

# QUANTIFYING THE YIELD/QUALITY TRADEOFF

Tracy Ackerly, Dan Putnam, and Steve Orloff<sup>1</sup>

## ABSTRACT

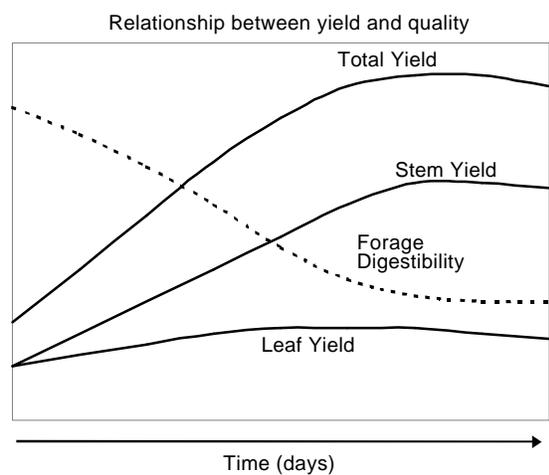
Generalized growth curves for yield and quality changes over time were developed for three California locations (the Intermountain region and the Sacramento and San Joaquin Valleys). Daily rates in change among the seasons and locations differed due to temperature and weather variations. Yield increased and quality decreased more rapidly in the late spring and summer cuts than in the early spring or fall. Also, yield increased and quality decreased more rapidly in the San Joaquin Valley than in the other two locations. Basing time of cutting on calendar dates or a 28-day cutting cycle ignores these seasonal and location changes in yield and quality. Knowledge of these changes may be helpful to growers in timing harvests to maximize both yield and quality.

**Key Words:** alfalfa, *Medicago sativa*, yield, forage quality, ADF

## INTRODUCTION

All alfalfa hay growers are confronted with a fundamental dilemma referred to as the yield /quality tradeoff. Simply stated, the yield/quality tradeoff means that while yield increases over time quality decreases. Cutting at an immature growth stage in order to make very high quality hay results in low yield. However, cutting at a more mature growth stage increases yield, but results in poor, often unacceptable forage quality. Obtaining maximum yield and high quality is not possible, as one can only be obtained at the cost of the other.

Increase in yield and decrease in quality as the alfalfa plant matures is attributed to physiological and morphological changes that occur in the leaf-to-stem ratio and stem lignification and elongation (Putnam et al, 2000). As alfalfa develops to advanced stages of maturity the amount of leaf material remains relatively unchanged, whereas the amount of stem material increases. Also, long days can increase the stem number per plant, stem diameter and or the internode length, which reduces the leaf-to-stem ratio while increasing yield (Mueller and Orloff, 1994). Stem lignification and elongation increase rapidly as the plant matures. All of these factors contribute to lower quality associated with plant growth and maturity.



<sup>1</sup>T. Ackerly, Graduate student, Dept. of Agronomy and Range Science, University of California, Davis, CA 95616; D. Putnam, Extension Forage Specialist, Dept. of Agronomy and Range Science, UC Davis; S. Orloff, UCCE Farm Advisor, Siskiyou Co, Yreka, CA. Published In: Proceedings, 2000 National Alfalfa Symposium, 11-12 December, 2000, Las Vegas, NV, UC Cooperative Extension, University of California, Davis.

We should expect that the changes in yield and quality will not be constant over seasons or even locations. When a grower bases the time of cutting on calendar dates or a 28-day cutting cycle, as is common in California, these seasonal and location effects are ignored. Although, decisions on cutting schedule are restricted by weather, irrigation, and labor schedules, harvest date is nevertheless one of the most powerful influences on profitability. Since missing the premium quality hay category by as little as half of a percent can mean a loss in value of up to \$70/ton, knowledge of the changes in yield and quality may be helpful for timing harvests across seasons and locations to maximize both yield and quality.

Studies were conducted in the Sacramento and San Joaquin Valleys and in the Intermountain region of California to quantify the tradeoff between yield and quality. The purpose of these studies was to develop generalized growth curves for yield and quality changes over time for a region. The data presented here may enable growers to make better harvest decisions to enhance profitability.

