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Dear Valued Forage Producer,

In this edition we highlight seeding strategies, weed management, cover crops, insect control and identification.

We would like to take this time to highlight the contributors to this edition:

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Sincerely,

University of Minnesota Forage Team

New Reduced Lignin Alfalfa Varieties: A Potential Forage Quality Breakthrough

Craig Sheaffer and Dan Undersander

Alfalfa is an important forage crop that provides feed to livestock as well as environmental benefits. Alfalfa forage is a good source of protein and fiber, but its digestibility and intake have been limited by low cell wall digestibility. Cell walls compose about 40-50% of harvested forage and are composed of cellulose, hemicellulose, lignin, pectin, and protein. Cell wall digestibility is variable and is negatively related to lignin concentration. Lignin is an indigestible phenolic polymer linked with cellulose, hemicellulose, and pectin in the cell wall. It constitutes about 6-9% of the dry weight of the whole alfalfa plant and about 20% of the cell wall (Hatfield et al., 2007). Within the plant, lignin strengthens cell walls that are the structural building blocks to support the stems and leaves. Cell walls also act as tubing for the vascular system that transports water and nutrients throughout the plant. However, lignin's

Reduced Lignin Alfalfa (Continued from page 1)

close association with cellulose and hemicellulose in alfalfa cell walls limits their rumen microbe degradation.

There have long been efforts to improve alfalfa forage quality through conventional plant breeding, but until now significant progress in forage quality improvement has not been made. Recently, three alfalfa breeding companies announced development of varieties with reduced lignin content (Holin, 2014). A transgenic, reduced-lignin alfalfa, branded as HarvXtra, was developed in a cooperative effort between from Forage Genetics International (FGI), the Samuel Roberts Noble Foundation, and the U.S. Dairy Forage Research Center (http://www.foragegenetics.com/forage-innovation/harvxtra%E2%84%A2-alfalfa.aspx). The new alfalfa was produced by deactivating enzymes in a lignin synthesis pathway. It contains about 12-18% less whole plant lignin and has improved cell wall digestibility (Undersander et al., 2009; Holin, 2014). Dairy cow feeding trials with this transgenic low-lignin alfalfa forage as a portion of the ration showed increased milk production of 2.6 lb/head/day compared to forage from conventional alfalfa controls (Mertens and McCaslin, 2008; Undersander et al., 2009).

A new reduced lignin alfalfa variety developed through conventional plant breeding, Hi-Gest, has been released by Alforex seeds (http://www.alforexseeds.com/alfalfa-product/hi-gest-360/). Hi-Gest contains 7-10% less lignin than conventional alfalfa varieties and in research trials had about 12% greater total tract digestibility (Total Tract NDFdigestibility as estimated by NIR analysis) than conventional varieties (Alforex, 2014). Another alfalfa breeding company, Pioneer Hi-Bred International has also developed an alfalfa variety, 54Q14, with about 5% less lignin (Holin, 2014)

Use of new reduced lignin alfalfa varieties has potential to be very advantageous to growers depending on the level of lignin reduction. At any given maturity stage, reduced lignin alfalfa will have greater cell wall digestibility and greater feeding value than conventional varieties (Figure 1).

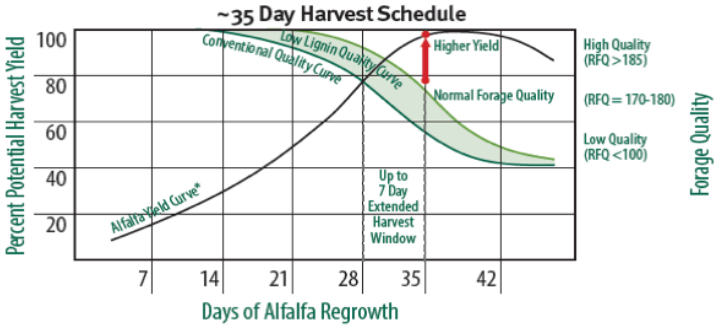

Figure 1. Relative potential changes in alfalfa forage yield and forage quality during regrowth by a conventional and a reduced lignin alfalfa variety. Reducing lignin concentration of alfalfa varieties (reduced lignin curve) will result in higher forage quality at all typical harvest times. In this example, growth of an alfalfa variety with reduced lignin concentration will allow about a 7-day delay (from 28 to 35 days) in harvest and growers will achieve greater forage yields while harvesting the same forage quality as for a 28-day harvest schedule. This graph assumes a conventional alfalfa with about 7% lignin. The extent of increase in forage quality and the harvest window extension will be dependent on the level of lignin reduction, which varies with alfalfa variety. Figure provided by Alforex Seeds.

In addition, the new technology also provides growers management flexibility to delay harvest to a later stage of maturity. It provides a wider harvest window without loss of digestibility. For example, harvesting three times at first flower has potential to provide the same quality as four cuttings at bud stage while providing greater yields. In trials at Minnesota and Wisconsin, yields from an early flower harvest regime were from 15 to as high as 40% greater for delayed harvests after bud stage. Less frequent harvests (e.g., three vs. four times) results in less harvest costs and less exposure of the crop to risk of poor weather conditions. A three-time harvest system with alfalfa flowering also results in less traffic and less stress on the alfalfa stands than a four-time harvest systems with alfalfa at bud. As a result, alfalfa stand persistence will likely be increased.

