FORAGE QUALITY ASSESSMENT OF SPRING FORAGES

D.J.R. Cherney¹, J.H. Cherney² and D. Parsons²
Department of Animal Science¹
Department of Crop and Soil Sciences²
Cornell University

INTRODUCTION

In response to the current interest in sustainable development of dairy farms, perennial grass forage crops have emerged as potential solutions to some environmental management challenges now encountered on intensively managed dairy farms (Cherney and Cherney, 1998). Grain surpluses and low grain prices often dictate that milk be produced with as little forage as possible. In the future it is likely that grain surpluses will decrease and maximum utilization of forages will be needed to maintain a competitive dairy industry. In addition, the impact of animal wastes on environmental quality is likely to increase the use of forages (Wang et al. 2000a). Forage production in an integrated farming system has the potential to improve the recycling and balance of nutrients (Wang et al. 2000b). Grasses may have some advantages over legumes in this area because of their ability to use excess farm generated N (Cherney and Cherney, 1993). Many dairy farms have land that is poorly suited to growing alfalfa because of low pH or poorly drained soils (Cherney and Kallenbach, 2006). Grasses will have advantages over legumes in these areas because they can use nitrogen from manure, support vehicle traffic and tolerate marginal soils. Perennial grass can also remove over twice the nitrogen/acre than corn (Kanneganti and Klausner, 1994). High yields are possible, but in many cases, forage quality is not where it should be. Significant advances have been made in recent years in recognizing the potential of well-managed grasses, but on average the level of management is still not as high as with alfalfa (Cherney et al., 2006b). Good harvest management for the season is set at the spring forage harvest. Crucial to good management is harvesting at optimum forage quality, but how is that optimum determined?

FORAGE QUALITY

Measures such as digestibility, fiber digestibility, Relative Forage Quality (RFQ), milk per ton, and milk per acre are possibilities. In perennial grasses, fiber digestibility is very highly correlated with in vitro true digestibility (Cherney and Cherney, 2006), so they are equivalent in usefulness. This relationship can only be significantly impacted by varieties with radically different forage quality, such as brown-midrib mutants which may have 15 percentage units higher fiber digestibility than normal varieties. Also, dry matter yield per acre is highly correlated with milk yield per acre. Again, it would take quality differences on the scale of a brown-midrib to impact these high correlations. None of the above parameters have an optimum value; however, the higher the better. Therefore, none of them provide useful harvest date targets.
Forage can be defined as a crop that can meet the effective fiber needs of a cow when fed as the primary forage source in the diet. We need to harvest forage grasses and legumes to optimize the fiber content for the class of livestock being fed; therefore neutral detergent fiber (NDF) is the most useful harvest date target. There is a relatively small range in optimal NDF for lactating dairy cows, making correct harvest management decisions critical relative to quality. A reliable method to estimate the fiber content of grass and alfalfa-grass mixtures would help producers in timing harvesting operations to optimize the quality of the harvested forage. Once the forage is harvested and stored, an accurate forage quality analysis is needed prior to ration balancing (Cherney and Cherney, 2003).

SELECTING GRASS VARIETIES

The number of grass varieties available has increased dramatically in the past few years. An effective method is needed to compare these varieties for both yield and quality. Currently for grass variety trials, all entries in a trial are harvested on the same day regardless of maturity, or an attempt is made to harvest entries at a similar maturity stage. It is difficult to make varietal comparisons using either of these methods. Same-day harvesting of varieties is biased by plant maturity differences. Harvesting on different days in an attempt to standardize plant maturity is biased by the environmental conditions preceding each harvest date. Normally forage NDF increases steadily in the spring, but it is possible for forage NDF to temporarily drop as much as 5 percentage units due to a stretch of cold weather. Harvest on different days cannot take weather shifts into account. Adjusting yield and quality for plant maturity (e.g. heading date) is not satisfactory, as the relationship between heading date and both yield and quality for a set of varieties is relatively poor.

