UNDERSTANDING THE ECONOMICS OF THE YIELD-QUALITY TRADEOFF

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ABSTRACT

Alfalfa harvest timing has a profound effect on forage yield and quality, as well as profitability. Unfortunately, yield and quality are inversely related. Yield increases but quality decreases as harvest is postponed. Producers must make the decision whether to aim for high forage quality to receive the premium price or to maximize yield but receive a lower price per ton. This paper provides information to assist growers with this decision. A simple equation is provided that can be used to compare the revenues obtained from two different harvest timings. In addition, historical price data for the different hay quality categories is presented for the last five years for Northern California and Fresno/Madera regions. These values are used to determine the yield increase that would be required to offset the reduced price for lower quality hay if harvest is postponed. Conversely, if harvest for yield is made another table illustrates how much yield could have been sacrificed if the grower had elected to cut for quality instead. The best option depends on market conditions that year and the price differential between the various categories.

Key Words: Alfalfa, *Medicago sativa*, harvesting, cutting management, forage quality, ADF, TDN, economics

INTRODUCTION

More attention is currently paid to alfalfa forage quality than ever before. A significant price premium is paid for high quality alfalfa. In fact, the effect of forage quality on hay price averaged $300 million dollars per year over the past five years (average difference in price between the highest and the lowest quality designations in California from 1996-2000). Unfortunately, high forage quality comes at a price to the grower—reduced yield.

The existence of a yield quality tradeoff for alfalfa is well known. Yield and quality are inversely related. Harvesting alfalfa at an immature growth stage (short interval between cuttings) results in relatively high forage quality, but low yields. Conversely, cutting alfalfa at a mature growth stage (long interval between cuttings) results in high yield but low forage quality. The grower must arrive at the proper compromise between yield and quality to maximize profit.

A concerted research effort over the past few years has focused on quantifying the yield/quality tradeoff for different environments. Alfalfa was harvested every two to four days over several cutting periods to determine the daily rate of change in yield and forage quality. Large differences were found between environments and seasons of the year. In general, the

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yield/quality tradeoff was most pronounced under warm environmental conditions—yield increased and quality decreased at more rapid rates. Changes in yield and forage quality occurred at a slower rate during the cooler times of the year (spring and fall) than in mid summer. Similarly, the rate of change in yield and forage quality is slower in the Intermountain region than in the Central Valley.

Understanding the yield/quality tradeoff and the effect of forage quality on price is important to maximize profit and for cutting management decisions. Given the existence of the yield/quality tradeoff, the decision of when to harvest alfalfa for maximum profits is not easy. Variations in market conditions from year to year further complicate cutting management decisions. The price differential between supreme and premium quality alfalfa and the lower grades depends on the supply and demand for dairy quality alfalfa and the current price for dairy products. Weather conditions that make it difficult to produce premium quality alfalfa can also widen the gap between premium and lower grades of alfalfa.

DECISION MAKING EQUATION

A decision-making tool was developed to compare gross returns for two different cutting times. Identifying which price/yield combination will generate the highest revenue is helpful to determine which strategy is more profitable for a given market situation.

The breakeven point for two cutting options is when the revenues for both cutting options are equal. It is assumed that costs for both cutting options are basically the same (there will however be slight differences due to yield—such as twine usage and time to harvest). Revenues are simply the yield multiplied by the price paid for a certain quality of alfalfa. Two harvest times can be evaluated by comparing the product of the yield and the price for the two harvest timings. Time 1 is when the yield still generates dairy quality hay (supreme or premium), time 2 is when yield has increased enough to exactly offset the lower price that will be received for the lower (good or fair) quality hay. The equation to express the breakeven point for two cutting timings in terms of price (P) and yield (Y) for two cutting times, time 1 (t1) and time 2 (t2), is as follows:

$$P_{t1} \cdot Y_{t1} = P_{t2} \cdot Y_{t2}$$

Manipulating this equation gives a decision rule to aid producers in deciding whether to cut at time 1 (for quality) or at time 2 (for yield). Expressed as a breakeven point, the relationship between price and yield is:

$$\textit{Price Differential} \quad \frac{P_{t1} - P_{t2}}{P_{t2}} = \frac{Y_{t2} - Y_{t1}}{Y_{t1}} \quad \textit{Yield Differential}$$

If the price differential equals the yield differential both cutting times would result in equal revenues. However, if the price differential (relative change in price from higher quality to lower quality) is greater than the yield differential (relative change in yield between the two

cutting times) it is better to cut for quality. Conversely, if the yield differential is greater than the price differential it is better to cut for yield.

