DAILY CHANGES IN ALFALFA FORAGE QUALITY

Glenn E. Shewmaker and Hank Mayland[1]

ABSTRACT

Several studies are reviewed which relate the daily variation in total nonstructural carbohydrates (TNC) to hay quality, implications for animal preference studies and hay tests, forage intake by animals, and resulting animal production. From these results we conclude that TNC concentrations in alfalfa can increase linearly during the day. Alfalfa forage samples taken for animal preference or TNC analyses should be taken within 1h to control daily variation within 5%. We estimate 136 (first cutting) and 81 lbs TNC/ac (fourth cutting) increase by PM- versus AM-cutting. Increasing windrow width in heavy hay from 48 to 60 in windrow allows for faster dry-down, however in light hay increased windrow width is not necessary. The "super conditioner" may provide faster dry-down of alfalfa hay in some conditions.

Key Words: alfalfa, hay quality, super conditioner, windrow width

INTRODUCTION

Alfalfa accumulates total nonstructural carbohydrates (TNC) during daylight because photosynthesis produces TNCs more rapidly than they are exported and utilized for new growth and maintenance. The TNCs are composed of starch, fructans, sucrose, glucose, and fructose. Continued plant respiration during darkness depletes TNC concentration. Our objectives in Study 1 were to: 1) determine daily variation of carbohydrate concentrations and accumulation rates in Alfalfa (*Medicago sativa* L.), 2) predict a time interval within which samples collected for TNC analysis or animal preference can be compared effectively without confounding with the time-of-day effect, 3) estimate impact of PM cutting on TNC yield. Study 2 objectives were to evaluate effects of windrow width and conditioner type on alfalfa hay moisture.

Diurnal variation of TNC in alfalfa has been reported (Lechtenburg et al. 1971; Putnam et al. 1998), however, the application of this knowledge to forage quality and animal preference studies is largely ignored. It is disconcerting to ponder the number of studies in which the results may have been confounded by harvesting at different times during the day. Cattle, sheep, and goats can distinguish between alfalfa hay harvested at sundown versus the next morning (Fisher et al. 1998) and they eat 30% more PM- than AM-harvested hay. The PM-harvested hay also translates into increased milk production (Kim 1995).

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[1] G.E. Shewmaker, Extension Forage Specialist, University of Idaho, Twin Falls R & E Center, Box 1827, Twin Falls, ID 83303-1827; H.F. Mayland, Soil Scientist, USDA-ARS, Northwest Irrigation and Soils Research Laboratory, 3793 N 3600 E, Kimberly, ID 83341; Published **In**: Proceedings, 29th California Alfalfa Symposium, 8-9 December, 1999, Fresno, CA, UC Cooperative Extension, University of California, Davis.

PROCEDURES

Study 1

Germain 'WL 322HQ' alfalfa was sampled at 3-h intervals during the 24-h periods prior to and after cutting. A 4-ha grower's field near Kimberly, ID was sampled along a transect midway in the field and perpendicular to irrigation furrows. Sampling by compositing 10 grab-samples per plot immediately preceded first and fourth cuttings in 1997. The TNC concentrations were predicted by Near Infrared Reflectance Spectroscopy (NIRS). The calibration of TNC was determined by an adaptation (Fisher and Burns 1987) of the wet chemistry method described by Smith (1969).

