# Herbage energy to protein ratio of binary and complex legume-grass mixtures

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## Abstract

Herbage with a greater ratio of energy availability to protein degradability increases dairy cow N-use efficiency. We determined the variation in this ratio among 18 binary legume-grass mixtures and 8 complex mixtures combining three or four grass species with one of two legume species. Species included in those two experiments were birdsfoot trefoil (*Lotus corniculatus* L.), lucerne (*Medicago sativa* L.), white clover (*Trifolium repens* L.), cocksfoot (*Dactylis glomerata* L.), Kentucky bluegrass (*Poa pratensis* L.), meadow bromegrass (*Bromus biebersteinii* Roemer & J.A. Schultes), meadow fescue (*Festuca pratensis* L.), reed canarygrass (*Phalaris arundinacea* L.), tall fescue (*Schedonorus phoenix* (Scop.) Holub), and timothy (*Phleum pratense* L.). Carbohydrate and protein fractions of the Cornell Net Carbohydrate and protein system were measured in herbage from two clippings of the first post-seeding year at two sites in eastern Canada. The water soluble carbohydrate to crude protein ratio ranged from 0.39 to 0.70 among binary mixtures and from 0.64 to 1.04 among complex mixtures, while the ratio of non-structural carbohydrates to non-protein N and rapidly degradable proteins ranged from 3.62 to 5.28 and from 4.33 to 5.64, respectively. Our results confirm the possibility of improving the balance between energy and proteins through the choice of species in legume-grass mixtures.

**Keywords:** herbage species, yield, carbohydrates, frequent clipping

## Introduction

Enhanced efficiency of N utilization and enhanced milk yield were reported for late-lactation cows fed only lucerne with greater non-structural carbohydrate concentration (Brito *et al.*, 2009) or high sugar grasses with some concentrates (Miller *et al.*, 2001). For improved N utilization by dairy cows, a dietary combination of high energy availability and reduced total N concentration, or reduced N solubility, has been suggested for better microbial protein synthesis in the rumen (Bryant *et al.*, 2012). Greater concentrations of NSC along with low concentrations of non-protein N and rapidly degradable proteins (protein fractions A and B1 of the carbohydrate and protein system (CNCPS), respectively) in herbage should improve N utilization by dairy cows. Two ratios can be considered: water soluble carbohydrate (WSC)/crude protein (CP) and non-protein N (NSC)/(NPN + rapidly degradable proteins (RDP)). Very little information exists for these ratios in herbage mixtures grown in eastern Canada.

## Materials and methods

Two experiments were conducted in the same field at each of two sites: Lévis and Normandin, QC, Canada. In the first experiment, 18 simple binary mixtures of one legume species (birdsfoot trefoil (*Lotus corniculatus* L.), lucerne (*Medicago sativa* L.), or white clover (*Trifolium repens* L.) and one grass species (cocksfoot (*Dactylis glomerata* L.), Kentucky bluegrass (*Poa pratensis* L.), meadow bromegrass (*Bromus biebersteinii* Roemer & J.A. Schultes), meadow fescue (*Festuca pratensis* L.), reed canarygrass (*Phalaris arundinacea* L.), tall fescue (*Schedonorus phoenix* (Scop.) Holub), or timothy (*Phleum pratense* L.)) were compared. In the second experiment, the 8 complex mixtures were made of one of 2 legume species

(a grazing-type lucerne or birdsfoot trefoil) and one of 4 grass mixes (GM1 = timothy, meadow fescue, Kentucky bluegrass; GM2 = timothy, meadow fescue, reed canarygrass, Kentucky bluegrass; GM3 = tall fescue, meadow bromegrass, cocksfoot, Kentucky bluegrass; GM4 = tall fescue, meadow bromegrass, reed canarygrass, Kentucky bluegrass). In both experiments, treatments were replicated three times in a split-plot layout with legume species as main plots and grass species as subplots. Treatments were considered fixed effects, while sites and replicates were considered random effects in the analyses of variance.

In the first post-seeding year (2011), plots were frequently clipped with a self-propelled flail harvester to 7-cm height when timothy reached around 25 cm in height. Only samples from the first two clippings were analysed because they were taken in the period with the greater variation in nutritive attributes due to flowering. The first and second clippings from successive regrowth were taken on 2 and 22 June 2011 at Lévis, and on 6 and 27 June 2011 at Normandin, respectively. Concentrations of WSC, CP, ether extract (EE), ash, neutral detergent fibre (NDF), NPN, and RPD were determined and NSC concentration was calculated (NSC=100-CP-EE-Ash-NDF) in a subset of samples. These nutritive attributes were then estimated by near infrared reflectance spectroscopy in all herbage samples (Simili da Silva *et al.*, 2013).

