ID # 09-36

# A SIMPLE METHOD FOR ESTIMATING ALFALFA FIBER CONTENT IN THE FIELD

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## Abstract

Predictive equations for alfalfa (*Medicago sativa* L.) quality (PEAQ) based on length of the longest stem and maturity stage of the most mature stem in a sample were developed and validated for estimating neutral detergent fiber (NDF) and acid detergent fiber (ADF) concentrations in alfalfa. The objective of this research was to validate PEAQ with a simplified maturity scale when estimating fiber content. Alfalfa samples varying in height and maturity were collected throughout the growing season from fields across six states in USA. Observed NDF and ADF values (determined via wet chemistry) were regressed on estimated values. The estimated values were calculated with PEAQ using the Kalu and Fick maturity scale (stages 2 to 6) and using a modified 3-stage scale consisting of vegetative stage (Kalu and Fick stage 2.0), bud stage (stage 3.5, i.e. averaged Kalu and Fick bud stages 3 and 4), and flower stage (stage 5.5, i.e. averaged Kalu and Fick flower stages 5 and 6). Regression equations for NDF and ADF were slightly biased (*b* 1.0 and/or *y*-intercept 0) for two of the three datasets regardless of the staging scale used. Prediction errors were similar regardless of the staging scale, ranging from 16.8 to 25.4 g $kg^{-1}$ for NDF and 14.3 to 19.3 g $kg^{-1}$ for ADF. We conclude that the 3-stage maturity scale can be used effectively in these equations for estimating alfalfa fiber content based on a combination of stem length and maturity.

**Keywords:** Alfalfa, forage quality, fiber, maturity stage, stem length, harvesting

## Introduction

A simple and reliable method for estimating forage quality of alfalfa in the field would help producers to graze, harvest, store, and inventory feed based on its potential value in animal rations. Calendar date and maturity stage alone are not reliable indicators of alfalfa quality. Hintz and Albrecht (1991) proposed simple equations based on length of the longest stem and stage of the most mature stem in the sample for estimating alfalfa fiber content. These equations (referred to as PEAQ) were validated in Wisconsin (Owens et al., 1995) and in four other states (Sulc et al., 1997), proving to be robust across the wide range of environments sampled.

When using PEAQ, maturity of the most mature stem is determined using the scale of Kalu and Fick (1981). Differentiating between the two bud stages and the two flower stages of this scale can be tedious in the field. We hypothesized that a simplified scale could be used without sacrificing the prediction accuracy of PEAQ. This paper presents data to test the hypothesis that a simple 3-stage scale for alfalfa maturity can be used effectively with PEAQ rather than the original Kalu and Fick (1981) maturity scale for alfalfa.

## Material and Methods

Alfalfa samples were collected in 1994 to 1996 from experiments and production fields in New York, Pennsylvania, Ohio, Wisconsin, and California. This five-state set is hereafter called the *National data set*. A second sample set was collected from production fields across Ohio in 1995 and 1996 and Wisconsin in 1996, and is hereafter called the *OH-WI data set*. In 1998, samples for a third set were collected in Ohio, Wisconsin, and South Dakota to evaluate the performance of PEAQ on a whole-field basis. Five subsamples were collected at random across a field on each sampling date, and later combined into one composite sample for laboratory analyses. Hereafter this data set is referred to as the *OH-WI-SD* data set. Most samples were collected from alfalfa cultivars with fall dormancy ranging between that of cultivars Vernal and Saranac. Samples consisted of 100 to 200 stems collected from weed-free portions of the field. The stems were clipped to a 5-cm stubble in an area ~0.1 to 0.2 $m^2$. Within each state, samples were collected to represent a range in maturity from vegetative through flowering stages during each of three or four growth cycles each year. The longest stem in each sample was measured to the nearest cm (MAXHT). The most mature stem in the sample was given the appropriate maturity rating (MAXSTAGE) from the scale of Kalu and Fick (1981), which included the following stages: 2 = stem length ≥ 31 cm with no buds or flowers, 3 = one to two nodes with buds, 4 = three or more nodes with buds and no flowers, 5 = one node with an open flower (standard open), and 6 = two or more nodes with open flowers and no seed pods. The most mature stem was also rated using a modified 3-stage scale: 2 = stem length ≥ 31 cm with no buds or flowers, 3.5 = one or more nodes with a visible bud, and 5.5 = one or more nodes with an open flower. Samples were dried in a forced-air oven for 48 h at 60 $^0$C and ground to pass a 1-mm screen. Concentrations of NDF and ADF were determined by sequential analysis as outlined by Hintz and Albrecht (1991).

Estimates of NDF and ADF were calculated with PEAQ using the two staging scales described above. The PEAQ of Hintz and Albrecht (1991) that were tested are:

NDF = 168.9 + 2.7(MAXHT) + 8.1(MAXSTAGE)

ADF = 115.7 + 2.1(MAXHT) + 7.9(MAXSTAGE)

These equations were tested by regressing observed quality (laboratory analyses) of the samples on the corresponding estimated values (from the predictive equations). The statistical validation of equations used here is a test of goodness of fit of predictions to observations.

