Maximizing the Nutritive Value of Forages

Cutting forages in the afternoon increases their nutritive value

Forages are a key part of the beef and dairy value chains. A clear link between forage quality and beef or milk production indicates the value of forages and the importance of enhancing the nutritive value of forages. Optimizing forage nutritive value can increase profitability for producers.

A key element of forages is “non-structural carbohydrates” (NSC), commonly known as sugars, which are made up of starch and water soluble carbohydrates (WSC). WSCs include glucose, fructose, sucrose along with fructans in grasses and pinitol in legumes. NSCs are an important source of energy and increasing these carbohydrates in forages has been shown to improve feed intake, milk yield, and nitrogen (N) use efficiency in dairy cows.

AAFC scientists carried out various studies looking at farming practices that optimize the nutritive value of forages including taking advantage of diurnal variations in non-structural carbohydrates and energy content of forages. They also evaluated the impact of the resulting high NSC forages on the performance of dairy cows.

KEY FINDINGS

1. Farming practices that favour the accumulation of energy in forages

Time of Cutting

Plant NSC concentration increases during the day when photosynthesis creates more carbohydrate than the plant utilizes. Studies conducted in different areas of North America and with different forage species have shown that cutting in the afternoon, particularly on a sunny day, results in greater NSC concentrations. (Figure 1).

Feeding forages cut in the afternoon can increase milk yield by up to 8% in dairy cows!
The AAFC studies showed that:

- The greatest NSC concentrations are usually reached 11-13 hours after sunrise in both grasses and legumes throughout the growing season (Figure 1).
- As an example, for alfalfa, afternoon (PM) cutting resulted in a 50% higher concentration in starch, 19% higher concentration in WSC, and 22% increase in NSC (Figure 2). The concentration of NSC remained higher throughout the wilting period.
- Related research showed that in four growth cycles the sugar concentration averaged 1.1 percentage units higher in PM-cut alfalfa forage (Figure 3).
- The benefits of afternoon-cut forages also include other nutritive attributes such as greater in vitro dry matter (DM) digestibility.

**Wide Swaths**

Leaving forages to dry in wide swaths speeds up wilting time benefitting NSC concentrations by decreasing post-cut NSC use by the plant. After cutting, during the wilting period, NSC concentration decreases by as much as 0.35% dry matter per hour until the plant cells die and stop using NSC for respiration. Recent research has shown that nighttime NSC losses in alfalfa cut in late afternoon are minimal and that these losses are more than compensated for by post-cut early morning photosynthesis within the cut herbage.

**Species Selection**

A diurnal increase in NSC has been observed in most forage species, although the extent of the increase varies with species. While selection of proper forage species and cultivars can increase NSC concentrations, there have been only a few studies done on NSC comparisons. Currently, there is insufficient information available to make specific recommendations.

**OTHER strategies that may increase carbohydrate concentrations in forages**

In addition to PM cutting, wide swathing, and species selection, factors such as climate, harvest management, and fertilization are also likely to affect plant growth, metabolism, and forage NSC concentration.

- **Nitrogen fertilization** - Lowering N fertilization has been shown to increase NSC concentration and reduce crude protein concentration of several grass species (timothy, orchardgrass, tall fescue) which can lower N losses and improve the N use efficiency of cattle. However, the challenge is to balance this with reduced grass yield.

- **Genetic selection and improvement** - NSC concentration can be improved by genetic selection. However, there are few reports on genetic variability and the possibility of genetic improvement for sugar concentration for most forage species. While development of perennial ryegrass varieties with an increased sugar concentration up to 8 percentage units have been reported out of the UK,
the results of recent AAFC investigations into genetic selection in alfalfa produced small (1 percentage unit) increases of NSC concentration.

- **Stages of development at harvest** - Variations of NSC concentration with stage of development are inconsistent, due in part to the confounding effects of stage of development and climatic conditions. However, in the fall, delaying harvest can result in significant increases in WSC because cool-season grasses generally have a higher concentration of NSC when grown at cool temperatures (5-10°C) than at warm temperatures (15-25°C).

- **Spring, summer and autumn growth** - Forage harvested in late fall (e.g. October in Eastern Canada) is likely to have greater NSC concentrations than forage harvested in summer or early fall. The effect of the growing season on NSC concentration is not clear as peaks in carbohydrate concentrations occur at different times of the year depending on, among other factors, forage species and location. The effect of temperature, photoperiod, and other factors affecting NSC vary among growth periods.

- **Silage fermentation** - The concentration of NSC decreases during fermentation and the decrease may vary with the silage DM concentration. Because of this, forages with high NSC concentration might lose some of their advantage during the fermentation process. However, afternoon cut alfalfa and timothy are still best for silage as they will have a greater initial concentration of NSC.

2. **Increased forage energy content IMPROVES dairy cow performance**

Feeding 16 late-lactation dairy cows a diet of afternoon-cut higher energy (higher NSC) forages, confirmed an improvement in the performance (Figure 4):

- Dry matter intake (DMI) by dairy cows increased;
- Intake of digestible organic matter also increased;
- Cows yielded 1.6 kg/d (3.5 lb/d) or 8% more milk;
- Milk urea N (MUN) was lower suggesting improvement in N use efficiency.

Other studies conducted with perennial ryegrass in the UK showed similar results.

**CONCLUSIONS**

Cutting forages in the afternoon (PM – 11 to 13 hours after sunrise) and leaving forages in wide swaths (to optimize rapid drying) raises the non-structural carbohydrate concentration in forages. Forages with high NSC concentrations have more energy and are more digestible.

Optimizing non-structural carbohydrates in forage feed improves productivity and profitability. Dairy cows fed higher NSC forages were found to have higher dry matter intake, improved nitrogen use efficiency, and increased milk production by up to 8%.
This fact sheet is based on two articles in “Cool Forages – Advanced Management of Temperate Forages”, Published by the Pacific Field Corn Association (www.farmwest.com) and Edited by Shabtai Bittman and Derek Hunt.