Study 2

Drying rate of alfalfa cut by identical swathers with a standard conditioner versus a "super conditioner"[2] (Circle C Equipment, Hermiston, Oregon) were compared as well as 48 versus 60 in. windrow widths. 'Pioneer 5364' alfalfa (third year of production) was grown at the Northwest Irrigation and Soils Research Laboratory, USDA-ARS, Kimberly, ID. Swathers were 1475 New Holland 'Haybine' on hydro-swing frames, and model 2300 header 14-ft cut. Swathers were pulled at 5 mph and powered by a minimum of 88 hp tractors with 540-rpm PTO hydraulic pumps. The standard conditioner has twin rubber chevron rollers, 2.59 m (8.5 ft or 102 in). The "super conditioner" has the same width rollers but the surface is flatter and not interwoven compared to the standard conditioner. Air cells apply high pressure to the rollers and flatten the entire stem (Cook 1998). First cutting was swathed from 3:30 to 6:00 pm (PM treatment) on 11 June 1999 and from 6:30 to 8:00 am (AM treatment) on 12 June 1999. The "super conditioner" had a 9 in diameter air cell with 35 psi producing about 2,500 lbs of force on each side of the rollers. There were no PM vs AM treatments for the third cutting. Third cutting was swathed from 3:45 to 5:10 pm 13 Sept. 1999. The "super conditioner" used during third cutting had a 7 in diameter air cell with 65 psi producing about 2,230 lbs of force on each side of the rollers. Each block was cut within 1 h to minimize time of day effect on total nonstructural carbohydrates (TNC).

An initial 500 g fresh sample was taken from each block, weighed, frozen, and stored in a plastic bag. A minimum of 8 grab samples (10 paces apart, 300-500 g fresh) per windrow was taken from the windrow at 3 pm each day following until baled. The 100 ft of windrow adjacent to each end of the field was avoided to allow the swathers to reach consistent conditioning and ground speeds. The conditioner and width treatments were completely randomized with four blocks.

Moisture content of each sample was determined by comparison of fresh weight with the weight after drying by freeze-drying (initial and final samples) or oven drying at 60° C 48 h or until samples did not change in weight. The formula used was: (fresh weight - dry weight)/(fresh weight).

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[2]Mention of a trade name does not imply an endorsement or recommendation by the University of Idaho or USDA over similar companies or products not mentioned.

RESULTS

Study 1

The TNC curves were sinusoidal over a 24-h period (Figure 1), but linear between 0900 MDT (Figure 2) and about 1800 h. On May 26 the TNC increased linearly from 58 g kg^{-1} dry matter (DM) at 0900 (harvest hour = 0) to 2100 MDT at the rate of 2.9 g TNC kg^{-1} DM h^{-1} (r^2 = 0.90). This is a 159% increase in alfalfa TNC concentrations from AM to PM. We estimate that by delaying cutting from 9 am to 7 pm would produce 136 more lbs TNC/ac for first cutting, assuming 2 ton/ac yield. On Sept. 22 the TNC increased linearly from 54 g kg^{-1} DM at 0900 (harvest hour = 0) to 1930 MDT at the rate of 4.6 g TNC kg^{-1} DM h^{-1} (r^2 = 0.88). This was a 200% increase in TNC concentration from AM to PM. We estimate 81 more lbs TNC/ac advantage for PM versus AM cutting for fourth cutting, assuming 3/4 ton/ac yield.

From these results, we conclude that TNC concentrations in alfalfa can increase linearly during the day. Alfalfa forage samples taken for animal preference or TNC analyses should be taken within 1h to control diurnal variation within 5%. The replication effect should account for some of the diurnal variation if harvests or grazing trials are completed within 1 h. Alternatives would be to use time of day as a covariate or develop a regression equation to correct TNC for time of day under your environmental conditions.