## Results and Discussion

Regressions of observed fiber values on PEAQ estimates using the modified 3-stage maturity scale demonstrate nearly identical $r^2$, *y*-intercepts, *b* values, and prediction errors (RMSE) as those previously reported for the same data sets when the 5-stage scale (stages 2 to 6 of Kalu and Fick, 1981) was used in calculating PEAQ estimates (Sulc et al., 1997). We found significant bias (*b* 1.0 and *y*-intercept 0, *P* = 0.01) with PEAQ estimates shown in Table 1; however, the prediction errors for PEAQ are lower than most of those reported for models based solely on maturity stage. Furthermore, the prediction errors for PEAQ are within an acceptable range for using these equations in pre-harvest decision-making.

Regressions of observed fiber values on estimated values for the *OH-WI-SD* data set demonstrate essentially identical results regardless of the maturity scale used in calculating PEAQ estimates (Table 2). The prediction errors for this data set were very low and no bias was found in the PEAQ estimates. These data demonstrate once again that PEAQ performs well across spring and summer growth cycles and over a wide geographic area. The *OH-WI-SD* data set also demonstrates what can be expected when PEAQ is used to estimate average quality of whole fields to be harvested or grazed. The PEAQ method (using the modified 3-stage scale) estimated NDF within ± 20 g $kg^{-1}$ of observed values in 63% of the samples, within ±30 g $kg^{-1}$ of observed values in 75% of the samples, and within ± 40 g $kg^{-1}$ of observed values in 93% of the samples.

The information gathered from pre-harvest estimates of fiber content can be used to time harvests and guide the order of paddocks to be grazed. These estimates might influence the storage location of the forage and may provide an estimation of concentrate needs in the ration. Since harvest and storage losses are not incurred with grazing, PEAQ should provide an excellent estimate of the fiber in alfalfa available to livestock on pasture; however, pre-harvest estimates of NDF do not replace the need to test the quality of stored forage before balancing rations. If performed correctly, PEAQ is more reliable than visual appraisals or harvesting by calendar date, age, or by maturity alone. Based on these data, we conclude that the 3-stage maturity scale can be used effectively when estimating alfalfa fiber content with PEAQ in the field. Incremental NDF or ADF markings based on MAXHT within each of the three stages can be placed along three sides of a four-sided stick, providing a convenient tool for making instantaneous fiber estimates when sampling areas across a field.

## References

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**Table 1 -** Parameters of the regression of observed forage quality of alfalfa on estimates of those observations. †

| Data set | $r^2$ | RMSE (g kg$^{-1}$) | Mean (g kg$^{-1}$) estimate | Mean (g kg$^{-1}$) observed | *b* | Prob *b* = 1.0 | *a* | Prob *a* = 0 | *n* |
|---|---|---|---|---|---|---|---|---|---|
| *Neutral detergent fiber* | | | | | | | | | |
| National | 0.71 | 25.4 | 376 | 369 | 0.86 | *** | 46.2 | ** | 192 |
| OH-WI | 0.75 | 20.2 | 372 | 383 | 0.79 | *** | 91.4 | *** | 296 |
| *Acid detergent fiber* | | | | | | | | | |
| National | 0.74 | 19.3 | 283 | 283 | 0.87 | *** | 37.3 | *** | 192 |
| OH-WI | 0.75 | 16.3 | 280 | 291 | 0.79 | *** | 69.3 | *** | 296 |

**, *** Significant at the 0.01 and 0.001 levels of probability, respectively.

† $r^2$ = coefficient of determination; RMSE = root mean square error (i.e. prediction error in this context); *b* = regression coefficient; Prob = probability; *a* = equation intercept, *n* = sample number. Estimated values were calculated from equations for alfalfa quality based on length of the longest stem and maturity stage of the most mature stem in each sample (Hintz and Albrecht, 1991). A modified Kalu and Fick (1981) maturity scale was used for staging the most mature stem in each sample: vegetative (2.0), bud (3.5), and flower (5.5).

**Table 2 -** Parameters of the regression of observed forage quality on estimates of those observations for alfalfa sampled in Ohio, Wisconsin, and South Dakota in 1998. †

| Maturity scale used‡ | $r^2$ | RMSE (g kg$^{-1}$) | Mean (g kg$^{-1}$) estimate | Mean (g kg$^{-1}$) observed | *b* | Prob *b* = 1.0 | *a* | Prob *a* = 0 | *n* |
|---|---|---|---|---|---|---|---|---|---|
| *Neutral detergent fiber* | | | | | | | | | |
| 5-stage | 0.89 | 16.8 | 359 | 340 | 0.96 | NS | -4.3 | NS | 57 |
| 3-stage | 0.89 | 16.9 | 357 | 340 | 0.97 | NS | -7.9 | NS | 57 |
| *Acid detergent fiber* | | | | | | | | | |
| 5-stage | 0.88 | 14.3 | 270 | 260 | 0.93 | NS | 7.2 | NS | 57 |
| 3-stage | 0.88 | 14.3 | 268 | 260 | 0.95 | NS | 4.0 | NS | 57 |

NS = no significant difference ($P > 0.05$).

† $r^2$ = coefficient of determination; RMSE = root mean square error (i.e. prediction error in this context); *b* = regression coefficient; Prob =probability; *a* = equation intercept; *n* = sample number.

‡ Estimated values were calculated from equations for alfalfa quality based on length of the longest stem and maturity stage of the most mature stem in each sample (Hintz and Albrecht, 1991) using either a 5-stage or a simple 3-stage maturity scale. The 5-stage maturity scale consisted of stages 2 to 6 described by Kalu and Fick (1981). The 3-stage maturity scale was a modification of the Kalu and Fick (1981) scale: 2.0 = vegetative stage, 3.5 = bud stage, and 5.5 = flower stage.