PRODUCTION FACTORS AFFECTING ALFALFA HAY QUALITY

Shannon C. Mueller[1]

Abstract: Numerous environmental and management factors influence the quality of alfalfa. While growers have no control over variables such as temperature and daylength, they do have control over cultural practices that can have a significant impact on the quality of the final product. Proper irrigation management, fertility, and pest control practices can contribute to high yield and quality. However, harvest management has by far the greatest impact on forage quality and is under the most direct control by the grower. Producing alfalfa for maximum yield and quality requires an understanding of how environmental and management factors influence crop growth and development.

INTRODUCTION

The term performance in a forage crop is not restricted to dry matter production alone. The widespread use of alfalfa forage in animal rations indicates that an increase in nutritional quality would further enhance its value in terms of animal productivity. The current objective of many alfalfa breeding programs is to improve the quality of alfalfa. Genetically improved nutritive value would lead to a general elevation in quality in spite of adverse environmental and management factors. Several varieties have been released that are reported to be multifoliolate, fine-stemmed or having other features that relate to high quality, but most of these characteristics are subject to environmental variation and cannot substitute for good management. Although selecting the best variety for your growing conditions is important, paying attention to management practices can do more to influence yield and quality than variety selection in most cases.

FORAGE QUALITY EVALUATION

Forage quality can be evaluated by a number of different methods. Visual inspection is the most common technique, practiced at some level by each and every person who comes in contact with the hay as it moves from the producer's field to the dairy cow. For a less objective determination, hay is often chemically analyzed to determine various quality components. This information can be used as the basis by which hay is bought and sold, and is used by the dairy operator to provide a balanced ration. In 1976, another method of evaluation, Near Infrared Reflectance Spectroscopy (NIRS), became available, providing a rapid and relatively inexpensive means of obtaining alfalfa quality estimates.

[1]Corresponding Author: Shannon C. Mueller, Agronomy Farm Advisor, University of California Cooperative Extension, 1720 S. Maple Avenue, Fresno CA 93702.

FACTORS INFLUENCING FORAGE QUALITY

The most important factors which influence plant growth and forage quality include growing conditions (such as soil type, fertility, local climate, moisture conditions, and pest pressure), stage of maturity at harvest, weather conditions during cutting, moisture at raking and baling, and storage conditions. The composition and quality of hay or silage is the cumulative result of its history. Management of alfalfa for maximum yield and quality requires an understanding of how environmental and management factors influence crop growth and development.

ENVIRONMENTAL FACTORS

Environmental conditions during growth determine plant composition which in turn controls the limits of nutritive value. A sequence of cause and effect relationships exists between the environment, plant response, and nutritive value. Seasonal variations in light, moisture, temperature, and photoperiod, and disease, weed, or insect pest effects are just a few of the factors that contribute to changes in yield and or forage quality during the growth of the crop (Table 1).

Table 1. Influence of environmental factors upon composition and digestibility of forage.

	Temperature	Light	Nitrogen	Water	Predation
Yield	+	+	+	+	
WSC[1]		+		-	+
Nitrate		-	+	NA	NA
Cell Wall	+		±		
Lignin	+	-	+	+	
Digestibility		+	±		+

[1]Water Soluble Carbohydrates

Generally speaking, forage quality declines as the summer progresses and tends to recover under autumn conditions. Alfalfa harvested in the spring or fall has a higher leaf and protein content than summer produced alfalfa, at the same maturity, due to the effects of temperature and photoperiod. High temperature, which increases the rate of plant maturation and cell wall lignification, has a dominant effect. Therefore, the rate of decline in digestibility with time is faster in summer when temperatures are high than in spring or autumn when temperatures are low. Structural components rapidly form at the expense of metabolites in the cell contents when temperatures are high. This affects the quality of the forage because lignification of the cell wall is the primary factor limiting forage digestibility.

Increasing daylength or light intensity have somewhat contrary effects to that of increasing temperature. As these two factors increase, amino acid and non-structural carbohydrate synthesis increases due to the greater photosynthetic rate. The cell wall content, relative to the total dry matter content, decreases.

EFFECTS OF STRESS ON FORAGE QUALITY

In general, any factor that retards plant development tends to promote the maintenance of forage quality. Moisture, fertility, and pest infestations are just a few of the factors that influence quality through changes in plant development. If the plant is stressed during growth, a shorter, finer-stemmed, leafier alfalfa is often produced. Because of this response to stress, the cutting interval can be extended without serious consequences with regard to quality.

