Sampling Requirements for Determining Forage Quality

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Introduction

Controlling input costs and achieving desired animal production levels are two goals of most livestock producers. Supplemental feeding is where these two factors generally collide and profitability is decreased. Dry hay is most often the primary source of nutrients for livestock during winter months, and to maintain desired production levels, many producers provide supplemental feed.

Forage testing is the first step, and possibly the most overlooked factor, in balancing a ration to meet livestock nutrient requirements. Techniques for hay sampling vary widely from hand-grabbed samples out of the windrow to core sampling multiple bales by lot. However, it is vital that each hay sample be truly representative of the particular lot of hay. Due to the time and labor involved in obtaining forage samples it is also important to know the minimum percentage of bales from a lot of hay to be core sampled to achieve a representative forage analysis. It is suspected that monoculture hay lots, such as those containing primarily bermudagrass, will require fewer core samples than lots with a large variation among forage species, and both will likely require more cores than are currently being obtained by most producers. Therefore, the objective of this study was to demonstrate the inaccuracies that could occur with too small a sample size, and to determine an appropriate sampling rate for hay bales from two types of fields (monoculture and mixed grass).

Experimental Procedures

Two fields on farms in the Arkansas River Valley were selected; these included an 8-acre field of Tipton 44 bermudagrass and a 12-acre field of mixed/native grass. Each field was divided into four quadrants ranging from 2 to 4 acres, and forage inventories were performed for each section using a step-point identification method to identify the species mix in the entire field and to show the random distribution of the various species across the entire field. Forage inventories were performed for both fields on June 20, 2002. The bermudagrass field was cut, tedded, raked, and then baled on July 12. The mixed grass field was cut, tedded, raked, and then baled on July 27. Fifty-one bermudagrass and 73 mixed grass bales were harvested. Hay bales were 5.0 by 5.5-ft round bales, weighing approximately 1000 lb. Within one week of baling, while bales were still in the field, all bales were cored with a 0.75-in internal diameter, 18-in-long Star Multi-Forage Sampler (Star Quality Samplers, Edmonton, AB, Canada). Each bale was cored three times on each rounded side, and these six cores were composited, in order to gain the necessary sample amount for each bale.

Forage samples were dried at 131°F and ground through a Wiley mill fitted with a 1-mm screen (Arthur H. Thomas, Philadelphia, PA). Crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) were determined on the composite sample from each bale. Crude protein was determined by rapid combustion (Elementar Americas, Inc., Mt. Laurel, NJ); and ADF and NDF were conducted using batch procedures outlined by ANKOM Technology Corp. (Fairport, NY).

Statistical Analysis. Chi Square analysis was performed on forage inventories. Analyses were conducted for each field using PROC Survey Select of SAS (SAS Inst., Inc., Cary, NC), to generate 10,000 random samples for each population size. Population size (sampling rate) ranged from 5 to 75% of the total lot in increments of 5%. Potential sampling outcomes for each sampling rate were generated. Results indicate that forage samples should include one core from at least 50% of all bales of a monoculture or pure forage stand and 35% of all bales when sampling a mixed/native grass field to achieve a representative hay sample useful for ration balancing.

Results and Discussion

Chi Square analysis indicated that there were no differences (P = 0.30) among the four quadrants in species composition in the bermudagrass field (Figure 1), and there were differences (P < 0.0001) in the species composition among the quadrants in the mixed grass field (Figure 2). The number of bales harvested and the mean forage quality data from each field are shown in Table 1.

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In order to interpret the results in a practical and useful manner, it was decided that the primary function of the forage analysis, in most applications, is balancing supplemental feed rations for livestock. It was determined that evaluating forages for total digestible nutrients (TDN) and CP is the primary purpose of testing; therefore, a baseline with an acceptable degree of error within the samples was set at a two percentage unit variation in TDN and a two percentage unit variation in CP (i.e. the mean ± one percentage unit).

The variables used in the Arkansas bermudagrass TDN equation include CP, ADF, and NDF \[TDN = 111.8 + 0.95(%CP) - 0.36(%ADF) - 0.7(%NDF)\]; however, the variables used in the Arkansas mixed/native grass TDN equation are CP and ADF only \[TDN = 73.5 + 0.62(%CP) - 0.71(%ADF)\]. Based on these TDN equations it was determined that variation in NDF would have the largest impact when calculating TDN for the bermudagrass field, and the variation in ADF would have the largest impact for the mixed grass field. These variables were considered the limiting factors and recommendations for sampling were based on meeting the acceptable range for these limiting factors.

Holding ADF and CP constant and using the minimum and maximum observations for NDF at each sampling rate, TDN was calculated for the bermudagrass lot. At the lowest sampling rate (5% of bales), calculated TDN ranged from 59.4 to 64.2% (Figure 3). As sampling rate increased, the range in observed TDN values (i.e. the difference between minimum and maximum values) became smaller. A sampling rate of 30% resulted in an acceptable, less than a two-percentage unit difference between the calculated TDN concentrations (Figure 3). This is the point (30%) at which sampling recommendations were determined to be the minimum acceptable for the bermudagrass field. The 30% sampling rate for 51 bermudagrass bales would require core sampling 15 bales.

For mixed grasses, ADF was the limiting factor in the TDN equation. Holding CP constant and using the minimum and maximum observations for ADF at each sampling rate, TDN was calculated. At the lowest sampling rate (5% of bales), calculated TDN ranged from 46.3 to 52.3% (Figure 4). As sampling rate increased, the difference between minimum and maximum observed TDN values became smaller. A sampling rate of 35% resulted in an acceptable, less than a two-percentage unit difference between the calculated TDN concentrations (Figure 4). This is the point (35%) at which sampling recommendations were determined to be the minimum acceptable for the mixed grass field. For the 73 bales of mixed grass, a minimum of 26 bales would be core sampled to reach the 35% sampling rate. At these sampling rates, CP concentration varied less than two percentage units (Figure 5) for both uniform and mixed grass hay meadows.

**Implications**

Livestock producers and industry professionals generally recognize the benefits of forage testing, but often overlook the importance of attaining a truly representative hay sample. In order to develop useful feed rations, forages must be sampled at a minimum level of 30 to 35% of the bales or greater depending on the variability of the forage stand.

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![Fig. 1. Bermudagrass field forage inventory, from four areas within the field and overall.](image1)

![Fig. 2. Mixed grass field forage inventory, from four areas within the field and overall.](image2)

**Table 1. Characteristics of the forage from the two fields that were used (dry-matter basis).**

<table>
<thead>
<tr>
<th>Field</th>
<th>Number of bales</th>
<th>CP, %</th>
<th>ADF, %</th>
<th>NDF, %</th>
<th>TDN, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermudagrass field</td>
<td>51</td>
<td>13.0</td>
<td>36.0</td>
<td>71.1</td>
<td>61.5</td>
</tr>
<tr>
<td>Mixed grass field</td>
<td>73</td>
<td>11.0</td>
<td>43.2</td>
<td>69.9</td>
<td>49.6</td>
</tr>
</tbody>
</table>

1 Calculated
Fig. 3. Variation in calculated TDN based on sampling rate for the bermudagrass field.

Fig. 4. Variation in calculated TDN based on sampling rate for the mixed grass field.

Fig. 5. Variation in crude protein due to sampling rate for bermudagrass (A) and mixed grass (B) hay.