Increased Sugar Concentration with PM-Cutting and Wide Swathing Improves Alfalfa Silage Fermentation

Gaëtan F. Tremblay
Agriculture and Agri-Food Canada, Canada

Chantale Morin
Agriculture and Agri-Food Canada, Canada

Gilles Bélanger
Agriculture and Agri-Food Canada, Canada

Annick Bertrand
Agriculture and Agri-Food Canada, Canada

Yves Castonguay
Agriculture and Agri-Food Canada, Canada

See next page for additional authors

The 22nd International Grassland Congress (Revitalising Grasslands to Sustain Our Communities) took place in Sydney, Australia from September 15 through September 19, 2013.

Proceedings Editors: David L. Michalk, Geoffrey D. Millar, Warwick B. Badgery, and Kim M. Broadfoot

Publisher: New South Wales Department of Primary Industry, Kite St., Orange New South Wales, Australia

Presenter Information

Gaëtan F. Tremblay, Chantale Morin, Gilles Bélanger, Annick Bertrand, Yves Castonguay, Réal Michaud, Robert Berthiaume, and Guy Allard

Increased sugar concentration with PM-cutting and wide swathing improves alfalfa silage fermentation

Gaëtan F Tremblay [A], Chantale Morin [AB], Gilles Bélanger [A], Annick Bertrand [A], Yves Castonguay [A], Réal Michaud [A], Robert Berthiaume [C], and Guy Allard [B]

[A] Agriculture and Agri-Food Canada, Soils and Crops Research and Development Centre, Québec, QC, Canada
[B] Université Laval, Québec, QC, Canada
[C] Valacta, Sainte-Anne-de-Bellevue, QC, Canada
Contact email: rberthiaume@valacta.com

Keywords: Time of cutting, swathing, carbohydrates, alfalfa silage.

Introduction

Extensive protein degradation during silage fermentation reduces the efficiency of N utilization by ruminants and excess N is excreted in the environment. Forage nonstructural carbohydrates (NSC) represent the main source of readily fermentable energy for lactic bacteria during silage fermentation. Increasing forage NSC concentration can enhance silage fermentation, lactic acid production, and the decline in pH with an overall reduction in the extent of protein degradation.

The NSC concentration increases during the day in alfalfa (*Medicago sativa* L.) to reach a maximum by the end of the afternoon. Under good wilting conditions, PM-cut alfalfa wilted in wide swaths had a greater NSC concentration than AM-cut alfalfa (Morin *et al*. 2012). Our objective was to study the effect of PM cutting and wide swathing on alfalfa silage quality attributes.

Methods

Laboratory silo experiment

Alfalfa (cv. AC Caribou) was sown in 2006 at the experimental farm of Agriculture and Agri-Food Canada in Lévis, Canada (46º48'N; 71º23'W). In 2008, at the early flowering stage of development, 12 alfalfa plots (2 × 12 m) were cut using a sickle-bar mower either in PM (1800 h) or AM (0800 h), raked by hand in narrow (0.9 m) or wide (1.8 m) swaths, and left to wilt until reaching 350 g DM/kg. It was a 2 × 2 factorial arrangement of treatments: 2 cutting times (PM vs. AM) and 2 swathing types (narrow vs. wide swaths). After wilting, one sample of 250 g was taken along the swath of each plot, heated in a microwave oven to stop the enzymatic activity, and then dried at 55°C for 48 h. This sampling was considered as time 0 of silage fermentation. The wilted material of each plot was chopped, sprayed with a *Lactobacillus plantarum* silage additive (100 000 CFU/g), and used to fill one polyvinyl chloride laboratory silo (40 cm length, 7.5 cm inner diameter). After compaction, the laboratory silos were sealed and kept at 20–23 °C for 128 days. At opening, two silage samples were taken, one was stored at -20°C and the other was rapidly dried at 55°C. Dried forage and silage samples were ground (1-mm) with a Wiley mill. The experiment was conducted twice in spring growth (12-14 June at early buds and 30 June-2 July at early flowers) and twice in summer regrowth (20-22 August at late buds and 26-28 August at late flowers) of 2008 and 24 laboratory silos were then made per growth cycle: 2 cutting times, 2 types of swathing, 3 field replicates, and 2 replicates in time.

Laboratory analyses

Dried forage and silage samples were analysed for soluble carbohydrates (SC) and starch as described by Morin *et al.* (2012). The NSC concentration was the sum of SC and starch. Proteolysis in silage samples was estimated using the Cornell Net Carbohydrate and Protein System (CNCPS). The non-protein N denoted as the fraction A plus the true protein fraction rapidly degraded in the rumen (B1) was then calculated as the difference between the total N and the N insoluble in a borate-phosphate buffer. The protein fraction B2 of intermediate rate of ruminal degradation was calculated as the difference between the N insoluble in a borate-phosphate buffer and the N insoluble in neutral detergent (Licitra *et al.* 1996). The silage pH and concentration of ammonia N were determined as in Tremblay *et al.* (2001), whereas lactate and total volatile fatty acid (VFA) concentrations were determined by ionic chromatography (Dionex Corporation 2007).

