BUL 1018

Predicting Alfalfa Forage Quality in Southern Idaho

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University of Idaho Extension

Introduction

The quality of alfalfa hay is determined by its maturity at cutting, environmental conditions prior to and during harvest, and by handling and storage processes postharvest. Because environmental conditions vary from year to year and day to day, factors other than calendar date must be used as harvest criteria. Of all the quality factors the producer can control, maturity at cutting is the most important. If the harvest is not timely, preservation processes cannot restore quality already lost. This publication describes two simple, inexpensive methods for predicting the harvest quality of first-cutting alfalfa hay in southern Idaho. These methods utilize only the length of the longest stem in a sample and the growth stage of the most mature stem.

Laboratory analyses determining the nutritional quality of standing alfalfa have been used in harvest scheduling in the past, but in the time it takes to receive results (usually two to three days), hay quality may deteriorate significantly. The Magic Valley Alfalfa Quality Watch Program demonstrated an average weekly decline of 2.0 percentage units of crude protein (CP) and an increase of 3.8 percentage units of acid detergent fiber (ADF).

Why should you predict alfalfa hay quality? Alfalfa producers who raise dairy-quality hay can expect higher returns per ton than producers of lower-quality hay. This is because higher-quality hay increases returns over feed costs for dairy producers. Cost comparisons developed by Bar Diamond showed that reducing ADF from 32% to 22% increased milk production by 4.68 pounds per head per day. This increase in milk production more than offsets any increased cost associated with feeding higher-quality alfalfa hay.

If your goal is to produce premium- or supreme-quality alfalfa hay, then you need to monitor the maturity of each field and predict when to cut the alfalfa in order to meet the premium- or supreme-quality criteria (Table 1). Two methods to accurately assess forage quality of standing alfalfa are provided so growers can determine proper harvest times to meet certain goals or marketing criteria.

Table 1. US alfalfa hay (not more than 10% grass) classification for domestic livestock use. The Livestock and Grain Market News branch of the United States Department of Agriculture-Agricultural Marketing Service (USDA-AMS) in 2003 began using these revised hay-quality guidelines for use in the nationwide Market News reporting program.

Quality	ADF	NDF	RFV	TDN	CP
Supreme	<27	<34	>185	>62	>22
Premium	27–29	34–36	170–185	60.5–62	20–22
Good	29–32	36–40	150–170	58–60	18–20
Fair	32–35	40–44	130–150	56–58	16–18
Utility	>35	>44	<130	<56	<16

ADF, acid detergent fiber; NDF, neutral detergent fiber; CP, crude protein
RFV is calculated by the Wisconsin formula: RFV = (DDM × DMI)/1.29, where DDM is dry matter digestibility (%) and DMI is voluntary dry matter intake (% of body weight)
TDN, 100% is total digestible nutrients using the Western (California) Formula on a 100% dry matter basis: TDN = 82.38 – (0.7515 × ADF) DDM = 88.9 – (0.779 × ADF) and DMI = 120/NDF

PEAQ: A Better Method for Estimating Hay Quality

Past characterizations of maturity were usually based on flower development, such as "pre-bud," "bud," and "1/10th" or "early bloom." Although these terms are helpful, they do not precisely define maturity and this vagueness allows some confusion. Bloom is an easily recognizable maturity characteristic, but by the time appreciable bloom is present, alfalfa is often too mature to meet dairy industry quality standards. The practice of feeling stem tips for the presence of buds is more useful, but it is still inadequate to accurately assess alfalfa maturity in a field.

The PEAQ (predictive equations for alfalfa quality) method is based on the tallest and the most mature stem of a sample. Although the method was developed in Wisconsin[1] it works well in southern Idaho to northern California. The PEAQ method provides a quick (1–5-minute) and simple (requiring just a ruler and chart) means of estimating alfalfa quality. The procedure involves collecting a random sample, measuring the longest stem in the sample, and determining the growth stage of the most morphologically mature stem in the sample. These two measurements can accurately predict ADF, CP, neutral detergent fiber (NDF), and relative feed value index (RFV).

