepared to say the stand will last longer, but certainly we’ll see less winter injury and faster growth in spring.”
At the same time, farmers who cut at the bud stage typically don’t need to worry about leaf diseases. But since these diseases worsen the longer alfalfa remains in the field, they could become an issue with HarvXtra alfalfa. “If we let it go a week longer, then we may need to use more fungicide to keep the leaves from getting diseased and falling off,” Undersander says. The leaves are already the most digestible part of forage, he adds. So, if a lot of them are lost to disease, this could offset any gains from the reduced-lignin trait.

Something else farmers will need to manage is the cost of the GM seed, which is about twice that of conventional seed. Here, Undersander recommends reducing the seeding rate. Alfalfa growers typically seed at 18 lb/ac to as high as 30 to 40 lb when studies have shown that 12 lb/ac is more than adequate, he says. To make a rate of 12 lb/ac work, though, farmers will need to employ good equipment and practices to prevent stand failures.

Additional challenges will likely crop up as more farmers begin working with the new, GM varieties. In the meantime, FGI is crunching the data and continuing to gather experiences from the growers who are participating in its on-farm trials. Detailed information will eventually be released in a series of case studies, but for now, Bollman says that HarvXtra alfalfa is “performing as expected.” And it’s sparking some excitement.

“The cost of the GM reduced-lignin alfalfa seed is about twice that of conventional seed. One way to manage cost is to reduce the seeding rate.” Screenshot of a YouTube video by Josh Cage (see https://youtu.be/RGg-jvE7wQU).

“One of the growers commented that based on the results they’re seeing, they’re thinking about putting more alfalfa back into the diet and growing more on their farm,” he says. “That, to me, was pretty powerful.”

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