Influence of Irrigation Management on Forage Quality

Either too much or too little water can have serious consequences in terms of the performance of alfalfa. The reduced vigor associated with drought often causes a stunted, leafier plant which has finer stems, low fiber, and increased digestibility. In other words, water stress retards plant development and induces a more digestible crop of lower yield. Too much water on the other hand reduces yield and can lower the concentration of feed nutrients.

To obtain the highest yield and quality, soil moisture must be available to avoid stress and allow continuous alfalfa growth throughout the cutting cycle, especially during the high water using months of the summer. The total amount of water required and the timing of applications varies with the water holding capacity of the soil. Poor water management not only stresses the plant, but can lead to reductions in plant populations, weeds (especially grasses), and diseases.

Influence of Fertility on Forage Quality

The composition and nutritive value of forages are affected by the availability of several essential elements in the soil. Plant development slows or stops when elements required for growth are deficient. Higher leaf to stem ratios may occur in plants when growth is restricted by a phosphorus or potassium deficiency. The increase in leaf to stem ratio results in greater crude protein concentrations. Adequate soil fertility, particularly phosphorus, is essential in providing good early growth and weed competition. Guidelines for testing the soil prior to planting, or sampling the plant itself once the crop is established, can provide information for fertilizer management to maintain alfalfa productivity and performance.

The Influence of Pest Effects on Forage Quality

Diseases, insects, and nematodes limit alfalfa production. Although producers may be concerned primarily with yield reductions and survival of the stand, the quality of the forage may also be affected by pests. As with other stresses, pest pressure that delays development will typically result in higher quality forage, but yields will be reduced. On the other hand, conditions reducing the leaf to stem ratio, increasing the fiber concentration, or reducing the protein concentration can be expected to lower feeding value. Resistant varieties are available to help prevent damage cause by pest infesta-

tions, but they must be used in combination with good management to prevent losses in quality or yield. Pest effects result in yield and quality losses in the current season, but damage also reduces vigor which carries over into other cuttings through slow recovery of regrowth, and may lead to winter kill when plants enter dormancy in a weakened state.

Diseases - Foliar diseases occur most often in the spring and fall. Symptoms vary for each disease, but the outcome is similar: infected leaves fall off plants reducing hay quality in the subsequent cutting. Crown and root diseases weaken root systems, reduce water and nutrient uptake, and result in stand loss. They exhibit their effects on forage quality primarily through retardation of growth and ultimately through stand persistence.

Insects - Insects can have either direct or indirect effects on the yield and quality of the forage. Sometimes the consequences of pest pressure appear to be quite obvious as in feeding by the alfalfa weevil. Heavy feeding results in a very low protein, high fiber forage since the majority of the leaf material is removed. Loss of leaves can reduce the feeding value up to 50% and yield up to 35%. Through insect feeding and egg laying, photosynthesis and productivity are both reduced. Alfalfa weevil feeding is an example of the direct effect a pest can have on forage quality. Aphids, on the other hand, influence the quality of the hay indirectly by depositing honeydew on plant tissue, which could contribute to mold growth and reduced feeding value.

Nematodes - In general, nematodes, weaken root systems, reduce water and nutrient uptake, and make roots more susceptible to disease. Under severe infestations, development is delayed and the stand declines allowing weeds to invade.

THE INFLUENCE OF WEEDS ON FORAGE QUALITY

In most crops, weed control generally leads to higher crop yields, but in established alfalfa, the response is variable. Research on alfalfa grown for hay indicates that first cutting hay yields are often highest when winter annual weeds are present. However the quality of the hay can be reduced drastically. Protein as low as 9% has been measured in hay containing 80% weeds.

Weeds reduce alfalfa yield through competition for water, nutrients, and sunlight, and reduce the quality and value of hay because they are often less palatable and less nutritious than alfalfa. Weeds generally contain more fiber than legumes which can potentially lower intake levels. This is important because energy intake is often a limiting factor in high producing and early lactation cows. Many weeds have been found to be comparable to forage species in chemical composition and forage quality, but are often beyond their optimum nutritional stage when harvested with alfalfa. Weed quality declines more rapidly with maturity than forages. Many weeds, even at their optimum nutritional stage are less nutritious than alfalfa. Some weeds are toxic or may cause mechanical injury, in both cases rendering hay unfit for livestock consumption. Weeds that retain moisture can increase curing time and lead to mold, rotting, and spontaneous combustion in stored hay.