How to Estimate Alfalfa Hay Quality with PEAQ

1. **Collect the sample**. Randomly sample at least 100 alfalfa stems. A representative sample of alfalfa can be collected by taking random grab samples from the field (usually 10–12 handfuls are sufficient). Cut stems to approximate mower height (1.5–2 inches of stubble). Measure the height of the tallest stem in the sample (in inches) and determine the growth stage of the most morphologically mature stem (Table 2).
2. **Estimate alfalfa hay quality**. Use tables 3–6 to estimate ADF, CP, NDF, and RFV, respectively, based on the longest and most mature stems. Select the height in inches in the left column and move across the row to the appropriate growth stage. For example, if the longest stem is 28 inches and the growth stage of the most mature stem is 3, the hay-quality parameters would be ADF = 28.9, CP = 23.0, NDF = 34.1, and RFV = 181. As the alfalfa plant matures, ADF and NDF increase while CP and RFV decrease.

Table 2. Morphological stages of development for individual alfalfa stems.

Growth Stage Number	Stage Name	Stage Definition
0	Early vegetative	Stem length less than 6 inches; no visible buds, flowers, or seedpods
1	Midvegetative	Stem length 6–12 inches; no visible buds, flowers, or seedpods
2	Late vegetative	Stem length greater than 12 inches; no visible buds, flowers, or seedpods
3	Early bud	One or two nodes with visible buds; no flowers or seedpods
4	Late bud	Three or more nodes with visible buds; no flowers or seedpods
5	Early flower	One node with one open flower; no seedpods
6	Late flower	Two or more nodes with open flowers; no seedpods

Source: Kalu, B. A., and G. W. Fick. 1983. "Morphological Stage of Development as a Predictor of Alfalfa Herbage Quality." Crop Science *23(6):1167–72. Note: Refer to "Stages of Alfalfa Development" in our bulletin for greater description and detail.*

Table 3.Estimate of percent acid detergent fiber (ADF) in first-cutting irrigated alfalfa in southern Idaho.

Longest Stem (inches)	Growth Stage of Most Mature Stem				
	2	3	4	5	6
20	25.2	25.7	–	–	–
22	26	26.5	27.1	–	–
24	26.8	27.3	27.9	–	–
26	27.6	28.1	28.7	–	–
28	–	28.9	29.5	30	–
30	–	29.7	30.3	30.8	–
32	–	30.5	31.1	31.6	–
34	–	31.3	31.9	32.4	–
36	–	–	32.7	33.2	33.7
38	–	–	33.5	34	34.5
40	–	–	34.3	34.8	35.3
42	–	–	35.1	35.6	36.1

Note: ADF = 16.2 + (0.41 × HT) + (0.52 × GS), where HT = height (inches) of tallest stem and GS = growth stage of most mature stem.

Table 4.Estimate of percent crude protein (CP) in first-cutting irrigated alfalfa in southern Idaho.

Longest Stem (inches)	Growth Stage of Most Mature Stem				
	2	3	4	5	6
20	25.2	24.7	–	–	–
22	24.8	24.3	23.8	–	–
24	24.4	23.9	23.4	–	–
26	23.9	23.4	22.9	–	–
28	–	23	22.5	21.9	–
30	–	22.6	22.1	21.5	–
32	–	22.2	21.7	21.1	–
34	–	21.8	21.3	20.7	–
36	–	–	20.8	20.2	19.7
38	–	–	20.4	19.8	19.3
40	–	–	20	19.4	18.9
42	–	–	19.6	19	18.5

Note: CP = 30.4 - (0.29 × HT) + (0.54 × GS), where HT = height (inches) of tallest stem and GS = growth stage of most mature stem.

Table 5.Estimate of percent neutral detergent fiber (NDF) in first-cutting irrigated alfalfa in southern Idaho.

Longest Stem (inches)	Growth Stage of Most Mature Stem				
	2	3	4	5	6
20	30.3	30.8	–	–	–
22	31.1	31.6	32.1	–	–
24	31.9	32.4	32.9	–	–
26	32.8	33.3	33.8	–	–
28	–	34.1	34.6	35.1	–
30	–	34.9	35.4	35.9	–
32	–	35.7	36.2	36.7	–
34	–	36.5	37	37.5	–
36	–	–	37.9	38.4	38.9
38	–	–	38.7	39.2	39.7
40	–	–	39.5	40	40.5
42	–	–	40.3	40.8	41.3

Note: NDF = 21.9 + (0.41 × HT) + (0.50 × GS), where HT = height (inches) of tallest stem and GS = growth stage of most mature stem.