Although the changes in lignin concentration in the new reduced lignin alfalfas may seem small, the new alfalfas have potential to greatly increase the feeding value of alfalfa because lignin concentration is so highly correlated

Reduced Lignin Alfalfa (Continued from page 2)

with digestibility of the forage, However, the level of reduction varies among the new alfalfas, so we should also expect variable effects on forage digestibility. The new low lignin trait was incorporated into highly productive, winterhardy, and disease varieties of each company so yields and persistence should be similar. Producers will need to evaluate this new technology in their harvest and cattle feeding systems to determine its benefits to their farming operations. Unfortunately, seed supplies will be very limited until 2016.

For more reading, see these references and links:

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Alfalfa Seeding Year Management

M. Scott Wells, Joshua Larson, and Craig Sheaffer

Minnesota forage production, including alfalfa hay and haylage, dry hay, and corn silage totaled more than 5.8 million acres[1]. Taking a closer look, there was more than 3 million tons

Picture 1.First production year alfalfa at St. Paul, MN after seeding year cutting treatments were applied during the seeding year (2014).

of hay produced in Minnesota 2014[1]. This level of production generated revenue from direct sales, not including animal utilization, of more than 1 billion dollars[1]. It is important to note that the total revenue of hay forages was based on an average yield of only 2.3 ton ac^{-1}. If annual production increased by 10%, this relatively small increase of 0.2 ton ac^{-1} would equate to over 100 million in annual revenues.

During the past 60 years, alfalfa yields, forage quality, and persistence has been increased through a combination of improved genetics, disease and insect control and more intensive nutrient and harvest management. Even though there has been substantial work in improving the production of alfalfa, these technologies and research finding focus on the 1st through 3rd production years resulting in limited research associated with seeding year yield improvements.

In 1972, Tesar and Jacobs reported that greater seeding year alfalfa yield in a 3-harvest compared to a 2-harvest system[2]. They also reported that under ideal situations maximal seed year yield expectations was 40 to 60% of those from established alfalfa[2]. In Minnesota, Sheafer (1983) found that seeding year yield and nutrient concentrations were maximized by early May seedings with initial harvests 60 days at bud stage with an additional 2-3 harvests per year. Brummer, et al.[3] explored the potential

Alfalfa Seeding Year Management (Continued from page 3)

for seeding year yield improvement by mixing seed of non-dormant alfalfa with more seeding year growth with conventionally dormant alfalfa varieties[3]. However, their findings demonstrated that inclusion of nondormant seed with dormant alfalfas in the seeding year reduced yields in the year following seeding because non-dormant died.[3]

With today's modern varieties that are capable in yielding 6 to 7 ton ac^{-1} and alfalfa hay prices ranging from 195 to 295 dollar ton^{-1} (Dan Martins, Sauk Centre Hay Auction, 2015), there is a incentive to develop management practices that not only improve seeding-year management, but also optimize the total revenue stream. One potential area for optimization is improvement in seeding-year yields. Current recommendations for seeding year management were designed to ensure enhanced persistence throughout the production years[4].

New moderately dormant to semi-dormant alfalfa varieties are characterized as "very winterhardy" to "winterhardy"[5]. The increase fall and spring growth potential of the new semi-dormant winterhardy alfalfa varieties, provides opportunities for the development of new management strategies that could increase both alfalfa in the seeding year while not hampering persistence and yield in production years. Our objectives were to evaluate effects of seeding year harvest regimes on forage yield, quality and persistence of new moderate to semi-dormant alfalfa varieties.

In spring of 2014, where six-alfalfa varieties (four from Alforex Seed, and two from Pioneer) with fall dormancies ranging from 2 to 5 were directed seeded at three Research and Outreach Centers (Rosemount, Becker, and St Paul, MN). The alfalfa varieties were subject to three different seeding year cutting managements of increasing harvest intensities: a.) the 'Standard 2-Cut' system involved harvesting at 60 and 105 day after planting, b.)'Improved Quality 2-Cut', and c.) 'Increased Yield 3-Cut' were both harvested 60 and 90 DAP whereas the 'Increased Yield 3-Cut' was harvest in the fall 135 days after planting (i.e. early October). Forage yield (dry matter) and quality was assessed for each of the harvest intervals. The newly seeded alfalfa was management weed free using post emergent broadleaf and grass herbicides.

Averaged across the three locations, yield did not differ across the six-alfalfa varieties (Figure 1). Alfalfa yields for both two-cut systems for all six-alfalfa varieties ranged from 0.9 and 4.0 ton ac^{-1} whereas yields from 3-cut system ranged from 1.5 to 5.0 ton ac^{-1}. The yield from alfalfa varieties was similar for the both of the 2-cut systems (Figure 1); Not surprisingly, the 3-cut system, out-yielded both of the 2-cut systems by nearly 1 ton ac^{-1} (Figure 1).