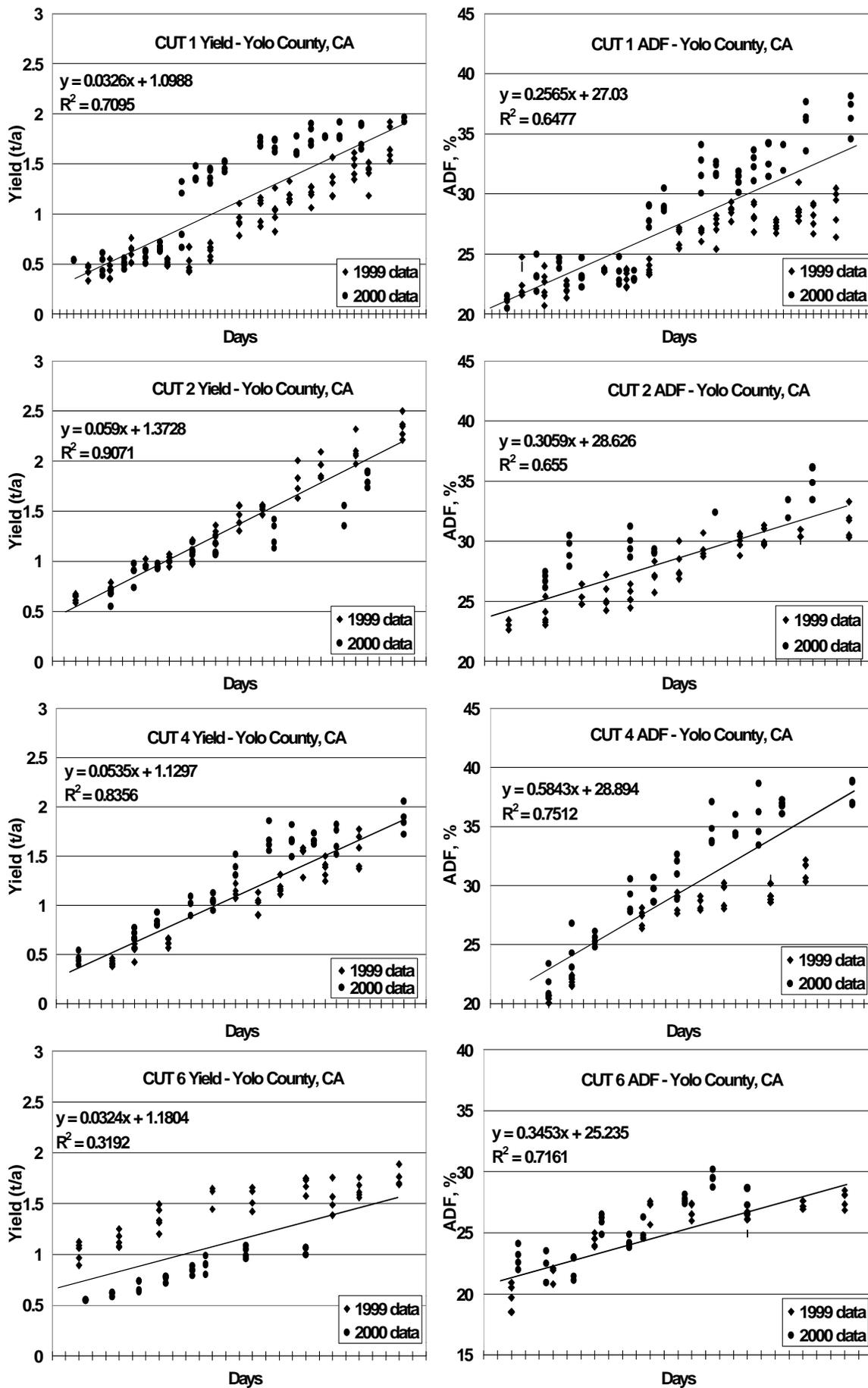
## **PROCEDURES**

Field trials were conducted on growers' fields to measure the relationships between date of harvest and alfalfa yield and quality. Experiments were carried out in two Intermountain valleys of Siskiyou County, CA (Scott Valley and Butte Valley 1996-1997), in the Sacramento Valley (Davis and Woodland, Yolo County, CA 1998-2000) and in the San Joaquin Valley (Kearney Agricultural Center, Fresno County, CA 2000). In Siskiyou County, Blazer XL and Archer were the alfalfa varieties used, representing a range in fall dormancy of 3 and 5, respectively. In the Sacramento Valley study, Royal (FD 7) was used the first year and Lobo (FD 6) the second year. Moapa 69 (FD 8) was used in the San Joaquin Valley.