We are proposing a method to compare yield and digestibility of entries in the spring cut on the same day by adjusting yield and digestibility to the same NDF level. This can be accomplished by determining the linear rate of change of yield and quality over time. While rates of change vary slightly among varieties, an average rate of change over time for yield or quality adequately represents all varieties in a trial. Ranking grass varieties for milk/acre is virtually identical to ranking them for dry matter yield/acre. Our system places more emphasis on quality and results in significantly different varietal rankings, compared with unadjusted yield and digestibility. The single best quality comparison under this system is to compare fiber digestibilities adjusted to a common neutral detergent fiber (NDF). The best comparison to combine yield and quality into one term is to rank dry matter yields of varieties that are adjusted to a common NDF.

To illustrate this, twenty tall fescue varieties with replicated small plots were established in Ithaca, NY in 2005. Varieties were harvested on May 24, 2006 and analyzed for quality. Dry matter yields ranged from 1.8 to 2.8 tons/acre and fiber digestibility on May 24 ranged from 70 to 77%. Yields and NDF digestibility (NDFD) were both corrected to the estimated date of 55% NDF for each plot. The number of adjustment days to 55% NDF was determined using a rate of change of 0.85 percentage units NDF/day. The number of adjustment days to 55% NDF was then
multiplied by 205 lb DM/day or 1.0 percentage units of NDFD/day, to generate estimated yield and NDFD on the day that the variety was at 55% NDF. The estimated rates used are averages of rates determined in several tall fescue studies over several years in New York State. Yield and NDFD were corrected to 55% NDF to minimize the overall amount of adjustment needed, because that was the average NDF of the 20 varieties harvested in this trial.

Figure 1 shows actual DM yield paired with the adjusted DM yield for each variety. Entries with an asterisk above the yield bars have a yield adjustment greater than the trial's least significant difference (LSD) value, as an indication of a major adjustment. Variety ranking is greatly impacted. For example, variety #5 was significantly lower yielding than varieties #9, #12 and #14, using the original yield data. After yield adjustment to the dates at which varieties reached 55% NDF, variety #5 was significantly higher yielding than varieties #9, #12, and #14. Figure 2 shows the NDFD adjustments for these varieties. For example, variety #9 was significantly lower in NDFD than #20 in the original data, but significantly higher in NDFD than #20 after adjustment to the date of 55% NDF.

Figure 1. Paired unadjusted and adjusted yields for 20 tall fescue varieties harvested May 24, 2006 in Ithaca, NY.

Figure 2. Paired unadjusted and adjusted NDFD values for 20 tall fescue varieties harvested May 24, 2006 in Ithaca, NY.
Grass

It is particularly difficult to assess standing quality of pure grass without actually analyzing samples. Grass morphology changes are not obvious until heading, and once grass has headed it is too late. Often a calendar date works as well as any morphological indicators for spring harvest (Reid, 1961). In our region this date varies from May 15 to May 30, but latitudinal and temperature differences make this method ineffective for prediction over diverse locations or regrowths (Van Soest, 1994). More recently research has concentrated on equations to predict NDF using growing degree days (GDD) (Dewing 1997; Cherney et al., 2001). The benefit of GDD_{32} over day of the year is that it better explains differences in growth over years with different weather patterns. Prediction equations developed from several locations and years did not accurately predict NDF or CP (Dewing, 1997). However, regression equations developed to predict NDF at individual locations, years, and fertility levels had low mean square error (MSE) and correlations (R^2) above 0.90. These equations could be used to assist producers in developing harvest strategies to optimize forage quality. Proximity to weather station was critical in equation development. Therefore producers may not be able to rely on local weather stations unless they are close.

Alfalfa-grass

A study was undertaken recently to develop a system for estimating standing NDF of alfalfa-grass mixtures (Parsons et al., 2006a) and for estimating alfalfa NDF in mixtures (Parsons et al., 2006b). Figure 3 shows the estimated optimum NDF of standing forage at harvest for mixtures and pure alfalfa or pure grass. This is based on the assumption that the optimum standing NDF is 38% for alfalfa and 50% for grass. Selecting different values would change the slope of the line in Figure 3. These goals assume a 10-15% decline in forage quality due to harvest, storage and feedout.