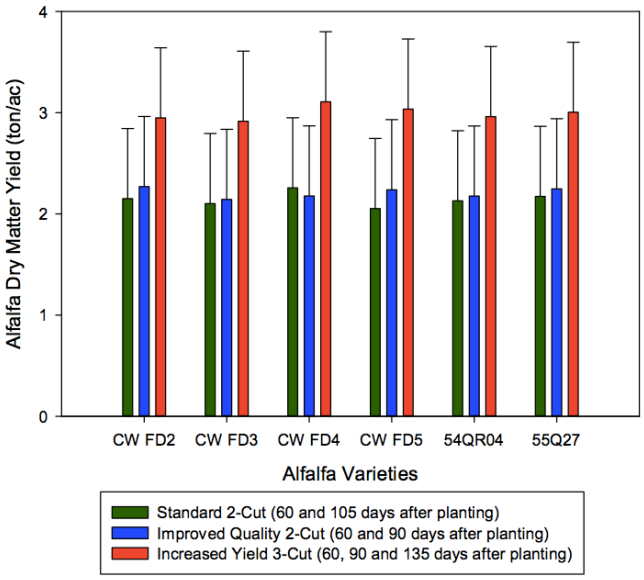

Figure 1.Seeding year alfalfa yield as influenced by alfalfa varieties and cutting management. Error bars indicate ± 1 standard error, which is the estimated deviation from the mean.

Although, forage quality was also similar across alfalfa varieties, cutting treatments did influence NDFd. Crude protein was similar across both alfalfa varieties and cutting treatment and ranged from 22 to 24%. The alfalfa varieties in the 'Improved Quality 2-Cut' regiment with cutting at 90 days after planting had increased NDFd values when compared to the 'Standard 2-Cut' and the 3-cut system (Figure 2). Along with the increased NDFd observed in

Alfalfa Seeding Year Management (Continued from page 4)

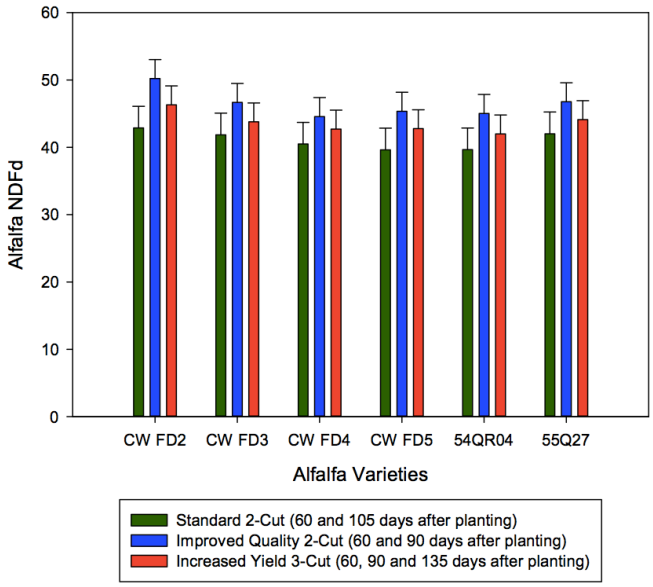

Figure 2. Seeding year alfalfa NDFd as influenced by alfalfa varieties and cutting management. Error bars indicate ± 1 standard error, which is the estimated deviation from the mean.

the 'Improved Quality 2-Cut', the alfalfa variety 'CW FD2', the most dormant variety in the study, had the highest NDFd. This is not surprising since maturation would have been slower (e.g. vegetative to bud) in the 'CW FD2' when compared to the other alfalfa varieties (e.g. bud to early flower) thereby increasing the quality.

Summary:

A cutting system with a fall cut greatly improved the total season year yields, however, the fall harvest did reduce first cut yields (1.28 ton ac^{-1}) in the year following seeding by 3% when compared to the 2-cut systems (1.38 ton ac^{-1}). Even thought cutting treatments did impact harvest yields, the six alfalfa varieties did not differ in yield. The analysis of forage quality is not complete. We are continuing this study year, and are adding two additional high-intensity cutting systems.

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Evaluation of Cover Crops for Grazing Systems

Brad Heins and Jim Paulson

We identified cover crop species that needed investigation to establish cultural practices and nutritional value if utilized for forage. To become more profitable, dairy producers may need forages that can fill slumps in grazing systems, extend the grazing season and provide emergency cover and forage. Dairy producers are looking for ways to integrate cover crops into their cropping and pasture systems. We designed a demonstration study that would determine the forage potential and nutritional value of selected cover crop species and mixtures on Minnesota farms.

The following cover crop species were evaluated: Annual ryegrass, Berseem clover, Buckwheat, BMR sorghum-sudangrass, Crimson clover, Fodder beets, Forage oats, Forage peas, Grazing corn, Kale, Lentils, Pearl millet, Phacelia, Rox Cane, Sorghum-sudangrass, Soybeans, Sugar beet, Sunn hemp, Teff, and Turnip.