Alfalfa was harvested every two to three days, for the first and second cuttings in the Intermountain locations and for the first, second, fourth, and sixth cuttings in the Sacramento and San Joaquin Valley locations. A randomized complete block design was used in all studies, with time as the randomized variable. Harvests began at the late vegetative pre-bud stage and continued to full bloom. A different area in the field was used for subsequent cuttings so as not to influence their yields by different previous cutting dates. Plots measuring 3 x 30 ft<sup>2</sup> were harvested with a flail-type plot harvester to determine yield for each harvest date. Each plot was sub-sampled using 6-8 randomly cut handfuls to calculate dry matter and measure forage quality. Maximum plant height (4 observations per plot) and maximum plant stage observations were recorded for the Sacramento and San Joaquin Valley locations. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein (CP) were determined using near infrared spectroscopy (NIRS) analysis, supported by wet chemistry.

## **RESULTS AND DISCUSSION**

Yield and quality changes for the four cuts in the Sacramento Valley of California (Yolo County) are shown in Figure 1. Yield and quality changes were similarly quantified in the Intermountain area (Siskiyou County) and the San Joaquin Valley (Fresno County) of California. Data from the trials in Yolo and Siskiyou Counties were averaged over two years.



**Figure 1.** Changes in yield (tons/acre/day) and quality (ADF, %) for cuts 1, 2, 4, and 6 averaged over two years for one site in this study, Yolo County, CA.

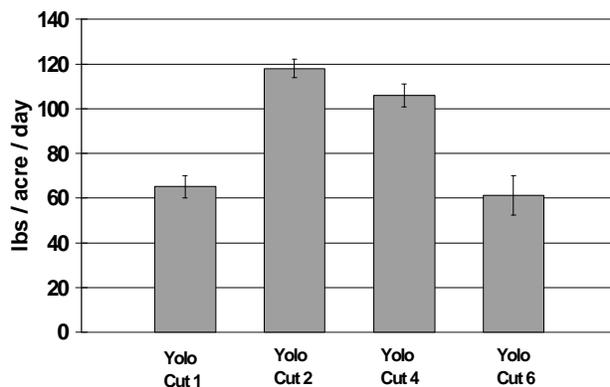
Weather conditions varied considerably among the years and caused significant differences in alfalfa development and rates of maturity at all sites. The differences in rates of maturity are reflected in the daily changes in yield and quality between the years (Figure 1). For example, in Yolo County, 2000 was generally warmer than 1999 for cuts 1, 2, and 4, hence, dry matter accumulation and forage quality decline were much more rapid in 2000. Although 2000 was much warmer than 1999, irrigation problems on the grower's field hindered growth during cut 2. 1999 however, was warmer than 2000 during the first half of the observation period for cut 6 and the subsequent increase in yield can be seen. During the Siskiyou County trials, the spring of 1996 was unseasonably cool and alfalfa development was delayed approximately 10 days to two weeks compared with 1997. This illustrates the problem with using calendar dates or 28-day cutting cycle to time harvests.

Although different varieties and different fields were used in the two-year trials, the intent was to quantify the changes in yield and quality, not to compare varieties or sub-locations within areas. Rather, they were included to develop robust relationships between time and yield and quality among the different California locations so that growers could predict changes in yield and quality in their fields.

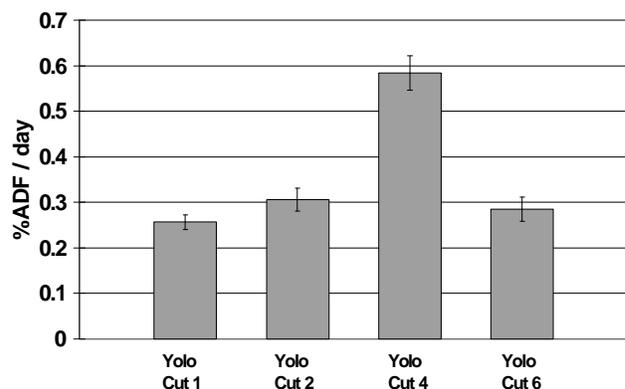
### Seasonal Differences

Daily rates of change in yield and quality differ between seasons at the same location (Figures 2 and 3). For example, in Yolo County, the daily increase in alfalfa yield as it matured from the late vegetative pre-bud stage to full bloom for cuts 1, 2, 4, and 6 were 65, 118, 106, and 61 lbs/acre/day, respectively. The late spring and summer cuts (cuts 2 and 4) had daily yield increases much greater than those of the early spring and fall cuts (cuts 1 and 6). This is due to the effects that longer days and higher temperatures have on alfalfa growth.

