RATE OF YIELD AND QUALITY CHANGE IN ALFALFA

Neal P. Martin, Geoffrey E. Brink, Marvin H. Hall, Glenn E. Shewmaker and Dan J. Undersander[1]

ABSTRACT

Cutting management investigations have documented the effects of harvest date and frequency on alfalfa (*Medicago sativa* L.) forage yield and quality during the production year; more frequent harvest generally reduces annual yield and increases quality. Information is needed on the change in forage quality relative to yield that occurs within individual harvest periods over the whole growing season. In spring, early summer, late summer, and fall, 'Standfast', 'WL 346', and 'Affinity' alfalfa were harvested at late vegetative stage in Idaho, Pennsylvania, and Wisconsin. Primary growth of each variety was harvested every 5 days thereafter to 20 days of maturity. At all sites, initial yield of the first cut was greatest for the first harvest period. In Idaho, yield increased 120 lb/acre/day during the first harvest period and 180 lb/acre/day during the second and third periods. In contrast, yield increased most rapidly during early harvest periods in Pennsylvania (first; 290 lb/acre/day) and Wisconsin (second; 250 lb/acre/day), but the rate of increase declined during the third (90 to 100 lb/acre/day) and fourth harvest (-20 to 40 lb/acre/day) periods. In Idaho and Pennsylvania, in vitro cell wall digestibility (NDFD) declined more slowly during the first harvest period than during later harvest periods, but in Wisconsin the rate of NDFD decline during the first harvest period was similar to or greater than later harvest periods. Acid detergent fiber (ADF) was not correlated with NDFD at any harvest period in Idaho. Our results suggest that because forage quality changes impact a larger proportion of the annual yield at first harvest, the decline in forage quality that occurs during the spring has a greater impact on feeding and cash value of hay than at any other time of the year.

Keywords: Alfalfa, *Medicago sativa*, forage, hay production, quality, fiber digestibility.

INTRODUCTION

The history of alfalfa harvest management research is a story of changing goals. Early research conducted in the Midwestern United States primarily addressed the effect of harvest frequency strictly on yield as it relates to persistence. Both Willard (1930) and Graber and Sprague (1938)

---

[1]N. Martin, U.S. Dairy Forage Research Center, USDA-ARS, Madison, WI 53706; G. Brink, U.S. Dairy Forage Research Center, USDA-ARS, Madison, WI 53706; M. Hall, Department of Crop and Soil Sciences, Pennsylvania State University, University Park, PA 16802; G. Shewmaker, Twin Falls R&E Center, University of Idaho, Moscow, ID 83844; D. Undersander, Department of Agronomy, University of Wisconsin, Madison, WI 53706; Email: npmartin@wisc.edu; gebrick@wisc.edu; mhh2@psu.edu; gshew@uidaho.edu; djunders@wisc.edu **In:** Proceedings, 2006 Western Alfalfa & Forage Conference, December 11-13, 2006, Reno, Nevada. Sponsored by the Cooperative Extension Services of AZ, CA, CO, ID, MT, NV, NM, OR, UT, WA, WY. Published by: UC Cooperative Extension, Agronomy Research and Extension Center, Plant Sciences Department, University of California, Davis 95616. (See http://alfalfa.ucdavis.edu for this and other alfalfa proceedings.)

found that increased harvest frequency reduced yield the following year even when alfalfa was cut at full bloom. As varieties with improved winter hardiness such as Vernal became available, it was found that harvest frequency could be increased from two to three cuts per season without impacting yield and persistence (Twamley, 1960). With the advent of more persistent varieties, the relationship between harvest management and forage quality expressed as nutrient yield began to receive more attention. Harvesting three times at first flower or 1/10 bloom before September 1 was recommended for maximum nutrient yield (Kust and Smith, 1961). A greater understanding of the effects of environment on plant survival suggested that alfalfa could be harvested four times per season to improve nutrient yield, although persistence could be negatively impacted (Matches et al., 1970). In California, Marble (1974) found that dormant alfalfa varieties were more productive than nondormant varieties when harvested at 33- and 42-day intervals.