Picture 1. Brown midrib sorghum-sudangrass.

Cover Crops for Grazing (Continued from page 5)

Table 1. Cover crop yield and forage quality

Cover crop	Dry Matter (kg/acre)	Ton/acre	Crude Protein	NDFd	Lignin	TDN
Annual ryegrass	2,183	2.4	21.7%	37.9%	5.4%	60.6%
Berseem clover	1,013	1.1	22.4%	38.5%	6.6%	60.9%
Buckwheat	1,507	1.7	13.6%	42.4%	7.3%	58.0%
BMR sorghum/sudan	4,045	4.5	14.3%	53.7%	2.8%	62.2%
Crimson clover	1,371	1.5	20.4%	38.1%	3.9%	63.6%
Fodder beets	1,266	1.4	24.0%	33.4%	3.7%	66.7%
Forage oats	1,436	1.6	16.6%	51.0%	3.7%	62.2%
Forage peas	2,909	3.2	13.5%	41.1%	7.2%	45.5%
Grazing corn	5,797	6.4	13.4%	32.7%	3.3%	48.4%
Kale	1,239	1.4	23.2%	39.0%	4.5%	65.2%
Lentils	566	0.6	14.8%	49.8%	4.8%	52.2%
Pearl millet	3,066	3.4	15.9%	54.8%	2.6%	60.6%
Phacelia	404	0.4	21.4%	34.2%	4.2%	63.7%
Rox Cane	9,130	10	12.7%	51.3%	3.0%	63.2%
Sorghum-sudangrass	6,580	7.2	10.9%	56.1%	3.3%	58.4%
Soybeans	612	0.7	22.1%	37.9%	4.4%	62.6%
Sugarbeet	2,845	3.1	21.7%	29.3%	3.3%	68.6%
Sunn hemp	1,790	2	19.8%	37.6%	4.9%	62.6%
Teff	3,059	3.4	17.7%	59.0%	4.0%	60.2%
Turnip	1,600	1.8	17.2%	28.6%	2.4%	67.8%

We planted replicated plots of cover crops at the West Central Research Center and on a dairy farm in Lanesboro, MN. The plots were planted June 24 and harvested August 20. A plot flail harvester was used to harvest the cover crops and dry matter yields were determined. A sample of harvested forage was retained from selected plots for dry matter determination and forage quality analysis. Forage quality analysis was conducted by Dairyland Laboratories, St. Cloud, MN.

Forage analysis differed among species and crude protein ranged from a high of 24.0% for fodder beet tops to a low of 10.9% for BMR sorghum-sudangrass. Total Digestible Nutrients (TDN) was highest for sugar beets and turnip tops of 68.6% and 67.8% respectively; however, TDN was the lowest for forage peas and grazing corn at 45.5% and 48.4%, respectively. Taller plants such as BMR sorghum-sudangrass and Rox Orange cane yielded greater amounts of dry matter per acre. The lush turnip and kale tops excelled in forage quality, but were lower in dry matter yield per acre. From these data, we can better recommend combinations of species to fit certain cover crop and grazing scenarios. This project was funded by a grant from the Midwest Forage Association.

Forage Survey

UMN Forage Team: Needs Based Survey

M. Scott Wells on behalf of the UMN Forage Team

When building an educational program, it is critical to understand not only who the audience is, but also what they want to learn and their learning preferences. In 2014, the U of M Forage Team in partnership with U of M Extension and the Midwest Forage Association initiated a mailed survey sent to approximately 1200 Midwest Forage Association members. Of the 1200 surveyed, 20% participated. We asked a series of questions that highlight educational gaps and learning preferences. Below is a summary of the results from the survey:

Nearly 70% of the respondents identified as forage producers with the Sterns and Fillmore as the counties with the greatest number of responds. The increased response rate from Sterns and Fillmore reflect the concentration of Midwest Forage Association members and predominate forage production areas (Figure 1).