Most weed problems are a result of poor management such as improper leveling and seedbed preparation, irrigation practices that bring on weed invasions, cutting in the early bud stage thereby reducing vigor and competitiveness of the alfalfa, and the choice of a poorly adapted variety that loses stand allowing weeds to grow. Establishing a thick, vigorous stand early in the late summer is an effective weed control technique with approximately 50% fewer weeds germinating than alfalfa planted in late fall or early winter. Planting too late often results in severe infestations of winter annual weeds since the rate of alfalfa development is reduced due to cool temperatures. A minimum of 12 plants/ft^2 is required to successfully establish an alfalfa stand, although populations on the order of 20 or more plants/ft^2 is better. Maintaining healthy vigorous stands will prevent future weed encroachment.

HARVEST MANAGEMENT EFFECTS ON QUALITY

The maturity of the crop at the time of harvest has the greatest impact on forage quality and is most easily controlled by the grower. Management decisions based on alfalfa maturity have been shown to work well since the cumulative effect of the environment on crop growth and alfalfa quality is expressed in large part by its morphological stage of development. Cutting according to the stage of growth uses the plant as a harvest indicator and generally provides more consistent yield and quality among varieties, and over years and locations. Percent bloom is not always a good indicator of maturity. Insect damage, disease, and short photoperiods in the spring and fall can all affect the appearance of bloom. When making management decisions based on stage of maturity, look also at crown bud development, or use techniques to more precisely estimate maturity.

Stage of maturity is not equivalent to age. Depending on the variety characteristics and growing conditions, plants of the same age can be at different stages of maturity and have significantly different nutritional value. For example, the number of days between cuttings does not necessarily represent the number of days of growth if regrowth is delayed for some reason. If a stand is stressed for water prior to harvest, shoots won't begin regrowing until the stand is irrigated. Depending on the number of days to cure the hay and to irrigate the field, a cutting interval of 29 days may really represent only 23-26 days of growth. Furthermore, if this pattern is repeated through the summer, alfalfa vigor will be reduced resulting in lower yields, more weeds, and weak stands (Table 2).

Although yield increases with advancing maturity, quality decreases as alfalfa stems become coarser and more lignified, and the leaf percentage declines (Table 2). This is a major factor contributing to the low quality of mature herbage. The highest quality alfalfa is cut early (pre-bud or bud stage) when the plants have a high proportion of leaves and the stems are not yet highly lignified. Protein content, for example decreases from 29% at the early bud stage to 21% at 10% bloom. Alfalfa can go from very high quality forage to very poor quality in a short period of time. The rate of decline in forage quality with increasing maturity is determined by environmental factors, the most important being temperature.

Table 2. **Effects of different alfalfa cutting frequencies on 3-year yield and quality, weeds, and stand life at the end of the third year.**

Maturity at harvest	Harvest interval	Harvests per year	Yield	TDN*	Crude protein	Leaves	Weeds	Stand
	(days)					%		
pre-bud	21	9-10	7.5	62.6	29.1	58	48	29
mid-bud	25	8-9	8.8	60.2	25.2	56	54	38
10% Bloom	29	7	9.9	58.2	21.3	53	8	45
50% Bloom	33	6-7	11.4	57.8	18.0	50	0	56
100% Bloom	37	5-6	11.6	55.7	16.9	47	0	50

SOURCE: V.L. Marble, 1974. How cutting schedules and varieties affect yield, quality, and stand life. In: Proceedings, 4th California Alfalfa Symposium, December 4-5, 1974, Fresno CA. Davis: Univ. Calif. Cooperative Extension; and V.L. Marble, unpublished.
*Total Digestible Nutrients (TDN) at 100% dry matter

Cutting alfalfa for maximum forage quality, yield, and stand survival may involve some compromises. Although the best quality feed is produced from immature alfalfa, the greatest financial return may at times be realized by harvesting at more mature stages depending on the need to maximize yield, reduce costs of harvest, or ensure stand survival. The producer's decision to obtain either the greatest yield of maximum quality alfalfa or the greatest total yield of forage should depend on the needs of the livestock being fed and the market value of the hay. During April and May hay quality is excellent and prices are usually highest. However, in June, July, and August, alfalfa hay yields are high but quality is low due to more rapid development associated with higher temperatures. These conditions can result in large supplies of hay with low market demand. If the difference in market price between high and low TDN hays is small, growers should manage their harvests for higher yields by extending the cutting interval. But when growers are paid for quality, the strategy changes. Higher prices can offset the reduction in tonnage resulting from producing a high quality product by reducing the cutting interval.

