Alfalfa (*Medicago sativa*) is often called the "Queen of Forage Crops" and has been used predominantly as a forage crop since the beginning of recorded history (Lacefield et al., 1997). The first known cultivation of alfalfa was in Iran, Turkmenistan, and Caucasus in 2000 BC according to archeological evidence and in Babylon in 700 BC according to written evidence (Yuegao and Cash, 2009). Alfalfa was brought to North America in the early 1700s by European colonists (Lacefield et al., 1997). Today, alfalfa is grown all around the world.

The popularity and spread of alfalfa is due to its high yield potential and high feed value for livestock as both an ensiled product as well as a dried hay (Lacefield et al., 1997). The average conventional alfalfa crop (harvested prior to flowering) in the United States contains approximately 19.2% crude protein (CP), 2.5% ether extract (EE), 41.6% neutral detergent fiber (NDF), 32.8% acid detergent fiber (ADF), 7.6% lignin, and 11.0% ash including 1.47% Ca, 0.28% P, 0.29% Mg, and 2.37% K (on a dry matter basis) (NRC, 2001). Alfalfa is often included in ruminant diets as a source of carbohydrates, protein, vitamins, and minerals.

As with all carbohydrates, alfalfa is made of a non-structural and a structural carbohydrate fraction. The non-structural fraction of carbohydrates includes sugar and starch. These two components are rapidly degraded in the rumen via microorganisms such as *Bacteriodes ruminicola*, *Bacteriodes amylophilus*, *Selenomonas ruminantium*, *Streptococcus bovis*, *Succinomonas amylolytica*, *Eubacterium limosum*, and *Megasphaera elsdenii* (Van Soest, 1994).

The structural fraction of carbohydrates includes pectin, hemicellulose, cellulose, and lignin. Pectin is degraded by rumen microorganisms such as *Succinivibrio dextrinosolvens* and *Lachnospira multiparus* (Van Soest, 1994). The remaining structural components; hemicellulose, cellulose, and lignin, make up the NDF portion of the feed. Under laboratory conditions, these are
the components that remain in the feed after an extraction is conducted at pH 7 with a solution of sodium lauryl sulfate and ethylenediaminetetraacetate (EDTA) (Van Soest, 1994). The sample can be extracted again using sulfuric acid hydrolysis, leaving only the cellulose and lignin portions of the feed, a separate fraction known as ADF (Van Soest, 1994).

Hemicellulose and cellulose are both characterized as polysaccharide polymers (Agrios, 1988). In the cell, hemicellulose functions are a major constituent of the primary cell wall and also make up the middle lamella and secondary cell wall (Agrios, 1988). The function of cellulose is to form microfibrils which make up the matrix of the cell walls (Agrios, 1988). Under ruminal conditions, hemicellulose and cellulose are degraded by *Ruminococcus albus*, *Ruminococcus flavafaciens*, *Fibrobacter succinogenes*, *Butyrivibrio fibrisolvens*, and *Eubacterium cellosolvens* (Van Soest, 1994).

Lignin, in contrast to hemicellulose and cellulose, is an amorphous phenylpropanoid (Agrios, 1988). It is distinctly different from both traditional carbohydrates and proteins, making it the most resistant plant substance to degradation (Agrios, 1988). In the plant, lignin is found in the middle lamella, xylem vessels, and in the fibers and functions to strengthen the plant (Agrios, 1988). However, lignin cannot be degraded by enzymes secreted by the animal or rumen microorganisms due to the anaerobic environment and lack of oxygen as a receptor, thus this portion of the feed is completely undigested and is expelled as waste.

There are varying digestibilities of the numerous components of carbohydrates due to their interactions in the rumen. Sugars, starch, and pectin are all extremely digestible in the rumen, having around 95-100% digestibility (Mazzia and Walker, 2008). Hemicellulose and cellulose are moderately digestible in the rumen, having around 20-80% and 50-90% digestibility, respectively (Mazzia and Walker, 2008). The final component of carbohydrates, lignin, is poorly digestible, having only 0-20% digestibility in the rumen (Mazzia and Walker, 2008). Although the digestibilities of the carbohydrate fractions tend to remain relatively the same, the proportion of these fractions in the plant have been demonstrated to change due to plant maturation.