An example will help illustrate how to apply this decision-making equation. First, in the year 2000 an alfalfa grower in the intermountain area of northern California wants to know whether it is better to aim for *Supreme* quality alfalfa or to delay harvest and produce *Premium* quality. He estimates his alfalfa would currently test 57 TDN, within the *Supreme* category. If this is the grower's first cutting he will get approximately 1.6 tons per acre, according to the yield/quality relationship described in Ackerly *et al*. The grower must decide whether to cut for quality and capture the *Supreme* price in Table 1 (P_{t1} = \$111.39) with a yield (Y_{t1}) of 1.6 tons, or wait until the yield increases enough to at least offset the lower price that will be received. To calculate the higher yield needed at time 2 to offset the lower price that will be received, the grower substitutes the current price for *Supreme* hay into the equation as P_{t1} and the current price for *Premium* quality hay as P_{t2}. Assuming that the market offers the average price for 2000 for hay in Table 1, P_{t2} is \$98.13. Calculating the left-hand side of the equation with these prices gives a price differential of 13.5%. This means to offset the 13.5% drop in expected price at time 2, the yield differential (increase) will have to be at least 13.5% of the current available yield. Thus, yield at time 2 will have to be at least 1.8 tons/acre (0.2 tons/A higher) to generate the same total revenue as cutting now for *Supreme* quality. Alfalfa yield increases approximately 80 lbs per day for the first cutting in the Intermountain region (Figure 1). This means that by delaying cutting 5 or more days the yield will exceed 1.8 and the grower is better off to produce *Premium* hay.

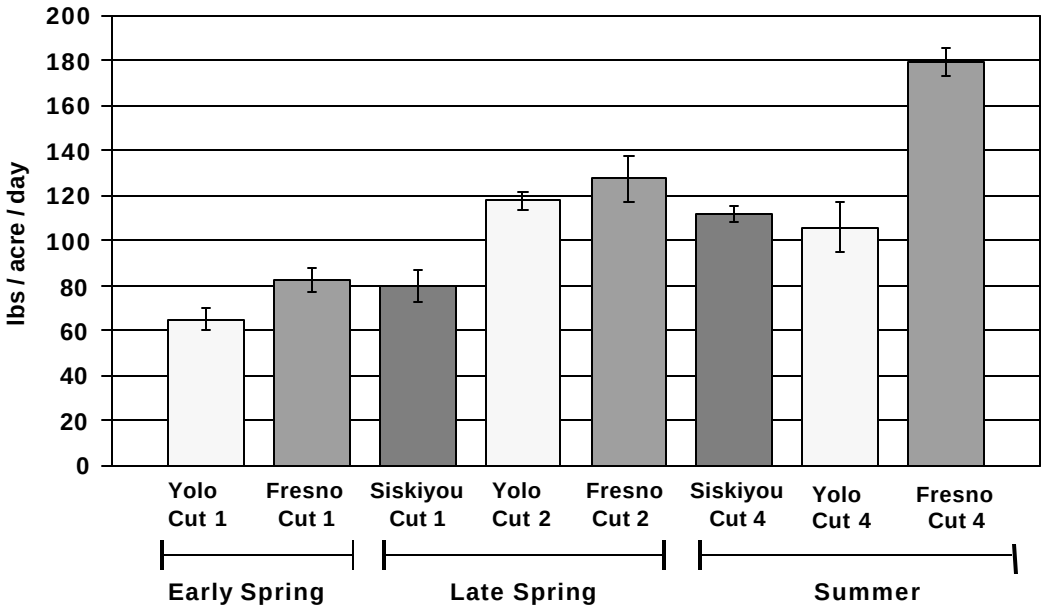

Figure 1. Daily changes in alfalfa yield (tons/acre/day) for early spring, late spring and summer cuts among the different California locations. Vertical bars indicate standard error. *Ackerly et al. 2000*

LIMITATIONS TO USING A DECISION RULE

The difficulty in using this approach is that it is predicated on knowing the current yield and forage quality. Then field data developed to predict the change in yield and quality over time is used to estimate the yield and forage quality at a later date. The problem is that oftentimes we do not have a reliable estimate of the current yield and quality of the standing crop. Another approach is to look at historical price levels. Using those prices levels we can make some simple economic comparisons to answer the question what is forage quality worth in different years. Or, on the other hand how much yield can be sacrificed for high forage quality. This will aid growers in estimating their optimum cutting times.

HISTORICAL PRICE LEVELS

The alfalfa market is not as volatile as the market for other higher value commodities, especially perishable fruits and vegetables. Nonetheless, there is significant variation in alfalfa price from year to year. In addition to overall fluctuations in price, the price differential between premium dairy quality hay and fair hay vary significantly. The fluctuations are great enough to make the difference which strategy is more profitable—aim for premium quality or aim for top yield. Average annual prices from 1996 to 2000 for the different hay quality categories are presented in Tables 1 and 2. The historic data provides an average annual alfalfa hay price for four distinct categories, defined by USDA and the California Hay Standards:

Supreme (>56 TDN; <27 ADF);
Premium (57-54.5 TDN; 27-29 ADF);
Good (52.5–54.5 TDN; 29–32 ADF);
Fair (50.5–52.5 TDN; 32–35 ADF).