The daily increase in ADF content was greatest for cut 4 at 0.58% ADF/day, least for cut 1 at 0.25% ADF/day and about the same for cuts 2 and 6 at 0.30% ADF/day. This rapid decline in forage quality during cut 4 is due to faster maturity rates caused by hot summer temperatures. For cut 4 this rate of change equates to a loss of 1% point in ADF within less than two days. Therefore, a grower in Yolo County who waits 5 days to gain a ¼ ton in yield will sacrifice 3 percentage points in ADF (Figure 1). It's no wonder why it is so difficult to make dairy quality hay during the summer cutting and why most growers will choose to maximize yield during summer harvests.



**Figure 2.** Average daily change in alfalfa yield (lbs/acre/day) for cuts 1, 2, 4, and 6 for Yolo County, CA. Vertical bars indicate standard error.



**Figure 3.** Average daily change in ADF content of alfalfa for cuts 1, 2, 4, and 6 for Yolo County, CA. Vertical bars indicate standard error.

### **Location Differences**

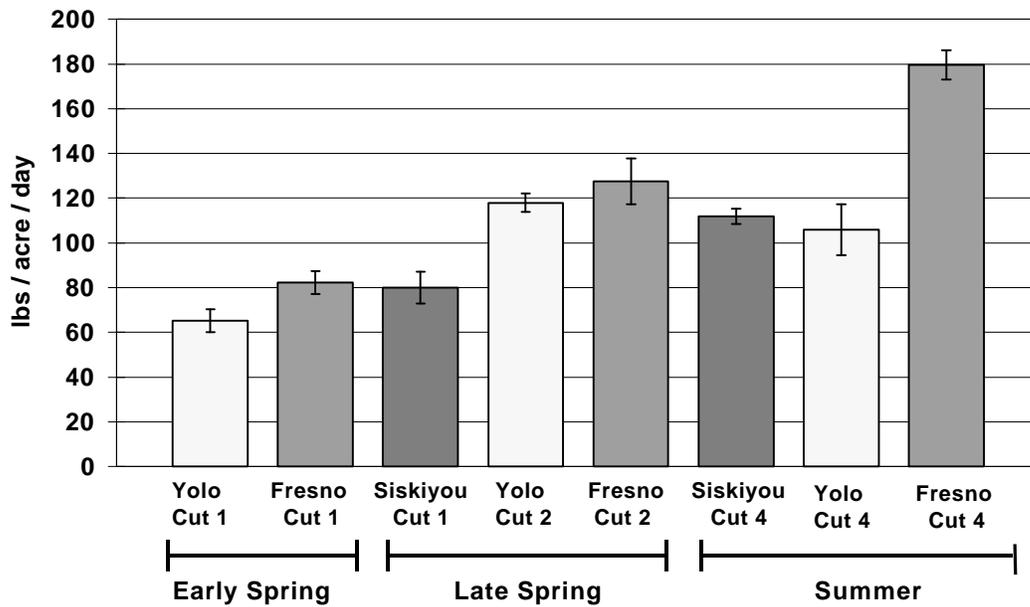
Rates of yield gain and quality decline differed significantly not only between seasons but also between locations (Figures 4 and 5). In the early and late spring cuts, alfalfa yields increased slowly due to cool weather. There was only a 17 lbs/acre/day difference between Fresno and Yolo Counties during the early spring harvest period. This difference was less than 10 lbs/acre/day for the late spring harvest due to the similar weather conditions in the two locations. However, in the late spring, the difference between Fresno County and the cooler Siskiyou County was close to 50 lbs/acre/day during this time. There was also a significant 40 lbs/acre/day difference in yield gain between Yolo and Siskiyou Counties during this time. Distinct yield differences between Fresno and Yolo Counties became apparent during the hot summer cut where Fresno yields increased 180 lbs/acre/day, whereas Yolo County gained 106 lbs/acre/day. Siskiyou County yields increased 112 lbs/acre/day during the second cutting that occurs in the mid-summer. Differences in growth rate are primarily due to environment, but variety is also important since growth rates are likely to be different for a FD 3 variety versus an 8.