Table 6.Estimate of relative feed value (RFV) in first-cutting irrigated alfalfa in southern Idaho.

Longest Stem (inches)	Growth Stage of Most Mature Stem				
	2	3	4	5	6
20	213	208	–	–	–
22	205	201	196	–	–
24	198	194	190	–	–
26	191	187	183	–	–
28	–	181	177	174	–
30	–	175	172	168	–
32	–	170	166	163	–
34	–	164	161	158	–
36	–	–	156	153	150
38	–	–	151	148	145
40	–	–	146	144	141
42	–	–	142	139	137

Note: RFV = [(120/NDF) × (0.889 – (0. 779 × ADF))] / 1.29, where ADF and NDF are fractions (/100).

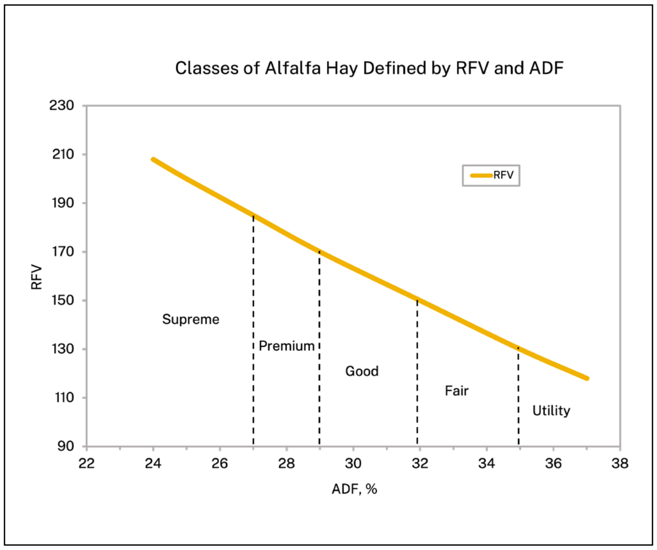

Figure 1. The relationship of acid detergent fiber (ADF) to relative feed value (RFV) and classification into USDA market-reporting guidelines.

Figure 2. Midvegetative stage, left half of photo. Late vegetative stage, right half of photo.

In southern Idaho, height measurements alone indicate that for premium-quality alfalfa hay, the stand should be harvested when maximum stem height reaches approximately 26–28 inches.

Caution: Tables 3–6 are based on the first cutting of a pure stand of irrigated alfalfa in southern Idaho and relate to actively growing plants. The data would not apply to grass-alfalfa or weed-alfalfa mixtures or to alfalfa grown in areas where climatic conditions may result in severe plant stress.

Relative feed value (RFV) can be calculated by the formula in the notes for Table 6 or by interpolating on Figure 1.

Stages of Alfalfa Development[2]

Vegetative Stages

At early stages of development, reproductive structures are not visible on alfalfa stems. Leaf and stem formation characterize vegetative growth.

Stage 0: Early vegetative. Stem length less than or equal to 15 cm (6 inches). No visible buds, flowers, or seedpods. The junction between the main stem and a leaf or branch is called the axil. An axillary bud is present in each leaf axil; however, they are so small at this stage that they are not easily seen.

Stage 1: Midvegetative. Stem length 16–30 cm (6–12 inches) as shown in Figure 2, left half. No visible buds, flowers, or seedpods. As the stem continues to develop, axillary branch formation begins with the appearance of one or two leaves in the axil. Development of axillary leaves is more pronounced in the midportion of the stem than at the base or apex.

Stage 2: Late vegetative. Stem length equal to or greater than 31 cm (12 inches) as shown in Figure 2, right half. No visible buds, flowers, or seedpods. Elongating branches are often found in the axils of the leaves at this stage. It may be possible to feel buds at the growing apex, but they are not visible without peeling back the enclosing leaves. Stage 2 stems are often rare in midsummer because of the rapid appearance of buds on shorter stems. This is a result of environmental conditions that hasten maturation.

