Feedstuffs Reprint

Time for a refresher on alfalfa production

I REMEMBER a time, almost 35 years ago, coming from Cornell University to attend the University of Wisconsin and being told to forget what I was taught back East about feeding corn silage because in Wisconsin, cows were fed alfalfa — the so-called "queen of forages."

Today, the pendulum has swung, and all you seem to hear about is corn silage, even in Wisconsin. However, as is common, maybe the pendulum has swung a bit too far.

This column is meant to re-sensitize the nutritional community to some of the key aspects of alfalfa production or procurement borne out of a selfish desire to make nutritionists' lives easier and the herds we consult for more profitable.

Maturity matters

Nothing influences the nutritional quality of alfalfa more than maturity. It has been my observation that increasingly busy nutritionists are not helping clients who harvest their own alfalfa keep this important fact in mind.

Thinking back once again, I remember the local Harvestore salesman being kind of an irritant because he was always stopping by farms to tell producers that they needed to get the mowers ready to harvest alfalfa (and he was absolutely right). Perhaps this is a role we should be undertaking as nutritionists rather than relying solely on the producer or crop consultant?

Granted, some regions have it easier than others due to more favorable environmental conditions for growing and harvesting alfalfa. Similar to corn genetics, alfalfa genetics play a small role in quality differences, but the growing environment and harvest maturity are the biggest drivers.

It is well documented that environmental factors have a smaller

*Bill Mahanna (Ph.D., Dipl. ACAN) is a collaborative faculty member at Iowa State University and a board-certified nutritionist for Pioneer Hi-Bred based in Johnston, Iowa. To expedite answers to questions concerning this article, or to submit ideas for future articles, please direct inquiries to *Feedstuffs*, Bottom Line of Nutrition, 12400 Whitewater Dr., Suite 160, Minnetonka, Minn. 55343, or e-mail comments@feedstuffs.com.

Bottom Line

with
BILL MAHANNA*

effect on quality than on yield and that most factors that limit plant development (e.g., lack of water, cold weather, plant diseases) tend to promote higher quality because of their effect on altering leaf: stem ratios (Van Soest, 1996).

The biggest environmental factors influencing alfalfa are temperature, water deficiency, solar radiation and — at a distant fourth — soil fertility.

Growing conditions that promote the highest alfalfa quality exhibit long day lengths, cool nights and moderately dry weather. Warm, wet weather results in the poorest-quality alfalfa. Cool, wet growing conditions produce high-quality alfalfa due to low neutral detergent fiber (NDF) and low lignification (Van Soest, 1996).

However, getting the crop harvested in these conditions can be a problem, with harvest delays resulting in maturity ramifications, in addition to the potential for higher respiration or leaching losses and fermentation/spoilage problems from increased exposure to soil-borne fungi and bacteria.

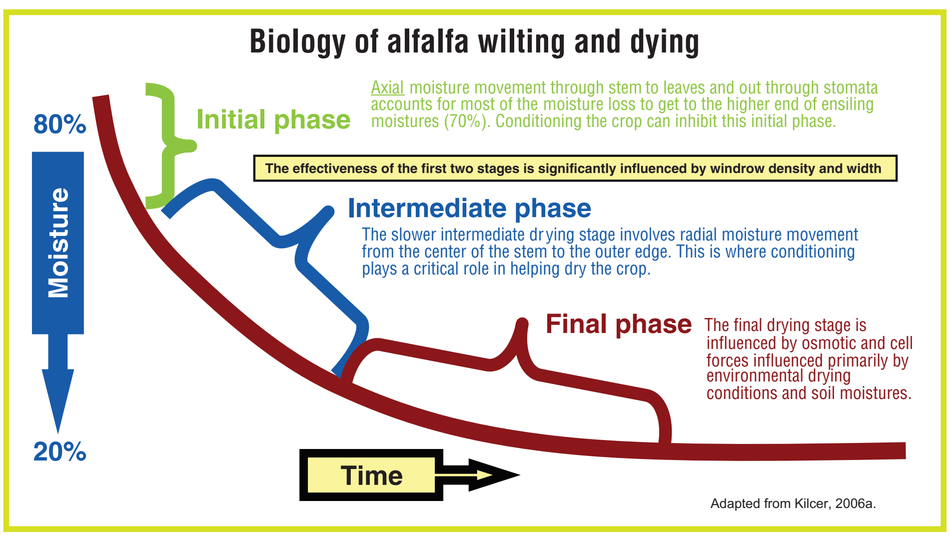
Solar radiation (light) is the only environmental factor promoting both yield and quality. Light promotes carbohydrate production; every one-hour increase in day length can increase digestibility by about 0.2 percentage units (Van Soest, 1996).