Ultimately, the dietary requirements of the livestock being fed dictates how alfalfa should be harvested to obtain feed of a given quality (Brink and Marten, 1989). As alfalfa matures through several identifiable morphological stages (Kalu and Fick, 1981), feeding value declines with the rate of change being strongly influenced by temperature (Onstad and Fick, 1983). Thus, harvesting at more immature stages (vegetative to bud) dictates a shorter cutting interval. The widespread culture and utilization of alfalfa across regions differing in environment, and its marketing as a cash crop for animal feed requires a greater understanding of the relationship between forage yield and quality. Our objective was to determine the rate of change in forage quality relative to yield of alfalfa with increasing maturity for each harvest period.

METHODS

The experiment was conducted in southcentral Idaho near Kimberly on a Portneuf silt loam (coarse_silty, mixed, superactive, mesic Durinodic Xeric Haplocalcid), in central Pennsylvania near State College on a Hagerstown silt loam (fine, mixed, semiactive, mesic Typic Hapludalf), and in southcentral Wisconsin near Prairie du Sac on a Richwood silt loam (fine_silty, mixed, superactive, mesic Typic Argiudoll). 'Standfast', 'WL346', 'Affinity' alfalfa were seeded in the fall of 2003 (PA and WI) or the spring of 2004 (ID) at 20 lb/A in plots measuring 5 x 18' (ID), 6 x 15' (PA), or 5 x 16' (WI).

In the spring, early summer, late summer, and fall of 2004 (PA and WI) and 2005 (PA, WI, ID), alfalfa was cut initially at late vegetative stage (stage 2, Kalu and Fick, 1981; stem length > 12 inches; no buds, flowers, or seed pods). Different plots of each variety were cut every 5 days thereafter to 20 days of maturity. Forage yield and quality were measured for each harvest. Plots not harvested for yield and quality analysis for a particular harvest period were cut at 1/10 bloom. Forage samples from each sequential harvest were dried for 48 hr at 150 F and ground through a 1-mm Wiley mill screen before quality analysis by near infrared reflectance spectroscopy. Prediction equations for crude protein (CP), neutral detergent fiber (NDF), and neutral detergent fiber digestibility (NDFD) were developed after laboratory analysis of samples from one replicate from each location, harvest period, and year. Data were subject to analysis of variance and regression equations were developed using SAS.

RESULTS AND DISCUSSION

Despite differences in regrowth and dormancy, all three alfalfa varieties exhibited similar yield and forage quality responses as they matured during each harvest period after an initial cut at late vegetative stage. Total seasonal yield was not measured in this study, but these results are in general agreement with those reported by Putnam et al. (2005) in California. They found that cutting interval, which directly impacts maturity, had a stronger influence on yield and quality than did variety.

At all three locations, initial dry matter yield at late vegetative stage (day 0) was greatest during the first harvest period, and declined at successive harvest periods until the last harvest period when it increased (Table 1). Initial NDFD was also greatest during the first harvest period at the Pennsylvania and Wisconsin sites. These results support previous findings that digestibility of first-cut alfalfa is usually superior to that of later cuttings (Marten et al., 1988). Initial CP concentration at the first harvest period was however lower than at the second and third harvest periods in Idaho and Pennsylvania.

Table 1. Regression equations describing trends for the change in yield and quality of alfalfa harvested initially at late vegetative stage and every 5 days thereafter to 20 days of maturity during four harvest periods at three locations in 2005.