When the alfalfa plant matures, there is a decrease in the leaf:stem ratio and an increase in lignification of the stems, which influences both the fiber digestibility as well as the protein fractions of the plant (Palmonari et al., 2014). Previous research by Palmonari et al. (2014) harvested an alfalfa hay crop at three different maturities; pre-bloom stage (21-d cutting schedule), first bloom (28-d cutting schedule), and full bloom (35-d cutting schedule). Their results demonstrated a decrease in crude protein (CP) content; 20.8, 17.3, and 17.0%, in addition to an increase in lignin content; 6.3, 6.9, and 7.3%, respectively, with no significant differences with NDF or ADF concentration (Palmonari et al., 2014). These results were conclusive with previous research, which found a decrease in CP and an increase in lignin concentration as the alfalfa plant matures (Elizalde et al., 1999a,b; Jung et al., 1997; Buxton et al., 1987; Nordkvist and Aman, 1986).

Not only is there an increase in the amount of lignin as the plant matures, this indigestible fiber is also believed to inhibit the digestion of other structural carbohydrate fractions. When an alfalfa plant ages and reaches the secondary growth phase during elongation, the amount and extent of lignification increases (Engels and Jung, 1998). The process of lignification begins in the primary wall and gradually progresses to the secondary cell wall, replacing hemicellulose and cellulose (Engels and Jung, 1998). During the biosynthesis of lignin, the amino acid phenylalanine enters the lignin pathway, eventually leading to pathway end-products known as hydroxycinnamyl alcohols (also known as monolignols) including predominantly coniferyl alcohol and sinapyl alcohol and lesser amounts of 4-coumaryl alcohol (Vanholme et al., 2010). These alcohols are used to form the lignin polymer, serving as the guaiacyl (G), syringyl (S), and p-hydroxyphenyl (H) units (Vanholme et al., 2010).

In dicots such as alfalfa, lignin molecules are only comprised of the G- and S-units (Vanholme et al., 2010). The formation of these two subunits requires the activity of p-hydroxy cinnamoyl-CoA: shikimate/quinate p-hydroxy cinnamoyl transferase (HCT), caffeic acid 3-O-methyltransferase (COMT), and caffeoyl
CoA 3-O-methyltransferase (CCoAOMT) (Guo et al., 2001a; Marita et al., 2003; Shadle et al., 2007; Rastogi and Dwivedi, 2008; Getachew et al., 2011). P-hydroxy cinnamoyl-CoA: shikimate/ quinate p-hydroxy cinnamoyl transferase is directly responsible for the conversion of 4-coumaryl CoA to 4-coumaryl shikimic acid/ 4-coumaryl quinic acid and the conversion of caffeoyl shikimic acid/ caffeoyl quinic acid to caffeoyl CoA (Rastogi and Dwivedi, 2008). Caffeic acid 3-O-methyltransferase and caffeoyl CoA 3-O-methyltransferase are directly responsible for the conversion of caffeoyl CoA to feruloyl CoA and the conversion of 5-hydroxyferuloyl CoA to sinapyl CoA (Rastogi and Dwivedi, 2008). The genetic regulation of these genes can be conducted by the turning on and off of the bean phenylalanine ammonia-lyase (PAL2) promoter (Guo et al., 2001a; Shadle et al., 2007).

Previous research by Shadle et al. (2007) observed the effect of down regulation of HCT in transgenic alfalfa on lignification, development, and forage quality. They found that alfalfa plants containing the down regulated HCT enzyme were phenotypically different; being only 25-50% the height, displayed a delay in flowering by as much as 20 d, and yielded significantly less biomass than the control alfalfa plants (Shadle et al., 2007). The HCT alfalfa plants were also nutritionally different; containing only 58-65% of the lignin content, 12-32% of the NDF content, and 13-35% of the ADF content when compared to the control alfalfa plants (Shadle et al., 2007). However, HCT alfalfa plants had an increase of 15-22% in in vitro dry matter digestibility (IVDMD) over the control (Shadle et al., 2007).

From the above study, researchers concluded that although there was a large reduction in lignin content of the HCT alfalfa plants, the reduction in NDF content was considered to be too great to account only for the decrease in lignin, suggesting that there was also a loss of nutritive quality despite the improved digestibility due to an increase in the proportion of pectin (Shadle et al., 2007). These results were consistent with previous research, which only observed height and found a decrease in overall plant height in regards to the HCT alfalfa plants (Chen et al., 2006). Additional research studies demonstrate that when the other enzymes responsible for formation of G and S units, COMT and CCoAOMT, are down regulated in alfalfa plants, there is a decrease in lignin by approximately 24 and 13% (Guo et al., 2001a; Marita et al., 2003; Getachew et al., 2011) and an increase in IVDMD by 16 and 4% (Getachew et al., 2011), respectively. The total biomass yield or phenotypic traits were not observed in these studies; however, other studies report that modification of COMT or CCoAOMT improves digestibilities less than by modification of HCT, but there are fewer negative phenotypic effects (Baucher et al., 1999; Guo et al., 2001a,b).