The shortening photoperiod in the fall has a negative effect on digestibility but is somewhat offset by cooler temperatures. Cloudy weather reduces photosynthesis, causing low sugar and mobilization of nutrients, which results in higher proteins; both can be problematic for silage production (Van Soest, 1996). There are also more pentose sugars in fall-harvested alfalfa, further contributing to fermentation challenges.

Drought conditions reduce yield, but the resulting stunted yet leafy plants are generally higher in protein and digestibility due to the higher leaf:stem ratio. The digestibility advantages would be greater if they weren't somewhat offset by increased lignification due to the high temperatures that typically accompany drought conditions.

Temperature accelerates plant development. Warm weather accelerates NDF development and lignification. Every 1°C increase in temperature will generally decrease the digestibility of forages 0.3-0.7 percentage units (Van Soest, 1996). This is one reason why forages produced in northern latitudes or higher elevations (cooler nights) tend to be of higher quality.

In the spring, light and temperature are positively correlated until June 21 — when maximum day length and light



occur — after which light decreases and temperature increases (bad for quality) until the fall, which is characterized by declining temperatures and decreasing day length and light (good for quality; Van Soest, 1996).

Relative forage quality

I am still amazed at how many growers, brokers and producers still reference relative feed value (RFV). I think another role nutritionists can play is promoting the value of relative forage quality (RFQ). We have all seen two lots of hay that have the same RFV but considerably different results. These differences are much reduced when NDF digestibility of the hay is factored into ration formulations.

The use of the PEAQ stick (predictive equations for alfalfa quality) for assessing alfalfa maturity and NDF levels (Rankin, 2009) has been around for decades, and I think this is a tool more nutritionists should be carrying with them. It is encouraging that research from the University of Wisconsin (Undersander, 2008) shows that PEAQ sticks can also be used to estimate RFQ of first-cutting alfalfa and that RFQ will be as high as (or higher than) the RFV estimates.

Cutting timing

The time of day to harvest alfalfa — morning versus afternoon — is an interesting topic, and research results fall on both sides of the debate. The basic idea is that cutting later in the day allows the crop to lay down more sugars to improve hay's palatability (Maryland, 2008) or aid in silage fermentation. Much of the positive research has been conducted on alfalfa hay harvested in western states.

Although morning versus afternoon forages differ in initial composition, it is not clear that these differences always exist after drying and/or fermentation. Cell respiration will reduce sugar levels at night or in the section of the windrow not receiving sunlight.

Research in Wisconsin (Undersander, 2003) showed that 11 of 14 Wisconsin farm samplings had higher sugars with afternoon-cut alfalfa, yet only one of the 14 had higher sugar levels in stored forage. There also appear to be adequate sugars to support fermentation when alfalfa is harvested at typical North American moistures/maturities compared to lower-dry matter European forages (Nasser et al., 2006).

Hay palatability is also less of a concern in total mixed rations when cows are not given a choice of feedstuffs. A Miner Institute study (Thomas, 2001 and 2007) showed no statistical difference in plant sugars, starches, NDF or *in vitro* digestibility. While afternoon-harvested alfalfa was numerically higher in sugar and starches, the small differences either decreased or disappeared entirely by the time the forage was at 40% dry matter.

Alfalfa mowed in the morning was ready for silage harvest in about nine hours, while alfalfa mowed in the late afternoon was not harvestable until after noon on the following day. Many researchers in the Midwest or East believe it makes more sense to harvest early in the day to maximize the hours of drying from solar radiation rather than expose the crop to delayed drying or increased weather risk.