Predicting 1st harvest date

Figure 4 is the estimated alfalfa height needed to harvest at optimum stand NDF. This provides a gross estimate of target alfalfa height (height of tallest stem) at harvest, for pure stands and mixtures. For mixtures, alfalfa height in the mixture is used. For 100% grass, estimated height in a pure stand of alfalfa nearby is used. Prediction equations for NDF of mixed alfalfa-grass stands were developed based on sampling and separating mixtures from fields across New York State in 2004 and 2005. Table 1 combines the information in Figures 3 and 4 into a format easily used in the field.
Figure 3. Optimum NDF of standing forage, assuming pure stand optimums of 38% for pure alfalfa and 50% for pure grass.

![Optimum stand NDF in alfalfa-grass mixtures](image)

Figure 4. Alfalfa height for optimum NDF of standing forage, assuming pure stand optimums of 38% for pure alfalfa and 50% for pure grass.

![Alfalfa height at optimum mixed stand NDF](image)
Table 1. Estimated stand NDF of a mixed alfalfa-grass stand based on alfalfa height and the percent grass in the stand. Target NDF for each mixture is highlighted.

<table>
<thead>
<tr>
<th>Max. alfalfa height, in.</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>23.5</td>
<td>26.7</td>
<td>29.9</td>
<td>33.1</td>
<td>36.3</td>
<td>39.5</td>
<td>42.7</td>
<td>45.9</td>
<td>49.1</td>
</tr>
<tr>
<td>15</td>
<td>24.3</td>
<td>27.5</td>
<td>30.7</td>
<td>33.9</td>
<td>37.1</td>
<td>40.3</td>
<td>43.5</td>
<td>46.7</td>
<td>49.9</td>
</tr>
<tr>
<td>16</td>
<td>25.1</td>
<td>28.3</td>
<td>31.5</td>
<td>34.7</td>
<td>37.9</td>
<td>41.1</td>
<td>44.3</td>
<td>47.5</td>
<td>50.7</td>
</tr>
<tr>
<td>17</td>
<td>25.9</td>
<td>29.1</td>
<td>32.3</td>
<td>35.5</td>
<td>38.7</td>
<td>41.9</td>
<td>45.1</td>
<td>48.3</td>
<td>51.5</td>
</tr>
<tr>
<td>18</td>
<td>26.8</td>
<td>30.0</td>
<td>33.2</td>
<td>36.4</td>
<td>39.6</td>
<td>42.8</td>
<td>46.0</td>
<td>49.2</td>
<td>52.4</td>
</tr>
<tr>
<td>19</td>
<td>27.6</td>
<td>30.8</td>
<td>34.0</td>
<td>37.2</td>
<td>40.4</td>
<td>43.6</td>
<td>46.8</td>
<td>50.0</td>
<td>53.2</td>
</tr>
<tr>
<td>20</td>
<td>28.4</td>
<td>31.6</td>
<td>34.8</td>
<td>38.0</td>
<td>41.2</td>
<td>44.4</td>
<td>47.6</td>
<td>50.8</td>
<td>54.0</td>
</tr>
<tr>
<td>21</td>
<td>29.2</td>
<td>32.4</td>
<td>35.6</td>
<td>38.8</td>
<td>42.0</td>
<td>45.2</td>
<td>48.4</td>
<td>51.6</td>
<td>54.8</td>
</tr>
<tr>
<td>22</td>
<td>30.1</td>
<td>33.3</td>
<td>36.5</td>
<td>39.7</td>
<td>42.9</td>
<td>46.1</td>
<td>49.3</td>
<td>52.5</td>
<td>55.7</td>
</tr>
<tr>
<td>23</td>
<td>30.9</td>
<td>34.1</td>
<td>37.3</td>
<td>40.5</td>
<td>43.7</td>
<td>46.9</td>
<td>50.1</td>
<td>53.3</td>
<td>56.5</td>
</tr>
<tr>
<td>24</td>
<td>31.7</td>
<td>34.9</td>
<td>38.1</td>
<td>41.3</td>
<td>44.5</td>
<td>47.7</td>
<td>50.9</td>
<td>54.1</td>
<td>57.3</td>
</tr>
<tr>
<td>25</td>
<td>32.5</td>
<td>35.7</td>
<td>38.9</td>
<td>42.1</td>
<td>45.3</td>