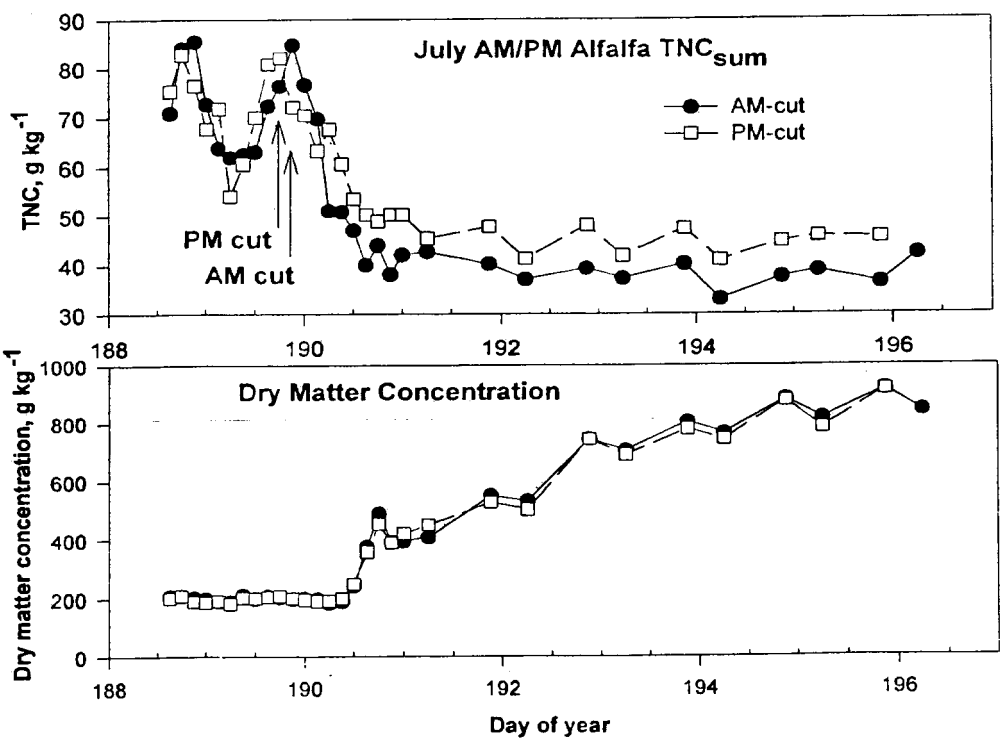

Figure 1. Daily variation in total nonstructural carbohydrate concentration and dry matter concentration and effects of PM- versus AM- cutting. The study was conducted near Kimberly, ID during July 1997.