	Yield (lb/A)	R^2	NDFD (%)	R^2	CP (%)	R^2
Idaho						
1	y = 3990 + 120x	0.84	y = 55.8 - 0.3x	0.70	y = 26.8 - 0.2x	0.97
2	y = 1590 + 180x	0.93	y = 60.9 - 0.6x	0.98	y = 27.1 - 0.3x	0.86
3	y = 2110 + 180x	0.95	y = 54.3 - 0.5x	0.98	y = 28.2 - 0.4x	0.92
4	-		-		-	
Pennsylvania						
1	y = 2640 + 290x	0.79	y = 59.4 - 0.2x	0.49	y = 24.8 - 0.1x	0.83
2	y = 1340 + 60x	0.93	y = 56.1 - 0.7x	0.88	y = 26.5 - 0.4x	0.84
3	y = 720 + 100x	0.99	y = 53.1 - 0.2x	0.59	y = 28.5 - 0.3x	0.98
4	y = 930 + 40x	0.58	y = 40.5 - 0.4x	0.83	y = 23.7 - 0.2x	0.86
Wisconsin						
1	y = 3240 + 130x	0.97	y = 58.3 - 0.4x	0.79	y = 26.1 - 0.3x	0.92
2	y = 1790 + 250x	0.91	y = 51.2 - 0.3x	0.44	y = 21.9 - 0.1x	0.30
3	y = 1760 + 90x	0.96	y = 52.4 - 0.4x	0.59	y = 24.8 - 0.3x	0.97
4	y = 2360 - 20x	0.85	y = 49.2 - 0.4x	0.88	y = 23.7 - 0.2x	0.93