The negative relationship between yield and quality is evident when comparing data from equal harvest intervals (Table 3). When harvested on 22, 26, 30, and 34 day regrowth schedules, alfalfa yields were generally greater with longer growing periods. Average TDN levels for the four harvest frequencies declined steadily from 22 to 34 days. The 30 day cutting schedule produced high yields and acceptable quality during May and September. June, July, and August yields were greatest with 34 day cuttings, but highest TDN values were obtained at 22 days during those months. In May, plants were still in the bud stage after a 34 day regrowth period. The 1/10th bloom stage occurred with the 30-day cutting schedule in June and August, at 26 days in July, and at 34 days in September. Regrowth of crown buds responded to temperature and to cutting frequency with longer shoot growth resulting during the warmer months for each regrowth period.

Table 3. Yield and Quality for Various Harvest Schedules (averages of two locations for two years).

Days Between Cuttings	May		June		July		Aug.		Sept.	
	Yield	TDN	Yield	TDN	Yield	TDN	Yield	TDN	Yield	TDN
	(T/A)	%	(T/A)	%	(T/A)	%	(T/A)	%	(T/A)	%
22	1.39	52.7	1.49	51.2	1.51	50.3	1.52	50.9	1.20	52.2
26	1.56	52.4	1.76	50.4	1.84	49.4	1.74	49.9	1.26	52.4
30	1.92	52.2	2.13	50.0	2.01	47.7	1.79	49.8	1.32	52.2
34	1.79	51.5	2.07	48.1	2.31	47.1	2.05	49.5	1.40	51.4

Table 4 lists quality and yield data from constant interval harvest schedules and two varied interval harvest schedules. The results of this study indicate that by varying the cutting schedule during June or July for one season, it should be possible to keep TDN levels higher without appreciably affecting seasonal yields. Although hay will be of higher quality in the bud stage as compared to hay cut in the 1/10 bloom stage, cutting in the bud stage throughout the season will reduce total production by about 15%, increase weediness by 200%, and increase harvest costs by 1/3 (because of one or two more cuttings per season).

Table 4. Alfalfa Hay Yield, Quality, and Physiological Response to Different Harvest Schedules.

Days Between Cuttings	Yield from 5 cuttings[1]	TDN	Crown Bud Regrowth
	(Tons/Acre)	(%)	(inches)
22	7.11	51.5	0.2
26	8.16	50.9	0.5
30	9.17	50.4	0.6
34	9.62	49.5	1.1
30-22-22-22-30	7.76	51.4	
30-26-26-26-30	8.58	50.8	

[1]Averages for 5 cuttings at two locations for two years. (A full season includes 7 to 8 cuttings).

Alfalfa hay cut in the mid to late fall is of superb quality. Many growers are making silage from clippings taken 20-40 days after the last normal cutting date. Cutting can't be too early in the fall, or extensive regrowth will occur depleting root reserves prior to the first frost. This will weaken the stand, reducing productivity and allow weeds to invade. Sheep grazing should also follow that same principle. In the Imperial Valley

where frosts are rare, longer cutting intervals in December and January result in both high yields and high quality. Growers need to make sure the alfalfa plants are left with sufficient root reserves to be competitive during the winter. Therefore, fields should be harvested or grazed late in the fall when temperatures are cold so there is little or no opportunity for regrowth to occur to reduce root reserves, or harvest or graze early enough to allow for a minimum of 25-30 days of regrowth which will store enough root carbohydrates to provide vigor during the winter.

SUMMARY

The nutritive value of a forage is the consequence of the conditions of plant growth. Understanding how environmental conditions and management factors interact to influence forage quality is important in making production decisions. Properly scheduling harvest operations and irrigation, maintaining fertility, and controlling pests can all contribute to produce good quality hay, maintain high yields, and productive stands.

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