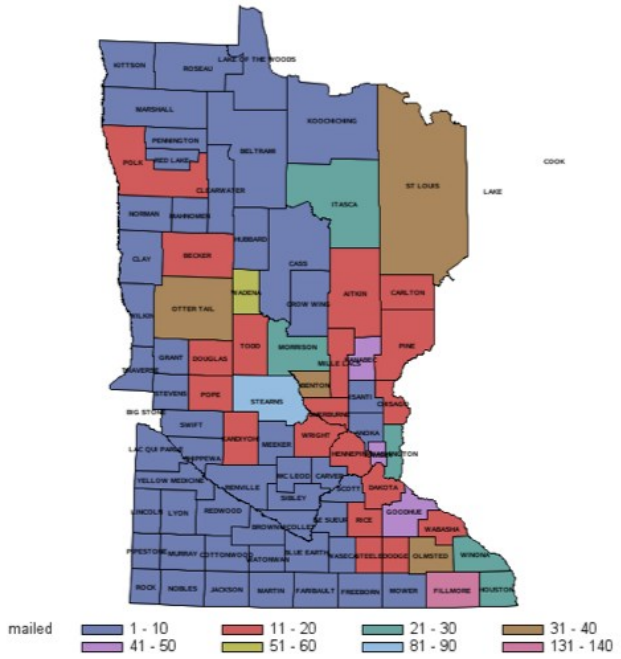

Figure 1. Counties where surveys were mailed

When asked what forage production system(s) best describes their operations, we allowed the respondents to select each category. Alfalfa and/or alfalfa grass mixtures were the most predominate production system representing over 80% of their production footprint. Although far less than alfalfa, corn silage and permanent pastures were also considered important ranging from 45 to 50% of the respondents reporting that their operations were involved those production systems.

In addition to asking respondents to describe their operations, we also inquired on the size of their operations. Over 60% of the respondents reported that their forage footprint was less than 350 acres (Figure 2).

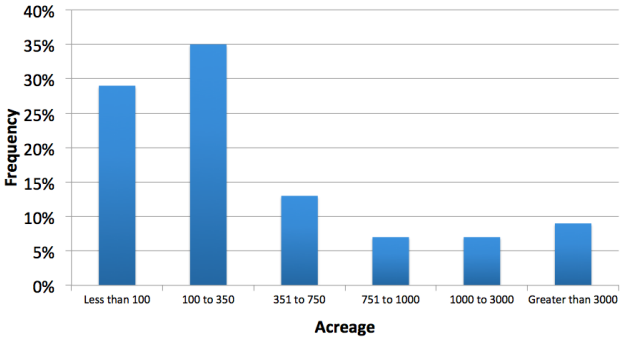

Figure 2. How many total acres of forages do you manage?

Through further investigation we determined crop consultants were managing greater than 1000 acres. To gain clearer picture of how large the farms were, we asked what percentage of their total acres were related to forage production. Averaging across all responses, we determined that greater than 50% of the acres were decided to forage production.

The next series of questions focus education and learning preferences (i.e. how to you like to receive information). We asked the following series of questions:

Question: In the past year, how often have you sought information about forage production?

Notice that more than 60% of respondents indicated that they search for forage related information at least every few months (Figure 3).

Survey (Continued from page 7)

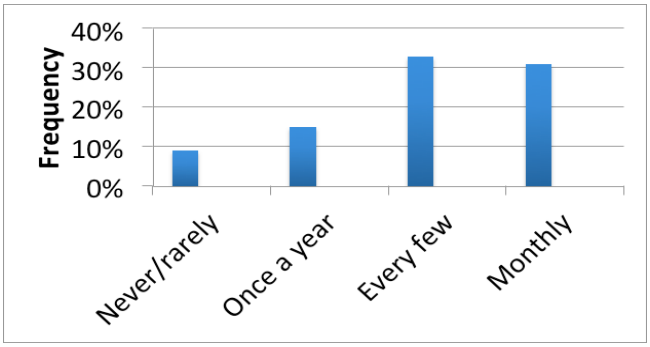

Figure 3. How often do those in forages seek out forage related information?

Question: In the past 12-months, how many forage educational programs or seminars have you attended? Since a large population of the respondents regularly sought information on forages, we wanted to know how many events they attended annually. We found that most of the respondents indicated that they go to at least 1 to 2 events a year (Figure 4). We were surprised to find out that nearly 30% of the respondents indicated that they attend zero meeting annually.

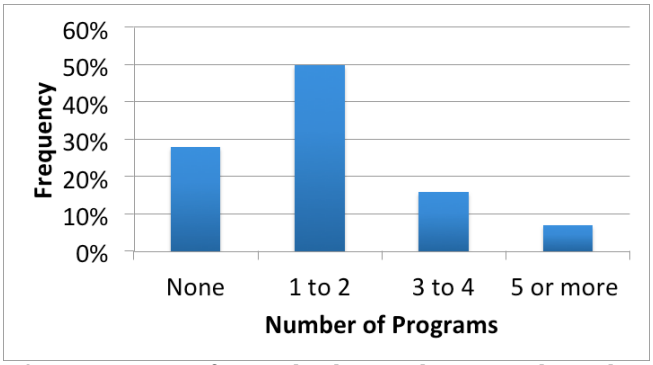

Figure 4. How many forage related events do you attend annually?

Question: How do you perceive the outcomes from the forage related advice asked in the previous question? More than 70% of the respondents reported that the information they received was helpful (Figure 5).

Question: How frequently do you utilize the below sources of forage information? Most of the non-federal and in-state organizations are utilized frequently (Figure 6).