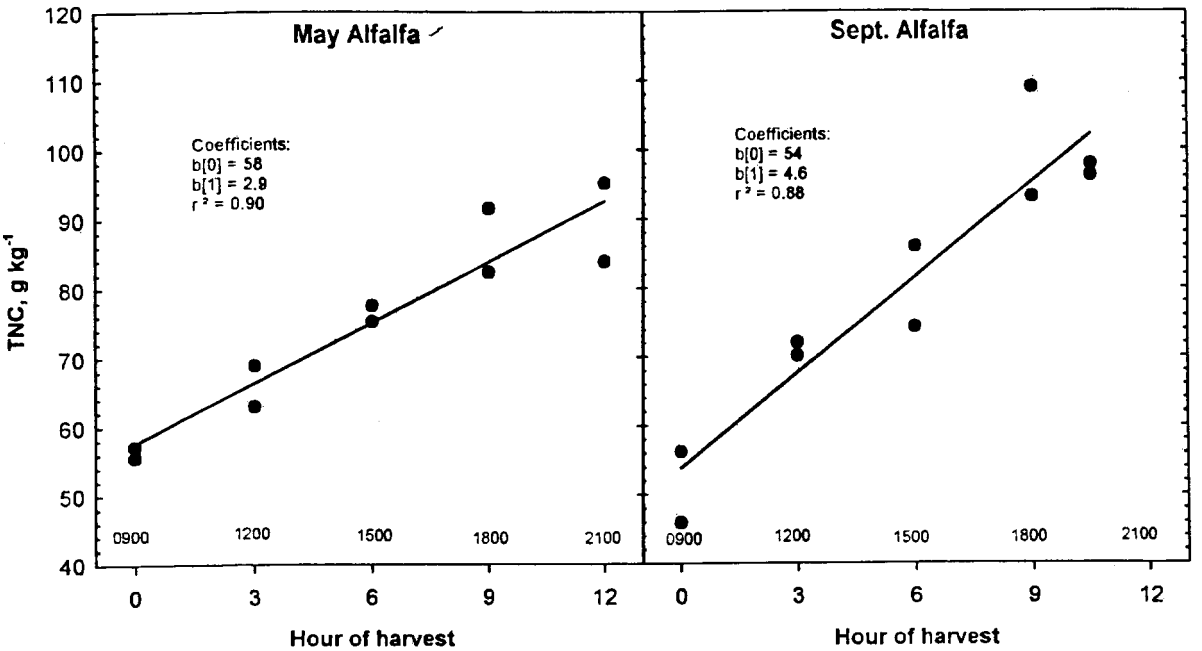

Figure 2. Daily variation of total nonstructural carbohydrates (TNC) in 'WL 322HQ' alfalfa at Kimberly, ID in May and September of 1997. The curves are sinusoidal over a 24-h period, but linear between 0900 (harvest hour = 0) and about 1800 MDT.

Study 2

Alfalfa hay moisture was unaffected by conditioner type in first cutting, however the "super conditioner" reduced hay moisture significantly over the standard conditioner in third cutting (Figure 3). The 60-in wide swath allowed hay to dry faster than the 48-in wide swath during first cutting, but swath width was not significant in third cutting. It should be noted that both first and third cuttings were done at bloom stage because the buyer's goals were to maximize yield and have feeder quality hay for wintering beef cows. Thus first cutting yields were about 3 ton/ac and windrow width was significant even after hay was rained on two days after cutting. Humidity averaged 47% during the hay drying period for first cutting. Third cutting yields were about 1 ton/ac and temperatures were unusually warm with no dews, so there was no advantage to extending the windrow width to 60 inches.

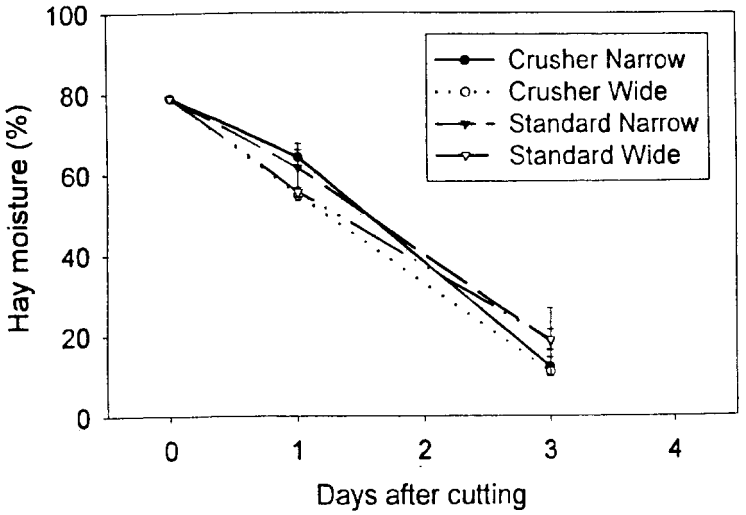

Figure 3. First cutting alfalfa moisture as affected by conditioner type ("crusher" or super conditioner by Circle C. Equipment, Hermiston, OR, or standard New Holland 2300 header) and windrow width (narrow = 48 inches wide, wide = 60 inches wide). Study conducted near Kimberly, ID 11-15 June 1999. Swathers were New Holland 1475 Haybine swathers with 14 ft cut.