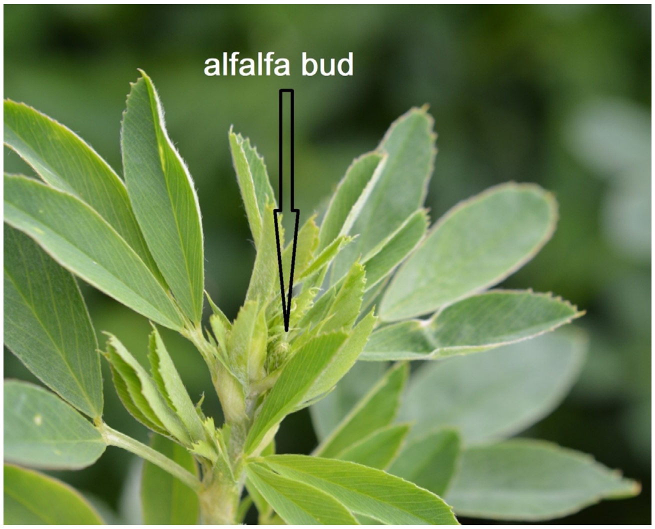

Figure 3. Early bud stage of alfalfa. The bud appears as a small swelling in the axil of leaves near the growing point. They are easier to feel than to see when small.

Flower Bud Development

Flower buds (Figure 3) first appear as small swellings in the axils of the leaves near the growing apex of a stem or an axillary branch. At the transition from vegetative stages to bud stages, flower buds can be difficult to identify. Buds are initially small, distinctly round, and have a hairy or fuzzy appearance. In contrast, new leaves are flattened and oblong.

Stage 3: Early bud. One or two nodes with visible buds. (A node is a region of the stem with one or more leaves attached.) No flowers or seedpods. Flower buds appear clustered at the stem tip because of the closely spaced nodes in that part of the shoot. As the nodes elongate during development into the next stage, it becomes easier to distinguish individual nodes for the purpose of counting.

Stage 4: Late bud. Three or more nodes with visible buds. No flowers or seedpods. This stage differs from the previous one only in the number of nodes with flower buds. The structure of the developing inflorescence (arrangement of flowers on the flowering stem) becomes visible with elongation and cleaner separation of individual flower buds in the raceme. (A raceme is a variety of flower cluster in which single flowers grow on short stems arranged at intervals along a single, larger stem.)

Figure 4. Early flower stage of alfalfa.

Flowering

When environmental conditions meet specific requirements for temperature and photoperiod, flower buds develop into flowers. Flowering normally occurs in the field, but in the autumn, with less than 12 hours of daylight, buds may abort without forming flowers. Flowers may be purple, blue cream, yellow, white, or variegated combinations of those colors.

Stage 5: Early flower. One node with at least one open flower and no seedpods (Figure 4). To be counted as an “open” flower, the standard petal of the flower must be unfolded. One or more flowers within the raceme may be open; however, the definition of stage 5 is open flowers at only one node. Because one raceme arises from each node, the number of racemes with open flowers is what is actually counted. Flowering usually begins near the apex of the stem while buds are still developing rapidly above and below the point of the initial flower opening.

Stage 6: Late flower. Two or more nodes with open flowers and no seedpods. This stage differs from stage 5 *in that stage 6 has more racemes with open flowers*. Nodes with flowers are spread throughout the midportion of the stem.

Seed Production

Seed production stages 7–9 are omitted since they have no relevance in determining high-quality hay.

Predicting Forage Quality Using the Alfalfa Quality Prediction Stick

The Alfalfa Quality Prediction Stick was developed for growers to evaluate the forage quality of the first crop of standing alfalfa. This method using the prediction stick is a rapid, reliable, and reasonably accurate method to predict alfalfa forage quality prior to harvest.

Development of the stick. The PEAQ method was found to provide accurate results while also being easy to use. The prediction stick is basically the ADF values determined by PEAQ as three scales (vegetative, bud, and bloom stages) on the stick. The scale for each of the three stages relates the predicted ADF values to stem height. Thorough evaluations in Siskiyou County, California, and southern Idaho showed favorable and similar results. The quality prediction stick was developed based upon 356 samples collected from both states.

Figure 5. Extend the most mature stem in the area and read the appropriate vegetation scale on the stick to predict forage quality. In this case the stem tip is at 30% ADF on the bud stage scale.

Using the stick to predict forage quality. The quality prediction stick is very easy to use and provides a rapid prediction of the forage quality of standing alfalfa (Orloff and Putnam 1997). The steps involved are as follows:

STEP 1: Select an average 2 ft^2 area to sample.