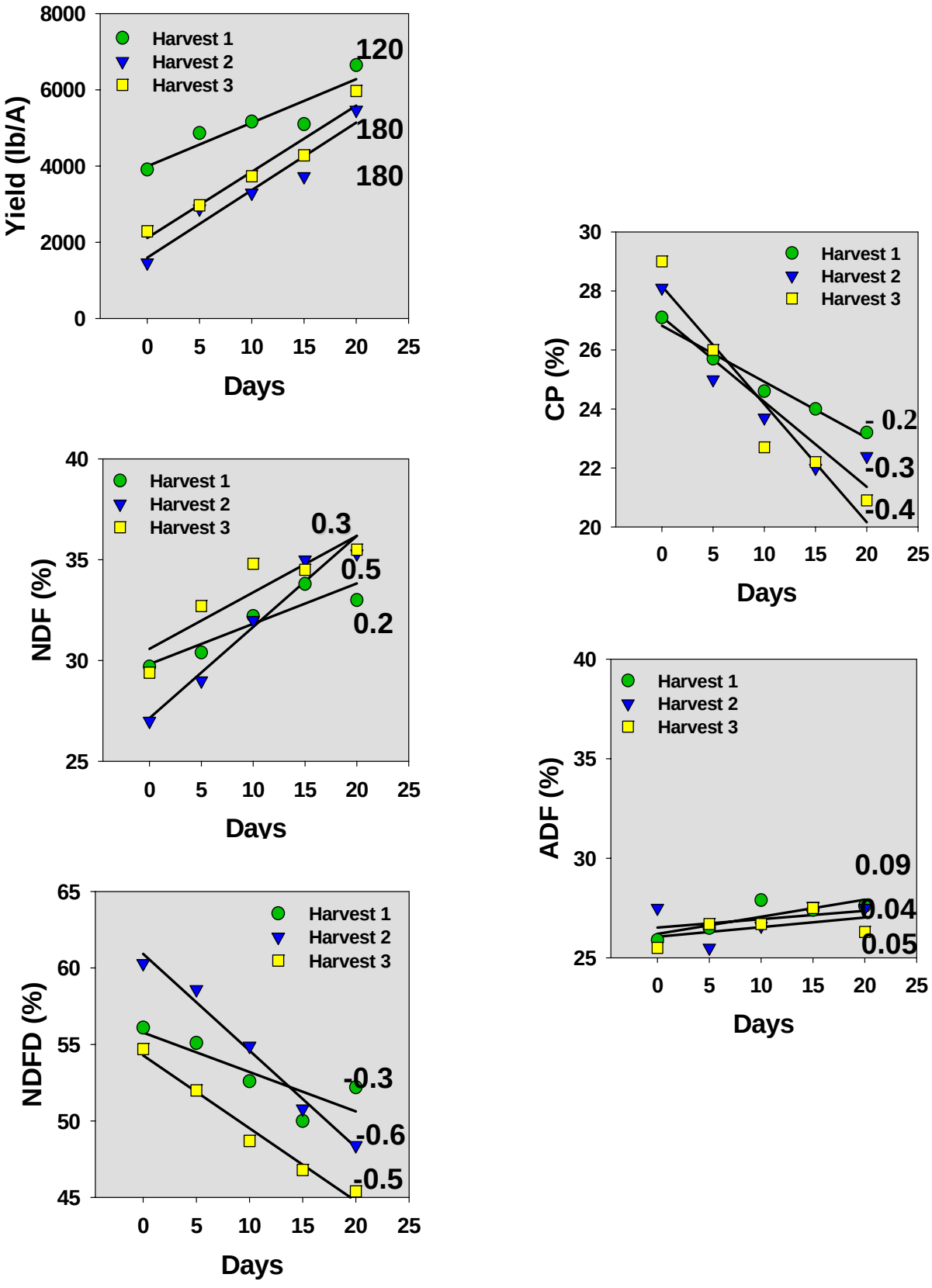

Figure 1. Rate of change of yield and forage quality within harvests in Idaho, 2005.

Yield. Yield increased more rapidly in Idaho during the second and third harvest periods of 2005 than during the first harvest period, increasing a mean of 180 lb/acre/day compared to 120 lb/acre/day (Fig. 1). In Pennsylvania and Wisconsin, however, yield increased most rapidly during the first and second harvest periods (290 and 250 lb/acre/day, respectively). Growing conditions during the spring and early summer in the east and Midwest are generally more favorable than in the summer when temperatures are higher and soil moisture may be limiting. During the fall, declining day length and temperatures account for the fact that the rate of dry matter accumulation after the initial cutting is lowest during the fourth harvest period (Table 1).

Forage quality. Previous investigations have reported that the decline in alfalfa forage quality is more rapid in the summer than in the spring because higher temperatures increase the rate of morphological development (Marten et al., 1988). Results from Idaho and Pennsylvania support those findings, where both NDFD and CP concentration declined more rapidly during later harvest periods than during the first (Table 1, Fig. 1). In Wisconsin, however, the rate of decline in NDFD and CP during the second, third, and fourth harvests periods was similar to or less than the first harvest period, indicating the need to carefully monitor changes in quality during all harvest periods.

Acid detergent fiber (ADF) is used extensively in the West to assess forage quality and predict energy concentration for use in dairy diets (Robinson, 2005). University of California Davis recommends forage energy predictions for alfalfa hay that use either ADF or NDF to predict either TDN or NE_L. The rate of increase within harvests over all harvest periods differed for ADF and NDF in Idaho, Fig 1. ADF increased slower than NDF. Acid detergent fiber was not correlated to NDFD at either harvest period in Idaho, (R^2 of -0.18, -0.08 and -0.13 for spring, early summer and late summer harvests). However, a significant negative correlation was determined at all harvests in Pennsylvania and Wisconsin (R^2 of -0.67, -0.51, -0.35 and -0.59 for four harvest periods in Pennsylvania and -0.87, -0.79, -0.87 and -0.82 for each harvest period in Wisconsin, respectively). Even though ADF concentration did not change over 20 days after first harvest within 3 seasonal harvests in Idaho, digestibility declined over each 20 day period. Testing alfalfa hay for fiber digestibility is needed, especially in Idaho.