Every farmer knows that forage harvesting is a compromise between quality and quantity (yield). After thorough research, it is believed the there is only one commercially available low lignin alfalfa seed available at this time for the 2015 planting season. According to the company’s preliminary claims, their low lignin alfalfa will allow for greater forage quality (Figure 1) and up to a 7 d extended harvest window allowing for increase yields (Figure 2) when compared to conventional quality alfalfa (Alforex Seeds, 2014). They also claim that their variety of low lignin alfalfa can yield 2.5 more pounds of milk per cow per day (calculated data) and have similar lodging tolerance, stand persistence, and field appearance and the same management practices can be used as with conventional alfalfa (Alforex Seeds, 2014).

To this researcher’s knowledge, there are no ruminant nutrition in vivo research trials (dairy or beef) to date regarding low lignin alfalfa containing the down regulated HCT, COMT, or CCoAOMT genes. Future research is warranted in this area to confirm preliminary data, both in situ as well as in vivo. However, if reports are confirmed to be accurate, there is the possibility to improve the efficiency of milk and beef production in the United States.
Figure 1. Low lignin verses conventional alfalfa yield and quality after regrowth with a 28 d harvest schedule (Alforex Seeds, 2014).

Figure 2. Low lignin verses conventional alfalfa yield and quality after regrowth with a 35 d harvest schedule (Alforex Seeds, 2014).

References are available upon request.
Top 5 Criteria to Help Choose Your Next Forage Inoculant

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Technical Services
Lallemand Animal Nutrition

Production of quality silage involves winning a war fought on a microscopic level between “armies” of microbes. Inoculants help reinforce the beneficial bacteria in this fight. Yet, there are several factors to consider when choosing an inoculant that can help improve the safety and hygienic quality of the resulting silage. Plus, inoculants can help save tons of dry matter (DM). For instance, preventing 10% in additional DM losses can save producers approximately $44,000 a year1.

Inoculants are often lactic acid bacteria (LAB) that provide an efficient front-end fermentation to maintain feed quality and stability. Inoculants also can help stabilize silage during feedout. Beyond these initial types of inoculants, there are fundamental criteria should be considered to help set the stage for silage success.

1. Look for a Fast pH Drop
As a general rule of thumb, producers can’t go wrong with an inoculant that drops the pH of the forage as quickly as possible. A rapid pH drop will help maximize DM and nutrient retention, plus it will minimize the risk of spoilage.

To achieve a rapid pH drop, look for homolactic LAB strains such as *Pediococcus pentosaceus*, *P. acidilactici* and *Lactobacillus plantarum* that are proven to convert sugars efficiently to lactic acid.

2. Feed the Bacteria through Enzymes activity
Ensure LAB have a plentiful food supply. A good inoculant will contain enzymes to help feed bacteria and direct the ensiling fermentation. Enzymes help break down complex sugars and feed the LAB. In addition, enzymes may help to increase fiber digestibility.

3. Select the Right Application Rate
Using the right number of colony-forming units (CFUs) per gram of forage will ensure there are sufficient amounts of “good” microbes to help win the fermentation battle. Look for an application rate of 100,000 CFUs or greater for front-end fermentation inoculants. This is the minimum level, as recognized by university researchers.

4. Consider the Crop
Take into account the specific crop to be fermented and the harvest conditions. For example, ensiling wet hay
crops can easily lead to growth of clostridia and a butyric fermentation. Choosing an inoculant proven to inhibit these types of undesirable fermentations can keep the resulting forage safe to feed.

5. Battle Silage Shortcomings
A farm’s specific silage challenges can help determine the best inoculant choice. For example, high-moisture corn or slow feedout rates may suggest an inoculant proven to increase aerobic stability is required to prevent spoilage yeasts.

For example, *L. buchneri* 40788 is the only bacteria reviewed by the FDA and allowed to claim improved aerobic stability. Products with a high dose of *L. buchneri* — 400,000 CFUs — combined with homolactic bacteria can help control the initial ensiling fermentation and keep silage stable through feeding.

Ask your nutritionist how a proven inoculant can contribute to the productivity and profitability of your operation today.