The area selected should be representative of the field (not an exceptionally good or poor growth area) and not stressed (i.e., poor growth due to insufficient water, insect damage, or weeds). After identifying representative areas of the field, select a specific 2 ft^2 area to evaluate at random. Do not intentionally look for the most mature or least mature area in the field.

STEP 2: Determine the growth stage of the most mature stem.

Sort through the stems in the 2 ft2 area to determine the growth stage (vegetative, bud, or bloom) of the most mature stem in that area.

STEP 3: Find the single tallest stem. Use the correct side of the stick (vegetative, bud, or bloom) to predict ADF.

Select the *tallest stem* in the 2 ft^2 area and measure it from the soil surface (at the base of the alfalfa crown) to the **stem** tip (NOT the tip of the highest leaf). The tallest stem may or may not be the most mature stem. Stretch the stem along the correct side of the stick (vegetative, bud, or bloom, which was determined in step 2) as shown in Figure 5 and record the ADF value.

STEP 4: Repeat steps 1–3 in *at least* five representative areas and average the results.

Take at least five observations per field and average the results. Remember that the more areas evaluated, the better the results reflect the forage quality of the entire field. Greater than five evaluations would be better, especially for larger or nonuniform fields.

Accuracy and limitations. The quality prediction stick is NOT intended to replace standard laboratory analysis for forage quality of baled alfalfa hay. It is not as accurate as standard laboratory analysis, but is more accurate than visual field estimates of forage quality. Also, the quality prediction stick estimates the forage quality of the standing crop prior to harvest. It cannot account for losses that may occur while the crop is curing or during harvest and storage. Significant reductions in forage quality are possible if rain occurs while the hay is curing or if the hay is raked or baled under excessively dry conditions and leaf loss occurs.

There are better nutritional parameters to predict animal performance: neutral detergent fiber digestibility, relative forage quality (RFQ), and total digestible nutrients (TDN) from the summative equation. However, the PEAQ and prediction stick methods weren't developed using these parameters. Relative forage value will predict forage quality for alfalfa within first cutting adequately for harvest-planning purposes.

Where and when can the stick be used. The stick will perform well in predicting the forage quality of alfalfa in other Western short–growing season areas (2–5 cuttings). The PEAQ method was evaluated in five states and performed well. This stick was customized for Western short-season areas with semidormant varieties and should only be used in those areas.

Samples were collected from the first cutting in southern Idaho and from first and second cuttings in the intermountain area of northern California. In Idaho, we recommend that the prediction stick be used only for the first cutting. Harvest scheduling for dairy quality hay usually requires midsummer cutting at 28–30-day intervals. The fall harvest is usually relatively higher quality at the same maturity than midsummer cuttings.

We recommend sampling the hay bales in the stack with a coring device and submitting the sample to a National Forage Testing Association certified laboratory, https://foragetesting.org/. For more information see CIS 1178, Proper Sampling (Coring) of Hay Bales and Stacks (PDF).

Using the stick as a decision-making tool. The alfalfa quality prediction stick is intended to be a tool that assists growers with harvest decisions. It can help growers determine when to harvest specific fields. For example, the stick may predict forage quality, as follows:

Dairy quality—the alfalfa should be cut as soon as possible.

Above dairy quality—the grower can delay harvest a few days and harvest another field where the alfalfa is not predicted to be significantly above dairy quality.

Below dairy hay quality—postpone harvest to maximize yield and target another market such as the horse- or stock-hay market.

Availability of the prediction stick. The prediction stick may be available by contacting

The Idaho Hay and Forage Association
Phone: 208-888-0988
55 SW 5th Ave., Suite 100
Meridian ID 83642

Further Reading

Orloff, S., and D. Putnam. 1997. "Judging Forage Quality in the Field Using the UC Intermountain Alfalfa Quality Prediction Stick." Agronomy Fact Series 1997-3. Department of Agronomy and Range Science, University of California, Davis.

Notes

[1]R. W. Hintz and K. A. Albrecht. 1991. "Prediction of Alfalfa Chemical Composition from Maturity and Plant Morphology." *Crop Science* 31: 1561–65.

[2]G. W. Fick and S. C. Mueller. 1989. "Alfalfa Quality, Maturity, and Mean Stage of Development." Information Bulletin 217. Ithaca, NY: Cornell University Department of Agronomy.

Acknowledgments

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