## Results and discussion

Binary mixtures of lucerne with meadow fescue (L-Mf, Figure 1a), timothy (L-Ti), or tall fescue (L-Tf) along with those of birdsfoot trefoil with meadow fescue (B-Mf) or tall fescue (B-Tf) had greater WSC/CP ratio (0.70, 0.65, 0.62, 0.63, and 0.62, respectively) than the average of all mixtures (0.52); L-Mf, B-Mf, and B-Tf mixtures had greater dry matter (DM) yield (1.74, 1.67 and 1.51 Mg ha$^{-1}$, respectively) than the average of all binary mixtures (1.48 Mg ha$^{-1}$). Binary mixtures of meadow fescue with lucerne (L-Mf) or birdsfoot trefoil (B-Mf) provided the best combination of a high ratio of WSC/CP and yield. All binary mixtures with lucerne, except the lucerne-meadow bromegrass mixture (L-Mb), had greater NSC/(NPN+RDP) ratio (4.41 to 5.28) than the average (4.11). Binary mixtures of Kentucky bluegrass with lucerne (L-Kb) or white clover (C-Kb) were the least productive.

The two ratios used to characterize the energy to protein balance varied significantly among the eight legume-grass complex mixtures (square symbols, Figure 1a,b) and this variation was due to both legume species and grass mixes. Lucerne-based complex mixtures had greater WSC/CP (Figure 1a) and NSC/(NPN+RDP) (Figure 1b) ratios than birdsfoot trefoil-based mixtures. The grass mix 2 (timothy, meadow

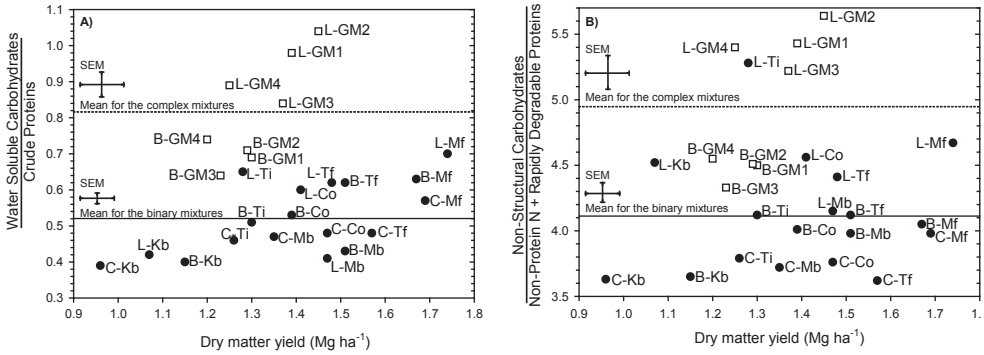


Figure 1. Ratios of (A) water soluble carbohydrates/crude protein and (B) of non-structural carbohydrates/(non-protein N + rapid degradable proteins) as a function of dry matter yield of 18 legume-grass binary mixtures (●, Experiment 1) and 8 legume-grass complex mixtures (□, Experiment 2). Values are averages of two clippings at two sites. B = birdsfoot trefoil, C = white clover, L = lucerne, Co = cocksfoot, Kb = Kentucky bluegrass, Mb = meadow bromegrass, Mf = meadow fescue, Rc = reed canarygrass, Tf = tall fescue, Ti = timothy, GM1 = grass mix 1 = Ti + Mf + Kb, GM2 = Ti + Mf + Rc + Kb, GM3 = Tf + Mb + Co + Kb, and GM4 = Tf + Mb + Rc + Kb.

fescue, reed canarygrass and Kentucky bluegrass) provided the best combination of high readily-available energy to protein ratios (WSC/CP = 0.87; NSC/(NPN+RDP) = 5.08) and high DM yield. The complex mixtures including lucerne and meadow fescue had the best readily-available energy to protein ratios and DM yield.

## Conclusions

These results from the first two clippings of the first production year at two sites provide useful and novel information on the desired species composition of binary and complex legume-grass mixtures that combine high readily-available energy to protein ratios and DM yield. They confirm the possibility of improving the balance between herbage readily-available energy and proteins through the choice of species. Research is ongoing to determine the feasibility of maintaining this desired composition throughout the growing season and over several cropping years.

## References


Brito A.F., Tremblay G.F., Lapierre H., Bertrand A., Castonguay Y., Bélanger G., Michaud R., Benchaar C., Ouellet D.R. and Berthiaume R. (2009) Alfalfa cut at sundown and harvested as baleage increases bacterial protein synthesis in late-lactation dairy cows. *Journal of Dairy Science* 92, 1092-1107.

Bryant R.H., Gregorini P. and Edwards G.R. (2012) Effects of N fertilisation, leaf appearance and time of day on N fractionation and chemical composition of *Lolium perenne* cultivars in spring. *Animal Feed Science and Technology* 173, 210-219.

Miller L.A., Moorby J.M., Davies D.R., Humphreys M.O., Scollan N.D., MacRae J.C. and Theodorou M.K. (2001) Increased concentration of water-soluble carbohydrate in perennial ryegrass (*Lolium perenne* L.): Milk production from late-lactation dairy cows. *Grass and Forage Science* 56, 383-394.

Simili da Silva M., Tremblay G.F., Bélanger G., Lajeunesse J., Papadopoulos Y.A., Fillmore S.A.E. and Jobim C.C. (2013) Energy to protein ratio of grass-legume binary mixtures under frequent clipping. *Agronomy Journal* 105, 482-492.