Statistical analyses

For each growth period, data were analyzed by ANOVA as a randomized complete block design with a factorial combination of cutting time and swathing as the main treatments and six replicates.

Results and Discussion

At ensiling, forage NSC concentration in spring growth was 9 g/kg DM greater in wide-swath PM-cut alfalfa than in narrow-swath AM-cut alfalfa; this difference between treatments reached 22 g/kg DM in summer regrowth (Table 1). The NSC concentration decreased during fermentation for all four treatments. Differences in initial NSC concentration among treatments disappeared during fermentation of spring growth but it was still significant

Table 1. Cutting time and swathing type effects on alfalfa concentration of nonstructural carbohydrates (NSC) at ensiling (NSC 0) and on NSC concentration (NSC 128), pH, and concentrations of lactate, total volatile fatty acids (VFA), ammonia-nitrogen (NH_3-N), soluble and rapidly degradable protein fractions (A+B1), and intermediary degradable true protein fraction (B2) in silage measured after 128 days of fermentation of the 2008 spring growth and summer regrowth.

Cutting Time (CT)	Swathing (S)	NSC 0 (g/kg DM)	NSC 128 (g/kg DM)	pH	Lactate (g/kg DM)	VFA (g/kg DM	NH_3-N (g/kg total N)	A+B1 (g/kg total N)	B2 (g/kg total N)
				Spring growth					
AM	Narrow	59	15	4.61	48.1	20.2	28	712	111
PM	Narrow	66	16	4.5	59	12.2	24	689	138
AM	Wide	63	16	4.45	60.4	13.4	23	674	151
PM	Wide	68	15	4.44	68.2	12.1	22	676	139
SEM		2.9	0.9	0.06	7.1	2.8	2	26	15
				Summer regrowth					
AM	Narrow	66	18	4.47	51.9	17.2	25	653	124
PM	Narrow	80	22	4.35	57.4	12.7	20	628	124
AM	Wide	78	22	4.34	60	7.6	15	591	162
PM	Wide	88	26	4.27	69.5	6.3	14	583	156
SEM		2.4	1	0.06	3.3	3.5	3	13	13
ANOVA	df	*P* value							
				Spring growth					
CT	1	*	ns	ns	ns	*	ns	ns	ns
S	1	ns	ns	*	ns	ns	ns	ns	ns
CT × S	1	ns	ns	ns	ns	ns	ns	ns	ns
				Summer regrowth					
CT	1	***	***	*	*	ns	ns	ns	ns
S	1	***	**	**	**	***	***	***	**
CT × S	1	ns	ns	ns	ns	ns	ns	ns	ns

*Significant at the 0.05 probability level. **Significant at the 0.01 probability level. ***Significant at the 0.001 probability level.

after 128 d of fermentation of summer regrowth. For spring growth, silages made with wide swathed alfalfa had a lower pH than those made with narrow swathed alfalfa, and silages made with PM-cut alfalfa had less VFA than those made with AM-cut alfalfa. For summer regrowth, pH was lower whereas lactate concentration was greater in silage made with wide-swath PM-cut alfalfa than with narrow-swath AM-cut alfalfa. Wide swathed alfalfa silage had lower concentrations of NH_3-N and soluble (A) and rapidly degradable (B1) protein fractions, and greater concentration of intermediary degradable true protein fraction (B2) than narrow swathed alfalfa silage.

Conclusions

In spring growth, the late PM-cutting was associated with a greater NSC concentration in alfalfa at ensiling and lower volatile fatty acid concentration in alfalfa silages. In summer regrowth, late PM-cutting and wide swathing caused a greater increase in alfalfa forage concentration of NSC at ensiling that was still evident after 128 days of fermentation. This greater increase in NSC concentration in alfalfa at ensiling due to late PM-cutting and wide swathing was then associated with a lower pH, lower protein degradation during fermentation, and greater lactate concentration in silages. Greater alfalfa NSC concentration at ensiling improves fermentation in the silo and the nutritive value of silage.

References

Dionex Corporation (2007) Determination of inorganic anions and organic acids in fermentation broths. Application note 123. http://www.dionex.com/en-us/webdocs/4082-AN123_LPN1030_2.pdf. Accessed 27 March 2013.

Licitra G, Hernandez TM, Van Soest PJ (1996) Standardization of procedures for nitrogen fractionation of ruminant feeds. *Animal Feed Science and Technology* **57**, 347-358.

Morin C, Tremblay GF, Bélanger G, Bertrand A, Castonguay Y, Drapeau R, Michaud R, Berthiaume R, Allard G (2012) Nonstructural carbohydrate concentration during field wilting of PM- and AM-cut alfalfa. *Agronomy Journal* **104**, 649-660.

Tremblay GF, Bélanger G, McRae KB, Michaud R (2001) Proteolysis in alfalfa silages made from different cultivars. *Canadian Journal of Plant Science* **81**, 685-692.