Although yield increases for Fresno were only 10 lbs/acre/day more than Yolo for cut 2, the drop in quality was more than twice as fast in Fresno. The average daily change in Yolo was 0.3 % ADF versus 0.74 % ADF for Fresno. It is not fully clear why the quality decline is so much faster in Fresno. Growing degree days (base temperature of 41 degrees F) certainly affect growth and development and help explain a portion of the slight yield difference since Fresno averaged 150 more growing degrees per day than Yolo. It appears that nighttime temperatures and respiration may also help explain the rate of maturity and quality decline differences. In Fresno for instance, nighttime temperatures from 21 days to 33 days of regrowth averaged 15 degrees higher and twice reached over 20 degrees higher than in Yolo. The rates of maturity were different between sites; both bud and bloom stages were reached 7 days earlier in Fresno. When comparing cuts 2 and 4 in Fresno, well over 250 more growing degrees were accumulated per day during cut 4, thus explaining the large yield increase during that cut. However, both cuts showed the same rate of quality decline per day. Nighttime temperatures were about the same for both cuts and bud and bloom stages were reached at exactly the same number of days of regrowth, 25 and 32 respectively. Variety and agronomic factors such as soil and irrigation may also explain the differences between seasons and locations.

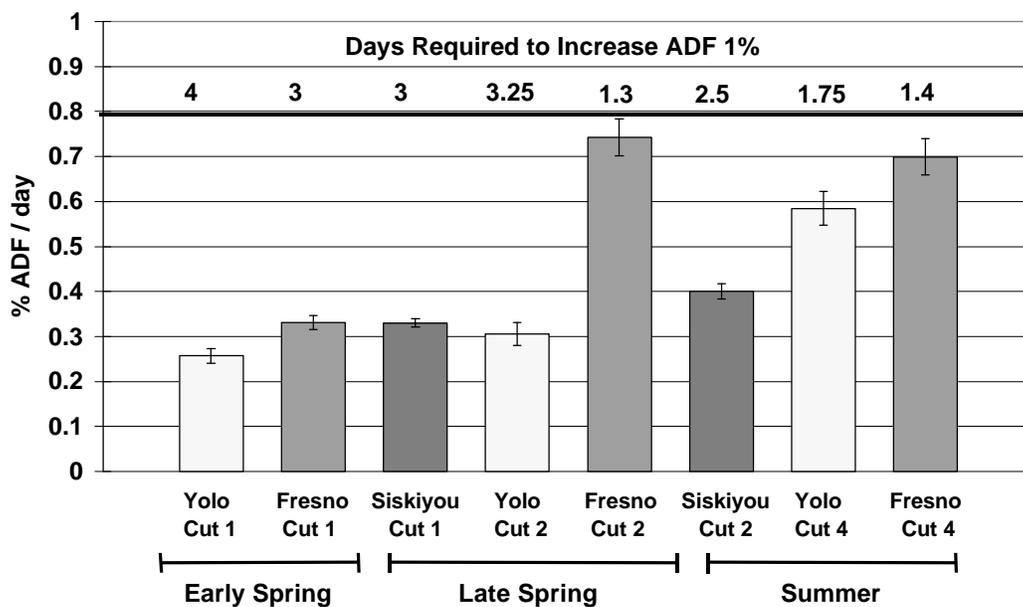
### **CONCLUSIONS**

Physiological and morphological changes that occur as an alfalfa plant develops and matures cause yield to increase and forage quality to decrease. Since alfalfa development and maturity is accelerated by increasing temperature and photoperiod a grower in Siskiyou County can expect approximately an 80 lbs/acre/day increase in the late spring and a 112 lbs/acre/day increase in the summer. In the late spring in Siskiyou, ADF will increase 1% in 3 days and in 2 ½ days in the summer. A grower in Yolo County however, can anticipate yields to increase about 65 lbs/acre/day in the early spring and fall and 115 lbs/acre/day during the late spring and summer. In Yolo, ADF will increase 1% in 3 days during the early spring, late spring, and fall and in only 2 days during the summer. A Fresno County grower can expect yields to increase 82 lbs/acre/day in the early spring, 127 lbs/acre/day in the late spring and 180 lbs/acre/day in the summer. In

Fresno, ADF declines 1% in 3 days during the early spring and in only 1½ days during the late spring and summer. Timing harvests by calendar dates or a 28-day cutting cycle does not consider these seasonal changes in yield and quality. Knowing the yield penalty for making dairy quality hay or the quality sacrifice for maximizing tonnage may enable a grower to make better harvest decisions and enhance profitability.



**Figure 4.** 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.



**Figure 5.** Daily changes in ADF content of alfalfa for the early spring, late spring, and summer cuts among the different California locations. Vertical bars indicate standard error.

## REFERENCES

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