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1 Based on 1,000 cows consuming 20 lb DM/day, for 3,650 tons of silage a year with silage valued at $120 per ton on a DM basis.

**Milk Protection Program for Dairy**

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The Margin Protection Program for Dairy (MPP-Dairy) established by the 2014 Farm Bill is a voluntary program for dairy producers. MPP-Dairy offers protection when the difference between the all milk price and the average feed cost falls below the dollar amount selected by the producer. Registration for 2016 will be administered by the county Farm Service Agency offices and the enrollment period will begin July 1 and end September 30, 2015.

An administration fee of $100 is required and if you were enrolled in 2015 you are automatically rolled into the catastrophic level if you fail to register for 2016. The catastrophic coverage is set at the $4 margin coverage level at 90 percent of the milk established by the farms production history.
The amount of premium paid will vary from farm to farm depending on the level of coverage selected. To calculate your premium you multiply the coverage percentage along with the production history of the farm. For example 1,200,000 lbs. of milk represents 90 percent milk production for a producer for a year. This producer chooses the $8.00 coverage level and pays $0.475 per cwt (see chart). The producer would pay $5700 in premiums (12,000 cwt X $0.475) plus the $100 administrated fee for a total of $5800.

There are some web tools that are available that allows producers to enter data and evaluate which level of protection may be of benefit. It may be accessed at [www.dairymarkets.org/mpp](http://www.dairymarkets.org/mpp). This website has a decision tool along with instructions as well as a margin dashboard.

**MPP Program Premiums** (USDA-Farm Service Agency)

<table>
<thead>
<tr>
<th>Coverage Level (Margin) per cwt.</th>
<th>Tier I Premium for 2014 and 2015</th>
<th>Tier 1 Premium for 2016-2018</th>
<th>Tier 2 Premium for 2014-2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered production history less than 4 million lbs. with 25 percent reduction</td>
<td>Covered production history less than 4 million lbs.</td>
<td>Covered production history greater than 4 million lbs.</td>
<td></td>
</tr>
<tr>
<td>$4.00</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>$4.50</td>
<td>$0.008</td>
<td>$0.010</td>
<td>$0.020</td>
</tr>
<tr>
<td>$5.00</td>
<td>$0.019</td>
<td>$0.025</td>
<td>$0.040</td>
</tr>
<tr>
<td>$5.50</td>
<td>$0.030</td>
<td>$0.040</td>
<td>$0.100</td>
</tr>
<tr>
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</tr>
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<tr>
<td>$7.00</td>
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<td>$0.217</td>
<td>$0.830</td>
</tr>
<tr>
<td>$7.50</td>
<td>$0.225</td>
<td>$0.300</td>
<td>$1.060</td>
</tr>
<tr>
<td>$8.00</td>
<td>$0.475</td>
<td>$0.475</td>
<td>$1.360</td>
</tr>
</tbody>
</table>

The production margin is the difference between the US national all milk price, reported by NASS, and the US national average feed cost. The corn and alfalfa hay prices are also those reported by NASS. The price of Soybean meal is the Central Illinois price delivered and is reported by AMS. The formula is as follows:

\[
\text{All milk Price} - (1.0728 \times \text{Shelled Corn Price/bu} + 0.00735 \times \text{SBM Price/ton} + 0.0137 \times \text{Alfalfa Price/ton})
\]

The production margin is calculated in consecutive two-month periods as follows: January/February, March/April, May/June, July/August, September/October, and November/December.

A payment will be issued whenever the dairy production margin for the consecutive two-month period is less than the coverage level the producer has selected. Let’s use the producer that was previously mentioned that covered 90 percent of his milk at the $8.00 level. Here is an example of how a payment is calculated: Assume that the average margin was $6.00 during a consecutive two-month marketing period. The producer is entitled to $2.00 per cwt on 2 months or one-sixth of the milk produced. The payment would be $4000 (2,000 cwt X $2.00).
It is important to note that once you are enrolled in MPP-Dairy you are in for the life of the Farm Bill which is in place until December 31, 2018. You may still use future and options contracts but are not eligible to participate in the Livestock Gross Margin for Dairy Cattle (LGM-Dairy). However with MPP-Dairy, every year, July 1 – September 30, you have a chance to adjust your percent of milk covered and your coverage level during the registration period. With the way milk prices have been trending it may be beneficial to sit down and work through different scenarios to evaluate if your current coverage is adequate.

If you would like more information feel free to contact Dan Severson at severson@ude.edu or call 302-831-8860.

References are available upon request.
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