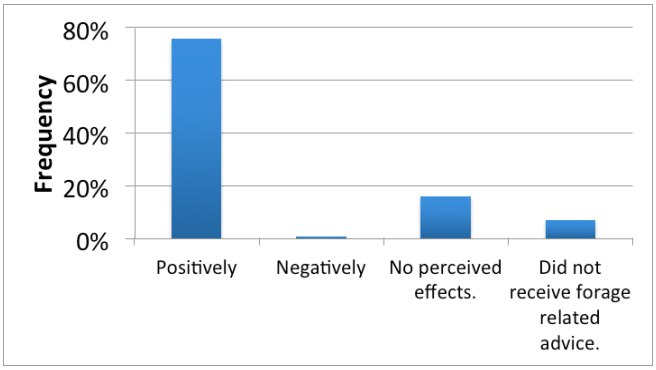

Figure 5. Was the forage related advice helpful?

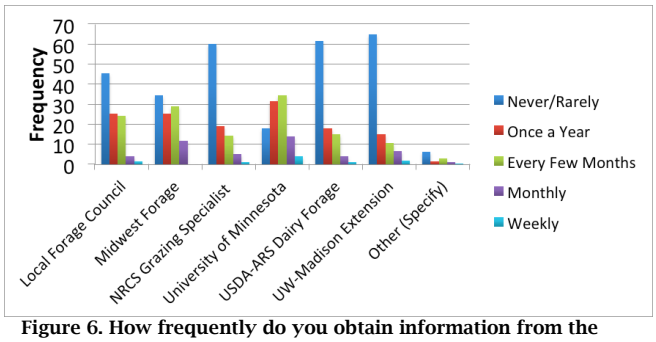

Figure 6. How frequently do you obtain information from the listed agencies?

Question: How often do you obtain inform about forages from the following resources? In the age of smart phones and high-speed internet, we were surprised that YouTube was not preferred. Over 70% of the respondents reported that they never or rarely used YouTube for forage related information (Figure 7).

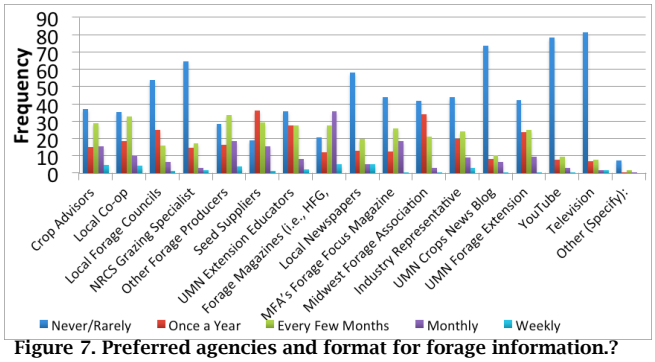

Figure 7. Preferred agencies and format for forage information.?

Question: What format do you prefer to receive forage related education and information? Similar low utilization of online resources sources was also observed (e.g. Twitter 90% do not prefer). However, magazines both mailed and electronic, seed and/or supply dealers, and short publications were among the most preferred

Survey (Continued from page 8)

sources for forage related information (Figure 8).

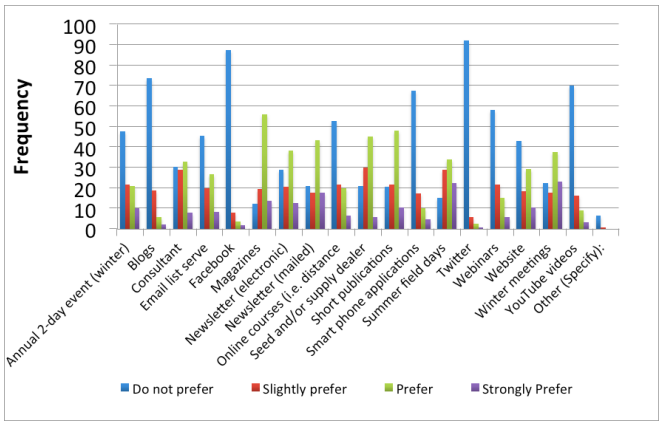

Figure 8. Electronic learning and information gathering preferences?

Question: How useful are the following events in terms of providing educational programing that supports and informs you decision-making? Respondents reported that local forage events, industry sponsored events, The Alfalfa Intensive Training Seminars, and UMN Extension Field Days were considered the most useful, with all rated above 40% useful in providing forage related information (Figure 9).

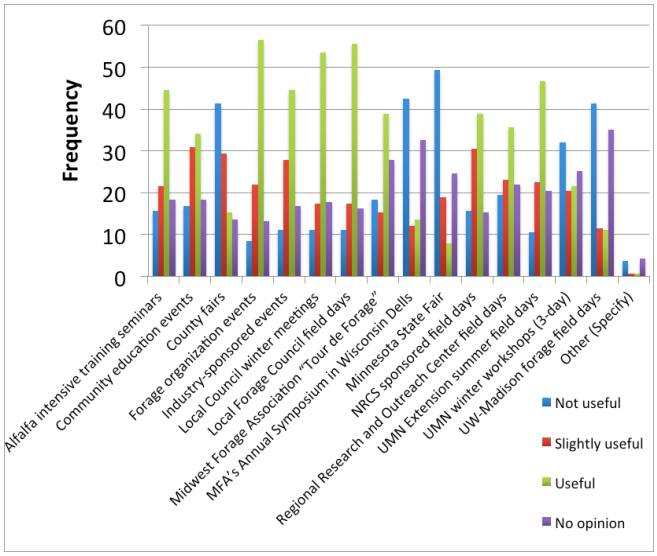

Figure 9. Events that are considered useful in providing educational materials to the forage community?