<td>48.5</td>
<td>51.7</td>
<td>54.9</td>
<td>58.1</td>
</tr>
<tr>
<td>26</td>
<td>33.4</td>
<td>36.6</td>
<td>39.8</td>
<td>43.0</td>
<td>46.2</td>
<td>49.4</td>
<td>52.6</td>
<td>55.8</td>
<td>59.0</td>
</tr>
<tr>
<td>27</td>
<td>34.2</td>
<td>37.4</td>
<td>40.6</td>
<td>43.8</td>
<td>47.0</td>
<td>50.2</td>
<td>53.4</td>
<td>56.6</td>
<td>59.8</td>
</tr>
<tr>
<td>28</td>
<td>35.0</td>
<td>38.2</td>
<td>41.4</td>
<td>44.6</td>
<td>47.8</td>
<td>51.0</td>
<td>54.2</td>
<td>57.4</td>
<td>60.6</td>
</tr>
<tr>
<td>29</td>
<td>35.8</td>
<td>39.0</td>
<td>42.2</td>
<td>45.4</td>
<td>48.6</td>
<td>51.8</td>
<td>55.0</td>
<td>58.2</td>
<td>61.4</td>
</tr>
<tr>
<td>30</td>
<td>36.7</td>
<td>39.9</td>
<td>43.1</td>
<td>46.3</td>
<td>49.5</td>
<td>52.7</td>
<td>55.9</td>
<td>59.1</td>
<td>62.3</td>
</tr>
<tr>
<td>31</td>
<td>37.5</td>
<td>40.7</td>
<td>43.9</td>
<td>47.1</td>
<td>50.3</td>
<td>53.5</td>
<td>56.7</td>
<td>59.9</td>
<td>63.1</td>
</tr>
<tr>
<td>32</td>
<td>38.3</td>
<td>41.5</td>
<td>44.7</td>
<td>47.9</td>
<td>51.1</td>
<td>54.3</td>
<td>57.5</td>
<td>60.7</td>
<td>63.9</td>
</tr>
<tr>
<td>33</td>
<td>39.1</td>
<td>42.3</td>
<td>45.5</td>
<td>48.7</td>
<td>51.9</td>
<td>55.1</td>
<td>58.3</td>
<td>61.5</td>
<td>64.7</td>
</tr>
<tr>
<td>34</td>
<td>40.0</td>
<td>43.2</td>
<td>46.4</td>
<td>49.6</td>
<td>52.8</td>
<td>56.0</td>
<td>59.2</td>
<td>62.4</td>
<td>65.6</td>
</tr>
<tr>
<td>35</td>
<td>40.8</td>
<td>44.0</td>
<td>47.2</td>
<td>50.4</td>
<td>53.6</td>
<td>56.8</td>
<td>60.0</td>
<td>63.2</td>
<td>66.4</td>
</tr>
</tbody>
</table>

STUBBLE HEIGHT ISSUES

Grasses

Recent studies with corn harvested for silage suggest that increasing the stubble height will improve the nutritive value of corn silage (Lewis et al. 2004), but this directly impacts the grain to stover ratio in grain crops. It is obvious that fully headed perennial grass cannot be turned into high quality forage through increased stubble height. It is not clear, however, if grass slightly past the optimum harvest window can be salvaged for lactating dairy feed by using a higher stubble height.

We studied the feasibility of harvesting grass at a higher stubble height to improve forage quality (Cherney and Cherney, 2005). Orchardgrass, reed canarygrass, and tall fescue were fertilized with 0, 100 and 200 lb N fertilizer/acre at spring greenu up. Grass stands were sampled in late May or early June in 2001, 2002, and 2003, just past optimum fiber content, with NDF in the mid to upper 50’s. Two sites were sampled, a fertile site in Ithaca, NY and a more marginal high elevation site in Dryden, NY. Rates of change per inch of increased stubble height on a percentage basis was small for forage quality parameters, resulting in small changes in milk/ton (0.83 ± 0.42%) and relative
forage quality (1.7 ± 0.84%) estimates. The much greater change in yield compared to quality with increased stubble height resulted in a -5.4 ± 1.3% change in milk/acre/inch.