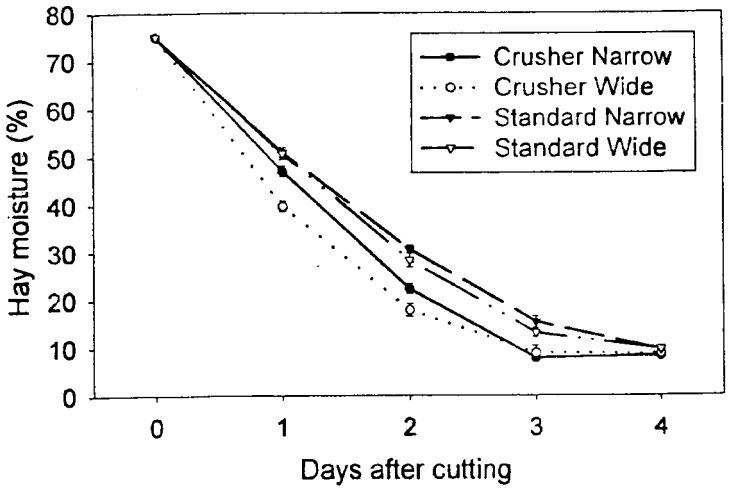

Figure 4. Third cutting alfalfa moisture as affected by conditioner type ("crusher" or super conditioner by Circle C. Equipment, Hermiston, OR, or standard New Holland 2300 header) and windrow width (narrow = 48 inches wide, wide = 60 inches wide). Study conducted near Kimberly, Idaho 13-20 Sept. 1999. Swathers were New Holland 1475 Haybine swathers with 14 ft cut.

CONCLUSIONS

- There is daily cycling in forage quality and this is important to consider when testing forage or testing animal preference or intake of forage.
- We estimate 136 (first cutting) and 81 lbs TNC/ac (fourth cutting) increase by PM- versus AM-cutting.
- Increasing windrow width in heavy hay from 48 to 60 in windrow allows for faster dry-down, however in light hay increased windrow width is not necessary.
- The "super conditioner" may provide faster dry-down of alfalfa hay in some conditions.
- The PM-cut hay quality is greater than AM-cut.
- Ruminants prefer PM- to AM-cut hays.
- Ruminants eat more PM-cut than AM-cut hay.
- More milk is produced when fed 40% of a totally mixed ration as PM-cut alfalfa versus AM-cut alfalfa.
- Increased forage quality appears on forage test.
- A decrease of 1% ADF is worth @ $10 to 15/ton at today's prices for premium alfalfa hay.

REFERENCES

Cook, I.J. 1998. Effect of harvest technique on alfalfa drying time. P. 211-220. *In* Proc. California/Nevada Alfalfa Symposium, Reno, NV. 3-4 Dec. 1998. Agronomy and Range Sci. Dept., Univ. California--Davis.

Fisher, D.S., and J.C. Burns. 1987. Quality of summer annual forages. I. Sample preparation methods and chemical characterization of forage types and cultivars. Agron. J. 79:236-242.

Fisher, D.S., H.F. Mayland, and J.C. Burns. 1998. Ruminant preference for alfalfa hay harvested in the afternoon. Agron. Abstr. P. 149, also J. Dairy Sci. 81:suppl. #1, p. 194.

Kim, D. 1995. Effect of plant maturity, cutting, growth stage, and harvesting time on forage quality. Ph.D. Dissertation. Utah State Univ., Logan, UT.

Lechtenburg, V.L., D.A. Holt, and H.W. Youngberg. 1971. Diurnal variation in nonstructural carbohydrates, *in vitro* digestibility, and leaf to stem ratio of alfalfa. Agron. J. 63:719-724.

Putnam, D., S. Mueller, D. Marcum, C. Frate, C. Lamb, M. Canevari, B. Balance, R. Kallenbach, S. Orloff, and F. Denison. 1998. Diurnal changes in alfalfa forage quality. p. 31-39. *In* Proc. California/Nevada Alfalfa Symposium, Reno, NV. 3-4 Dec. 1998. Agronomy and Range Sci. Dept., Univ. California--Davis.

Smith, D. 1969. Removing and analyzing non-structural carbohydrates from plant tissues. Res. Rep. 41. College of Agricultural and Life Sciences, University of Wisconsin, Madison.

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