Forage quality index. Relative forage quality (RFQ) is an index used for legumes and grasses based on potential intake and fiber digestibility (Undersander and Moore, 2002). The index is used to price forage and to allocate forage to appropriate ruminant livestock performance levels. Averaged over all sites in 2005, RFQ dropped 4.5, 4.1, 4.6 and 3.7 units per day for spring, early summer, and late summer and fall harvests, respectively. In Idaho, RFQ dropped an average of 2.2, 5.3 and 3.3 units for spring, early summer and late summer, respectively.

CONCLUSIONS

Due to known differences in climate and cultural practices (the use of irrigation at the Idaho site), location differences in the rate of dry matter accumulation and forage quality decline among harvest periods were expected. A finding common to all locations was that initial yield was greatest at the first harvest period. Whether the rate of decline in forage quality during the first harvest period is greater or less than that for subsequent harvests, a larger proportion of the annual yield is negatively impacted, particularly in more temperate areas where irrigation is not

available. Harvest management considerations are thus most critical for the first harvest period. Testing for fiber digestibility detected greater differences in quality decline at all three locations.

REFERENCES

Brink, G.E. and G.C. Marten. 1989. Harvest management of alfalfa - nutrient yield vs. forage quality and relationship to persistence. J. Prod. Agric. 2:32_26.

Graber, L.F., and V.G. Sprague. 1938. The productivity of alfalfa as related to management. J. Am. Soc. Agron. 30:38-54.

Kalu, B.A., and G.W. Fick. 1981. Quantifying morphological development for studies of herbage quality. Crop Sci. 21:267–271.

Kust, C.A., and Dale Smith. 1961. Influence of harvest management on the level of carbohydrate reserves, longevity of stands, and yield of hay and protein from Vernal alfalfa. Crop Sci. 1:267-269.

Marble, V.L. 1974. How cutting schedules and varieties affect yield, quality, and stand life. p. 47-57. *In* Proc. 4th California Alfalfa Symp. Fresno, CA. 4-5 December. Cooperative Extension, University of California, Davis.

Marten, G.C, D.R. Buxton, and R. F Barnes. 1988. Feeding value (forage quality). p. 463-492. *In* Hanson et al. (eds.) Alfalfa and alfalfa improvement. Agronomy monograph no. 29. ASA-CSSA-SSSA, Madison, WI

Matches, A.G., W.F. Wedin, G.C. Marten, Dale Smith, and B.R. Baumgardt. 1970. Forage quality of Vernal and Dupuits alfalfa harvestee by calendar date and plant maturity schedules in Missouri, Iowa, Wisconsin, and Minnesota. University of Wisconsin, College of Agricultural and Life Sciences, Res. Rep. 73.

Onstad, D.W., and G.W. Fick. 1983. Predicting crude protein, in vitro true digestibility, and leaf proportion in alfalfa herbage. Crop Sci. 23:961-964.

Putnam, D.H., S.B. Orloff, and L.R. Teuber. 2005. Strageties for balancing quality and yield in alfalfa using cutting schedules and varieties. *In* Proc. 35th California alfalfa and forage symposium. 12_14 December 2005, Visalia, California. Dept. Agron. and Range Sci. Cooperative Extension, Univ. of California, Davis, CA.

Robinson, P. H. 2005. The changing role of forage fiber in dairy rations. P. 185-194. *In* Proc. California Alfalfa and Forage Symp. Visalia, CA. 12-14 December. UC Cooperative Extension, Agronomy Research and Extension Center, Plant Sciences Department, University of California, Davis, CA.

Twamley, B.E. 1960. Variety, fertilizer, management interactions in alfalfa. Can. J. Plant Sci. 40:130-138.

Undersander, Dan and Moore, John E. 2002. Relative feed quality (RFQ) indexing legumes and grasses for forage quality. Cooperative Extension, University of Wisconsin. June, p3. http://www.uwex.edu/ces/forage/pubs/rfq.htm

Willard, C.J. 1930. Root reserves of alfalfa with special reference to time of cutting and yield. Agron. J. 22:595-6