Guidelines for acceptable levels of ingested butyric acid

Silage butyric acid levels (% dry matter)	Butyric acid, g/lb.	------Pounds of dry matter to ingest:------ 50 g of butyric acid	150 g of butyric acid	250 g of butyric acid
0.25	1.1	44.1	132.2	220.3
0.50	2.3	22.0	66.1	110.1
0.75	3.4	14.7	44.1	73.4
1.00	4.5	11.0	33.0	55.1
1.25	5.7	8.8	26.4	44.1
1.50	6.8	7.3	22.0	36.7
1.75	7.9	6.3	18.9	31.5
2.00	9.1	5.5	16.5	27.5
2.25	10.2	4.9	14.7	24.5
2.50	11.4	4.4	13.2	22.0
2.75	12.5	4.0	12.0	20.0
3.00	13.6	3.7	11.0	18.4
3.25	14.8	3.4	10.2	16.9
3.50	15.9	3.1	9.4	15.7
3.75	17.0	2.9	8.8	14.7
4.00	18.2	2.8	8.3	13.8
4.50	20.4	2.4	7.3	12.2
5.00	22.7	2.2	6.6	11.0
5.50	25.0	2.0	6.0	10.0
6.00	27.2	1.8	5.5	9.2
6.50	29.5	1.7	5.1	8.5
7.00	31.8	1.6	4.7	7.9
8.00	36.3	1.4	4.1	6.9
9.00	40.9	1.2	3.7	6.1

Wilting/drying biology

No area of the country has done more to help producers manage the harvest of alfalfa haylage and hay than New York. Producers there commonly mow alfalfa (often with conditioners removed) into a wide swath for faster drying, followed by merging and chopping, all within a 24-hour period (Putnam, 2009).

This reduces the risk of the crop being exposed to rain showers if a harvest window of 24 hours can be confidently predicted. Not only does this reduce weather risk, but it also preserves quality by retaining more sugars and protein — in the protein/peptide form rather than degraded to ammonia-nitrogen (Kilcer, 2006a).

The Figure details the phases of alfalfa wilting and drying. Cornell Extension (Kilcer, 2006b) stated in a popular press article that when wide-swathing, conditioning was of no benefit because conditioning interfered with moisture loss from leaf stomata. This article created considerable controversy since conditioning was such an accepted practice.

Wisconsin researchers (Shinners and Schuler, 2006) responded by citing research showing that conditioning plus wide-swathing produced the shortest time to acceptable harvest moistures and that unconditioned windrows needed to be nearly twice as wide as the conditioned windrows to produce a drying advantage.

Some of the debate centered around recommended silage harvest moistures. Producers today are targeting much drier alfalfa silage than the 65-70% moisture that was once the norm.

My interpretation of this body of research is that if producers are wide-swathing, conditioning is not as important to get to the high-60% moisture range. However, if equipment limitations prevent adequate wide-swathing, conditioning is still recommended, especially if moisture levels in the low-60% range are desired.

Chop height

Lowering the cutter bar obviously results in higher yields of alfalfa. Research shows that alfalfa can be cut as short as 1.5 in. and that each inch above this will result in a half-ton-per-acre reduction in annual yields (Undersander, 2009).

However, increased yields must be balanced against the tendency for disc mowers to vacuum soil (which contributes to ash values) into the crop, resulting in lowered digestibility and the potential for increased soil-borne bacteria and spores that can have a negative effect on fermentation.

For most producers, cutting pure-alfalfa stands at 2.5-3.0 in. seems to be a good compromise. To prevent shortened stand life, this should be increased to 3-4 in. if the stand includes bromegrass, orchardgrass or timothy (Undersander, 2009).

Fermentation issues

Many nutritionists would rather that producers delay alfalfa silage harvest and deal with lowered digestibility than suffer with feeding rained-on, poorly fermented silages.

Field experience has also conditioned nutritionists to target ideal moisture levels at around 60% to reduce protein degradation and the potential for clostridial alfalfa silages.