The *Supreme* category was not created until 1999 so is not presented in the table until that year. Note that each category represents a grouping of forage quality. This paper uses alfalfa prices for northern California (the intermountain area) and for the western Fresno/Madera area of California as examples. They represent two distinct production and marketing areas for comparison purposes. A similar analysis could be performed for other areas using the appropriate data from the USDA Hay Market News Service.

Prices paid for *Premium* hay were higher in the Fresno/Madera area than in northern California in each of the five years. Over the 5-year time period the average annual price of *Premium* alfalfa hay was $114.27 in northern California and $125.38 per ton in western Fresno/Madera. Average price for the *Supreme* hay averaged over the two years was $110.84 and $127.70 for northern California and Fresno/Madera, respectively. Prices for *Good* and *Fair* quality hay were more similar between the two regions (Tables 1 and 2). As a result of these differences the price differential between *Premium* and *Fair* hay tended to be greater in the Fresno/Madera area than in northern California.

Table 1. Five-Year Historic Alfalfa Hay Prices in Northern California (1996–2000).

	Price by Quality Grade				Premium vs Fair	Premium vs Fair Differential
Year	Supreme	Premium	Good	Fair	Difference	
	----------$/ton----------					----%----
1996		118.81	108.63	95.47	23.34	24.4
1997		129.79	111.11	95.70	34.09	35.6
1998		127.34	106.40	84.77	42.57	50.2
1999	110.29	97.29	87.89	63.29	34.00	53.7
2000	111.39	98.13	89.57	72.97	25.16	34.5
Average	110.84	114.27	100.72	82.44	31.83	38.6

Source for prices: *Agricultural Marketing Service*. Difference and differentials were computed in this study.

Table 2. Five-Year Historic Alfalfa Hay Prices in the Western Fresno/Madera area of California's San Joaquin Valley (1996–2000).

	Price by Quality Grade				Premium vs Fair	Premium vs Fair Differential
Year	Supreme	Premium	Good	Fair	Difference	
	----------$/ton----------					----%----
1996		127.56	111.52	97.30	30.26	31.1
1997		148.33	125.71	113.53	34.80	30.7
1998		140.23	118.67	91.02	49.21	54.1
1999	128.18	101.78	74.24	65.77	36.01	54.8
2000	127.21	109.00	86.85	72.02	36.98	51.3
Average	127.70	125.38	103.40	87.93	37.45	42.6

Source for prices: *Agricultural Marketing Service*. Difference and differentials were computed in this study.

WHAT IS FORAGE QUALITY WORTH?

Using these historic price levels we can estimate how much forage quality is worth. More precisely, under the average market conditions for that year what percentage would yield have to increase to compensate for a reduced price received for a lower forage quality. These values are useful for choosing between a low-yield high-quality harvest and a high-yield lower-quality harvest. Based on your experience and the rate of yield increase presented in Figure 1, is it conceivable for yield to increase to the degree specified in Table 3? If it is likely that yield could increase to that degree or more then the better decision is to postpone cutting and go for yield. On the other hand, if that degree of yield increase is unlikely, it is better to cut early for quality. This is a simple approach, but it may be quite useful in practical terms to guide the harvest decision.

Let's consider a couple of examples in Table 3. Yield would have to be at least 10 percent higher than current yield levels for a grower in the intermountain area to consider not harvesting *Premium* quality hay and harvesting *Good* hay instead. A ten percent increase in yield is easily achievable. In contrast, yield of *Good* hay would have to be at least 37% more than the yield of *Premium* hay to consider delaying harvest in the Fresno/Madera area in 1999. A yield increase

of this magnitude is not likely. These types of comparisons help predict which option brings the highest returns.

Table 3. Minimum percentage yield increase necessary to compensate for the reduced price received as forage quality drops between hay-quality categories. As quality declines from high to low categories over a growth period, lowering price/ton, the yields must increase to compensate for this quality loss

Year	Supreme to Premium	Premium to Good	Good to Fair	Premium to Fair
	% yield increase required to achieve the same income as the higher quality hay			
Northern California (Intermountain)				
1996		9	14	24
1997		17	16	36
1998		20	26	50
1999	13	11	39	54
2000	14	10	23	34
Average	14	13	23	40
Fresno/Madera				
1996		14	15	31
1997		18	11	31
1998		18	30	54
1999	26	37	13	55
2000	17	26	21	51
Average	22	23	18	44

HOW MUCH YIELD CAN BE SACRIFICED FOR HIGH FORAGE QUALITY

The decision of when to harvest can also be viewed by asking this question: How much yield could I sacrifice if I were to cut early for quality instead of cutting at a normal time or later for yield. This type of analysis is presented in Table 4. For example, in the Intermountain area, for both years that the Supreme category was in existence, you could afford a yield loss of 12% if you decided to produce *Supreme* quality alfalfa hay instead of *Premium*. In the Fresno/Madera area where the price spread is greater you could afford no more than a 21 and a 14 percent yield reduction for the years1999 and 2000, respectively. By comparison, in the year 2000 you could only justify a 9% decrease in yield (or less) in the Intermountain area if you were considering producing *Premium* quality alfalfa hay instead of *Good* quality hay.