Summary:

This survey highlights the need for extension to work on a more grass-roots level, develop more informative short electronic and published fact sheets, and strengthen relationships with both public and private originations.

Special thanks to Beth Nelson at MFA, and Jeff Gunsolus UMN Extension.

In-field assessment of alfalfa quality: Current tools and future directions

Reagan Noland, Craig Sheaffer, and M. Scott Wells

Throughout the alfalfa production season, careful and informed harvest decisions increase the chances of meeting production goals. The growth of a stand, from one cut to the next, will always vary according to stand health as well as a range of environmental factors. Accurate in-field assessment of an alfalfa crop is critical to maximize profitability, in terms of both quality and yield. In the upper Midwest, where forage demands are driven by the dairy industry, the value of a crop is especially dependent on forage quality. Higher quality means higher milk/ton, which means greater profitability per ton of forage.

Alfalfa maturity is currently the most accurate and consistent indicator of quality. As maturity increases, forage quality decreases (Figure 1). Generally speaking, good quality means higher crude protein and lower fiber fractions. Quality is highest when the leaf-stem ratio is highest (more leaves, less stems). As alfalfa develops and growth shifts from vegetative to reproductive, quality begins to decrease quickly.

Photo 1-4. Top left: Vegetative alfalfa stages 0, 1, & 2 (left to right). Top right: Alfalfa buds (indicator of stages 3 & 4). Bottom left: Open flowers (indicating stages 5 & 6). Bottom left: Alfalfa seed pod (indicator of stages 7, 8, & 9).

Growth staging alfalfa on the 0-9 maturity scale (established by Kalu and Fick, 1981) enables the calculation of maturity indices such as mean stage by count (MSC) and mean stage by weight (MSW). The MSC or MSW

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values can then be interpreted as indicators of forage quality parameters. A sample of alfalfa stems can be individually categorized into the appropriate stages described below and illustrated in Photos 1-4. To calculate MSC, the stems in each stage need to be counted and the resulting values entered into the index equation. To calculate MSW, each maturity group needs to be dried and weighed, then the corresponding values plugged into the equation

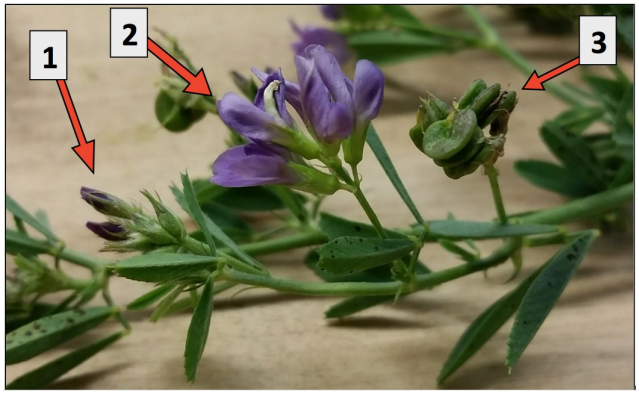

Photo 5. Alfalfa reproductive morphology: 1) Closed flower, 2) Open flower, 3) Seed pod.

The efficacy of these maturity indices may change as alfalfa is harvested earlier for higher quality and as new, novel varieties of alfalfa are being developed with lower lignin (i.e. higher digestible fiber). The introduction of these lines will introduce new flexibility into alfalfa harvest management and limit the applications of traditional assessment tools. Although alfalfa maturity will still correlate with quality in these new lines, higher quality will be maintained with greater maturity. Therefore, equal quality can be achieved with higher yields, or higher quality can be achieved with equal (conventional) yields. Precise and intensive management will be critical to optimize the use of these resources and maximize profit margins.

Various new tools and applications in the area of precision agriculture are enabling maximum resource use efficiency and profitability in other major crops (i.e. accounting for in-field variability with variable rate fertilizer application and variable rate planting). Unmanned aerial vehicles (UAVs) or "drones" are being equipped with GPS technology and a wide array of sensors/cameras to assess crop health, progress, disease/insect pressure, nutrient deficiencies, etc. and are informing management decisions.