The Table shows recommendations (Oetzel, 2005) for the amount of silage dry matter one can safely feed to keep daily levels of ingested butyric acid under three different threshold levels: (1) 50 g, which increases the risk of ketosis and lowers dry matter intake in early-lactation cows, (2) 150 g, which creates a high risk of ketosis in early-lactation cows or (3) 250 g, which creates a high risk of ketosis in all lactating cows.

Alfalfa hay project

Dr. Carl Old (Old, 2009) provided the following update on a project first reported in the Aug. 11, 2008, Bottom Line of Nutrition.

To refresh your memory, the California chapter of the American Registry of Professional Animal Scientists (ARPAS), in partnership with Sapienza Analytica LLC, the University of California-Davis and the U.S. Dairy Forage Research Center, is conducting a study with the goal of predicting metabolizable energy, rate, site and extent of digestion of pure-stand alfalfa hays using near-infrared spectrophotometry.

During the 2008 growing season, more than 100 samples of alfalfa hay representing the diversity of alfalfa grown and fed throughout California were collected. The variability in acid detergent fiber (ADF), NDF and crude protein in these samples was greater then that found in 3,000 samples in the library at Dairyland Labs.

NDF from samples at Dairyland Labs ranged from 31.0% to 50.1%; all samples collected in California had a range of 24.0-65.4%.

Ten samples representing the range of diversity seen in crude protein and ADF were selected for use in an *in vivo* digestion study that is underway at the forage research center. Crude protein concentrations in those samples ranged from 12.6% to 23.1% and ADF from 21.0% to 51.0%. Weaned wether lambs are being fed alfalfa hay at two levels of intake — one approximating maintenance and the other *ad libitum*; urine and feces are being collected. *In vitro* estimates of methane will allow for determinations of metabolizable energy.

An *in vitro* study is ongoing at Sapienza Analytica to determine the extent of degradation of crude protein, dry matter and NDF. The *in silico* portion of the study is examining several models for parameter estimation. Estimators from all models are unbiased as no arbitrary pool separation times are used; benefits of using unbiased estimators in predictive models are well understood.

As of this writing, only two models have been employed. The first model (deterministic) is:

$$C_t = \sum_{i=1}^{n} C_{0i} e^{-k_i t}$$

The dimensions of C_t and C_{0i} are mass, e is dimensionless, t has a dimension of h and, therefore, k (rate) has a dimension of h^{-1}. For fibrous entities, this model generally lacks utility to estimate C_{0i} and k_i for n equal to or greater than three.

The other model is:

$C_t = D(1+beta(t-tau)^{-alpha})+I$

This is a heterogeneous, stochastic model and assumes a gamma distribution for rate and shape estimators alpha and beta.

Kinetic analyses have been performed for 16 samples collected early in the 2008 growing season. Data from the deterministic model indicate a lack of uniqueness of solution regarding compartment number, ranging from two to four. Residual sums of squares are less for the latter model.

The 95% confidence intervals about the slopes of linear regressions of 24-hour dry matter disappearance versus either total digestible nutrients (TDN; University of California equation) or RFV include zero. Significant regressions were found for 48-hour dry matter disappearance versus either TDN or RFV. However, differences in TDN and RFV explain only about half of the variation in differences in 48-hour dry matter disappearance.

Data from the *in vivo* portion of the trial will be available for analysis later this year. *In silico* work should be completed by mid-2010, and a beta test version of the near-infrared model will be available in late 2010.

Animal studies are not inexpensive, and California ARPAS has raised about half of the estimated $105,000 required to fund the entire study. Further information is available from John Miller at (559) 731-7146.

The Bottom Line

Alfalfa is arguably one of the most variable feeds on many dairies. This is due to field-by-field variations in the age of stand (grass content), harvest maturity and moisture, fiber digestibility affected by the growing environment and issues surrounding fermentation and palatability.

Nutritionists have a great opportunity to improve income over feed costs for clients by getting more involved in the decisions surrounding alfalfa management and procurement.

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