This same type of analysis could be used for other factors in addition to the cutting timing decision. It can be used for variety selection purposes. For example, the yield/quality tradeoff often exists for alfalfa varieties. Varieties with the highest forage quality are sometimes lower yielding and visa versa. This table can be used to assess how much yield you could sacrifice. For example, if you were confident that one variety of alfalfa would consistently be one forage

quality designation higher than another variety you can determine how much lower yielding it could be and still be a better choice. The values in Table 4 indicate that as long as the yield reduction was less than 10% you would be better off to select the variety with higher forage quality. However, if the higher forage-quality variety is over 10% lower yielding, for example 15 or 20% lower yielding, and the difference in forage quality was usually only one or 1.5 percentage point TDN, the wiser decision would be to plant the higher-yielding variety. Under many circumstances, yield is still economically more important than quality.

Table 4. Maximum percent yield reduction acceptable when cutting at a shorter interval to attain higher quality hay. Since harvesting earlier results in higher quality and higher price, some yield loss is acceptable. This chart provides guidance for acceptable yield losses for different market conditions.

	How much yield loss can you afford?			
Year	**Fair to Good**	**Good to Premium**	**Fair to Premium**	**Premium to Supreme**
	% yield reduction			
Northern California				
1996	-12	-9	-20	
1997	-14	-14	-26	
1998	-20	-16	-33	
1999	-28	-10	-35	-12
2000	-19	-9	-26	-12
Average	-19	-12	-28	-12
Fresno/Madera				
1996	-13	-13	-24	
1997	-10	-15	-23	
1998	-23	-15	-35	
1999	-11	-27	-35	-21
2000	-17	-20	-34	-14
Average	-15	-18	-30	-18

ASSUMPTIONS USED IN ANALYSIS

This type of analysis is useful to make a gross comparison of cutting strategies. However, the grower must also recognize the conditions and assumptions that were used. The hay prices utilized were based on data provided by the USDA Hay Market News. Local price data may differ. These values assume that price is determined solely by forage quality (ADF or TDN). There are other factors that affect price, especially for non-dairy hay. Such factors include the overall physical appearance (color and the presence of weeds or mold) and the suitability of the hay for the export or horse market. Additionally, some quality changes cause hay to become unsaleable, or more difficult to sell. If hay must remain in the barn unsold for periods of time, the economic penalty for low quality increases due to cash flow problems.

This analysis primarily focuses on the timing decision for an individual cutting. However, the timing of an individual alfalfa cutting changes the amount of growing time available for

subsequent cuttings. Therefore, to fully analyze different cutting management strategies it is preferable to consider the entire production season rather than just individual cuttings. In addition, this analysis does not account for the potential long-term effect of cutting date on stand persistence and weed encroachment.

CURRENT RESEARCH

Additional research is currently underway to further investigate cutting schedules and profitability over an entire growing season. Field studies in the intermountain area are designed to compare a staggered approach to cutting management to a traditional sequential harvest. Customarily, fields on a ranch are cut in the same sequence from one cutting to the next (sequential harvest). An alternative is under investigation where the cutting order is altered so that some fields are harvested at an immature stage for high quality while the harvest of others is delayed for higher yield giving the plants more time to replenish root reserves. The order is altered so that fields cut early one cutting are "given a rest" the next cutting and cut for yield. Another trial was just initiated at UC Davis to evaluate the effect of fall dormancy of a variety and cutting schedule on yield, quality and economic return. The varieties represent a range of fall dormancy scores from 4 to 10. This study will help answer the question whether it is more profitable to grow a more dormant variety with the intent of higher forage quality or produce a less dormant variety and cut more frequently. These studies should improve our understanding of cutting management practices to improve profits.

SUMMARY

There is no single best harvest strategy for all situations. Which approach is best depends largely on the market conditions at the time and the price spread between the different hay categories. A large price spread favors cutting for *Supreme* or *Premium* quality. In contrast, a low price spread, which often occurs in high-price years, favors cutting for yield, especially during summer months when the rate of yield increase and quality decrease is most rapid. While this type of analysis can be revealing, an understanding of the effect of cutting schedules on yield and quality over the entire growing season is preferable. Research is currently underway with this objective in mind in both the Intermountain Region and the Sacramento Valley.

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