Predicting alfalfa hay quality in southern Idaho

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The quality of alfalfa hay is determined by its maturity at cutting, by environmental conditions before and during harvest, and by handling and storage processes after harvest. Because environmental conditions vary from year to year and from 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 can not bring back quality already lost. This publication describes a simple, inexpensive method for predicting harvest quality of first-cutting alfalfa hay in southern Idaho using 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 get the results back (usually two to three days), hay quality may deteriorate significantly. The Magic Valley Alfalfa Quality Watch Program in 1991 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 raise dairy-quality hay?

Alfalfa producers who raise dairy-quality hay (table 1) 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, Inc., showed that reducing ADF from 32 percent to 22 percent 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.

Table 1. Approximate dairy hay quality standards.

Quality classification	Maximum ADF[a] (%)
Premium[b]	29 or less
Good	32
Fair	37

Source: USDA Agricultural Marketing Service and California Department of Food and Agriculture Market News Branch. 1996. Hay Market News 46(11). March.

[a]100 percent dry matter basis.

[b]Premium quality dairy hay should be free of odor and foreign material and contain more than 20 percent crude protein and less than 29 percent acid detergent fiber.

PEAQ: a better method for estimating hay quality

Past characterizations of maturity were usually based on flower development, for example, "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.

The method of assigning numerical values to alfalfa growth stages allows the mean morphological growth stage to be easily determined in the field. This method, referred to as "mean morphological stage of growth by count," or MSC, uses the number of stems in each developmental stage to quantify maturity. When MSC has been determined, forage quality parameters such as acid detergent fiber (ADF), crude protein (CP), and neutral detergent fiber (NDF) can be quickly estimated.

MSC has been very useful in predicting forage quality at harvest in first cuttings of alfalfa in southern Idaho. However, the method requires separating and counting stems for each growth stage and calculating the weighted average, which takes approximately 15 to 20 minutes. A newer method, PEAQ (predictive equations for alfalfa quality),

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based on the tallest stem and the most mature stem of a sample, was developed in Wisconsin[1].

The PEAQ method provides a quick (1 to 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, and NDF.

How to estimate hay quality

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 to 12 handfuls are sufficient). Cut stems to approximate mower height (1 1/2 to 2 inches of stubble). Measure the height, in inches, of the tallest stem in the sample and determine the growth stage of the most morphologically mature stem (table 2).

2. Estimate alfalfa hay quality. Use tables 3, 4, and 5 to estimate ADF, CP, and NDF, respectively, based on the longest stem and most mature stem. 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, and NDF = 34.1.

As the alfalfa plant matures, ADF and NDF increase while CP decreases.

◆ *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 to 28 inches.*

***Caution*:** Tables 3, 4, and 5 are based on the first cutting of a pure stand of 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 severely stress the plant.

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 seed pods
1	Mid vegetative	Stem length 6 to 12 inches; no visible buds, flowers, or seed pods
2	Late vegetative	Stem length greater than 12 inches; no visible buds, flowers, or seed pods
3	Early bud	One or two nodes with visible buds; no flowers or seed pods
4	Late bud	Three or more nodes with visible buds; no flowers or seed pods
5	Early flower	One node with one open flower; no seed pods
6	Late flower	Two or more nodes with open flowers; no seed pods

Source: Kalu, B. A., and G. W. Fick. 1983. Morphological stage of development as a predictor of alfalfa herbage quality. Crop Science 23:1,167-1,172.
Note: Refer to "Stages of Alfalfa Development" for greater description and detail.

Table 3. Estimate of percent acid detergent fiber 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 x HT) + (0.52 x GS), where HT = height (inches) of tallest stem and GS = growth stage of most mature stem.

[1]Hintz, R. W., and K. A. Albrecht. 1991. Prediction of alfalfa chemical composition from maturity and plant morphology. Crop Science 31: 1561-1565.

Table 4. Estimate of percent crude protein 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	—	23.0	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	—	—	20.0	19.4	18.9
42	—	—	19.6	19.0	18.5

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

Table 5. Estimate of percent neutral detergent fiber 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	37.0	37.5	—
36	—	—	37.9	38.4	38.9
38	—	—	38.7	39.2	39.7
40	—	—	39.5	40.0	40.5
42	—	—	40.3	40.8	41.3

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

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 seed pods.

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 to 30 cm (6 to 12 inches). No visible buds, flowers, or seed pods.

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). No visible buds, flowers, or seed pods.

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.

Flower bud development

Flower buds first appear 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. At first, buds are small, distinctly round, and appear hairy or fuzzy. 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 seed pods.

Flower buds appear clustered at the stem tip because of the closely

[2]Fick, G. W., and S. C. Mueller. 1989. Alfalfa quality, maturity, and mean stage of development. Information Bulletin 217. Ithaca, New York: Cornell University Department of Agronomy, College of Agriculture and Life Sciences.

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 seed pods.

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.)

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 when there are fewer 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 seed pods.

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 initial flower opening.

Stage 6: Late flower. Two or more nodes with open flowers and no seed pods.

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 to 9 are omitted since they have no relevance in determining high-quality hay.

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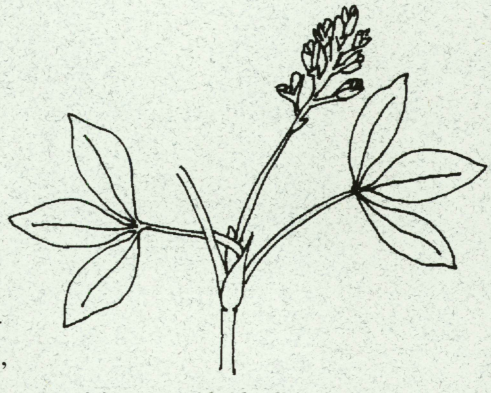
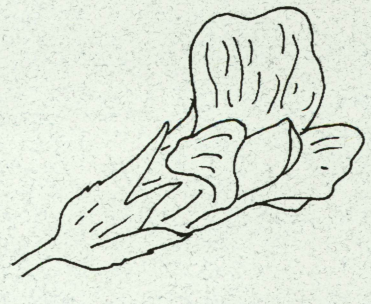
The authors—Robert V. Vodraska, UI extension educator, Twin Falls County, and Mir M. Seyedbagheri, UI extension educator, Elmore County. Drawings at right are from *Alfalfa Quality, Maturity, and Mean Stage of Development*, Information Bulletin 217, Cornell University Department of Agronomy, College of Agriculture and Life Sciences, Ithaca, New York.

Flower buds become visible as their basal stalk elongates.



At bloom, alfalfa flowers are clustered in a loose raceme at the end of a branch.



The individual flower has five petals; the standard petal is the largest and first to unfold.

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