Once first-cutting perennial grasses have past the harvest window for optimum forage quality, raising the cutter bar at harvest will not improve overall quality sufficiently to warrant this practice as a management tool. Cutting high enough to increase forage CP by one percentage unit, or to reduce NDF by one percentage unit, reduces overall DM yield by 12% on average. We sampled just past optimum quality, so cutting at a more mature stage would have even less impact on forage quality. The small increase in forage quality with increased stubble height does not offset the significant loss of DM yield, regardless of grass species or level of N fertilization. There is no reason to cut perennial cool-season grasses any higher than the minimum stubble height needed to avoid hitting stones or soil in rough fields.

Alfalfa-grass

Stubble height has more of an impact on alfalfa quality than it does on grass (Table 2). A Wisconsin study looked at the impact of stubble height on alfalfa yield and quality (Wiersma, 2000). Both small plot and field scale experiments were conducted. On average for spring harvest, alfalfa yield changed 470 lbs/inch, while grass averaged 207 lbs/inch. NDF in alfalfa changed approximately 1 unit per inch, while it changed only 0.38 units/inch for grasses. Once a grass nears heading, the top of the plant is relatively high in NDF. The top of an alfalfa plant is considerably lower in NDF than the lower stem, and more immature at harvest compared to grasses. Increased stubble height when cutting alfalfa-grass stands, however, is not economical. For alfalfa-grass stands it is best to cut as low as possible. The exceptions to this rule relate to stand persistence of alfalfa. Winter-damaged alfalfa should be cut higher in the spring, and a higher stubble height might be helpful on alfalfa-grass stands in the late fall to help catch snow.

Table 2. Change in yield and quality of grass and alfalfa due to stubble height.

<table>
<thead>
<tr>
<th></th>
<th>NDF units/inch</th>
<th>RFV/RFQ units/inch</th>
<th>Yield lbs/inch</th>
<th>Milk/acre lbs/inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass</td>
<td>0.38</td>
<td>2.3</td>
<td>207</td>
<td>318</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>0.68</td>
<td>4.0</td>
<td>420</td>
<td>645</td>
</tr>
</tbody>
</table>

1 From Cherney and Cherney, 2005, and Wiersma, 2000. Grass data is the average of species, sites, years and replicates. Alfalfa data is an estimate of the average of replicates of small plots.

2 RFQ was calculated for grass, RFV was calculated for alfalfa.

ENSILING

Grass is the most common crop ensiled in the world, followed by corn and alfalfa. Perennial grasses typically have higher fiber levels, which have the potential to limit
intake and production. Management of grass for optimum silage fermentation and preservation will maximize the potential of this forage. Laboratory silos are now a practical method of comparing grass species and managements (Cherney et al., 2006). Small scale silos are necessary when evaluating numerous experimental variables and their interactions involving different grass silages. The pH and VFA fermentation characteristics of vacuum-sealed polyethylene bags are stable in as little as four days after ensiling. This system will be a valuable evaluation tool in the future as the number of grass varieties proliferates.

![Graph showing changes in pH during ensiling of grasses in vacuum-sealed bags.](image)

Figure 5. Changes in pH during ensiling of grasses in vacuum-sealed bags.

**CONCLUSION**

Improved management for high quality has made grass and grass-legume mixtures attractive options for dairy producers. Grasses and grass-legume mixtures also have significant nutrient management benefits, particularly regarding manure management. Grass species and variety evaluation should be focused on maximum yield at optimum silage quality. Once proper species and varieties are selected, harvest management will determine the success or failure of grass as high producing dairy cow forage. A harvest date target based on optimum forage NDF for the class of livestock being fed is the goal. New methods to predict first harvest date will make harvesting quality forage easier and more predictable.

**REFERENCES**