One of most widely used technologies in crop remote sensing is the measurement of canopy reflectance. Broadband spectral indices such as NDVI (Normalized Difference Vegetative Index) are valuable indicators of greenness, crop health, or percent ground cover. More specific indices such as MTCI (Meris Terrestrial Chlorophyll Index) are designed for more precise applications. Indices designed for

Alfalfa Growth Staging Guide* *adapted from Kalu and Fick (1981)

Stage number	Stage name	Stage Definition
0	Early vegetative	Stem length < 15 cm; no buds, flowers, or seed pods
1	Mid-vegetative	Stem length 16 to 30 cm; no buds, flowers, or seed pods
2	Late vegetative	Stem length- > 31 cm; no buds, flowers, or seed pods
3	Early bud	1 to 2 nodes with buds; no flowers or seed pods
4	Late bud	≥ 3 nodes with buds; no flowers or seed pods
5	Early flower	One node with one open flower (standard open); no seed pods
6	Late flower	≥ 2 nodes with open flowers; no seed pods
7	Early seed pod	1 to 3 nodes with green seed pods
8	Late seed pod	≥ 4 nodes with green seed pods
9	Ripe seed pod	Nodes with mostly brown mature seed pods

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Photo 6. Alfalfa plots representing a wide range of maturity stages (Rosemount, MN 2015).

specific purposes utilize the spectral reflectance of particular wavebands (ranges of nanometers in the visible and near-infrared spectrum), and the wavebands of importance can vary depending on the crop and target application. Drones or ground vehicles equipped with these sensors can travel through the field and collecting and mapping data that correlates to the current status of the crop across the whole field.

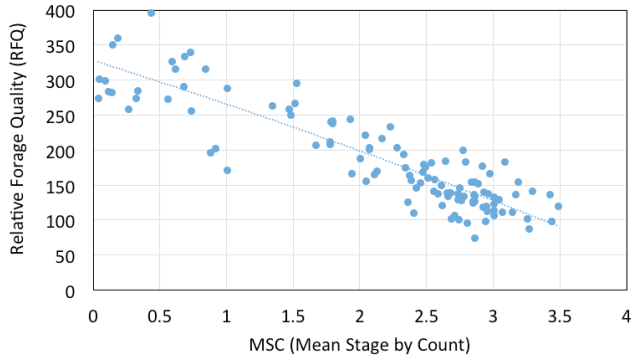

Figure 1. Relative Forage Quality (RFQ) compared to alfalfa maturity (MSC) from periodic sampling of a stand in Rosemount, MN (2014).

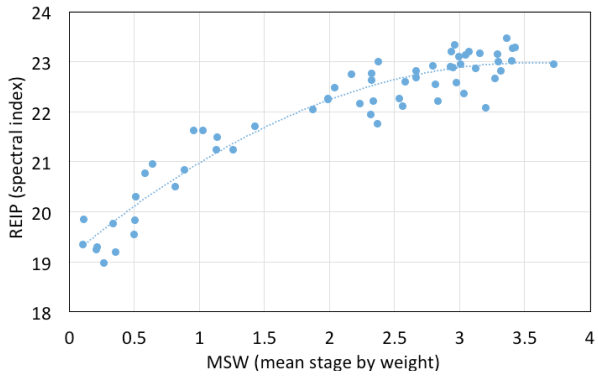

Figure 2. A spectral vegetative index called REIP (Red Edge Inflection Point) compared to alfalfa maturity. Spectral measurements were taken prior to periodic destructive sampling throughout the growth of a stand in Rosemount, MN (2014).

In 2014, a pilot study was conducted to determine whether spectral indices could be used to predict alfalfa maturity. A full range spectrophotometer, measuring reflectance values 350-2500 nm was used to periodically scan alfalfa plots throughout the growth of a stand, followed by destructive harvest, sampling and analysis for yield, quality, and maturity. Preliminary analysis indicate that there is potential for known spectral indices to predict alfalfa maturity (Figure 2). However, alfalfa-specific indices have not yet been developed.

A follow-up study with similar principles is currently underway (2015). Treatments within a replicated experiment are being mowed periodically to set up a maturity gradient in the field (Photo 6). The resulting stand represents a range of maturity, from early vegetative to full flower. Then, all plots are scanned with multiple forms of remote sensing instrumentation prior to harvest and analysis. An added technology this year is the use of LiDAR (Light Detection and Ranging) to remotely measure crop height. Preliminary results indicate potential for this estimated crop height to predict biomass as long as the stand is still erect (prior to lodging) (Figure 3). As this project continues, we aim to develop an alfalfa specific remote sensing platform as a practical tool for optimized decision making in alfalfa management.

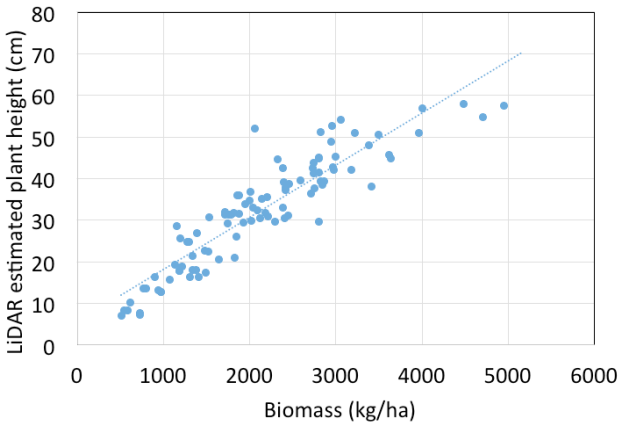

Figure 3. Estimated stand height as it correlates to actual alfalfa biomass.