Factors affecting the fatty acid patterns of *Lolium perenne*

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Abstract

Fresh forages provide the most natural and environmentally sustainable source of fatty acids (FA) for ruminants. Several factors influence the concentration and proportion of FA in herbage. This study evaluated the influence of N application levels (0, 45 and 100 kg N ha^{-1}) and regrowth interval on the FA composition in *Lolium perenne* L. during three periods in 2004. In each experiment, the α-linolenic acid (C18:3) concentration decreased with an extended regrowth interval, whereas levels of C16:0 and C18:2 increased. Higher N application increased total FA and C18:3 concentrations. A positive correlation between herbage N and C18:3 concentrations was established throughout the entire period. Moreover, total FA, and C18:3 concentration and proportion gradually increased with N fertilization level, from May to October. Grassland management can affect levels of FA in herbage, which is important for the quality of ruminant products.

Keywords: *Lolium perenne*, herbage, nitrogen, fertilization, regrowth interval, fatty acids.

Introduction

The lipid fraction in leaves of forage species ranges from 30 – 100 g kg^{-1} dry matter (DM) High fatty acid (FA) concentrations occur during primary growth, leafy regrowth, and late in the season (Bauchart *et al.,* 1984). Besides, Hawke (1973) reported a positive correlation between the amounts of FA and the chlorophyll concentration in a leaf tissue. The chlorophyll concentration is affected by the solar radiation and by the nutrition of the plant. The primary nutrient, nitrogen, is a necessary part of all proteins, enzymes, and metabolic processes involved in the synthesis and transfer of energy. Consequently, with a sufficient supply of N, levels of all plant proteins as well as the density or mass of chloroplast and perhaps associated lipids raise, giving a plant the "lush" appearance. Still, the nature and interactions between factors influencing the FA levels in herbage remain unclear. As forage is a cheap and environmentally sustainable source of FA, these relationships are important to enhance levels of beneficial FA in ruminant products. Thereby, this study evaluated the influence of N application levels and regrowth interval on FA composition of *Lolium perenne* during three periods in 2004.

Material and methods

The experiment was conducted at an experimental field of Wageningen University, the Netherlands. The experimental set-up was a randomized block design with three replicates (Elgersma *et al.,* 2005). Three N treatments (0, 45 and 100 kg N ha^{-1}) were applied before three subsequent periods (*May – June*, *Aug. – Sept.*, and *Oct.*) in 2004. During each period, three harvest dates were chosen to simulate various cutting regimes (early, normal, and late). Fresh herbage was sampled immediately with dry ice and stored in a freezer (-18˚C), before analysis of FA. Other random samples of the herbage were taken to asses the DM content and morphological characteristics. Samples used for DM determination were analyzed for total nitrogen and water-soluble carbohydrates. Multiple regression analyses were carried out, according to a model taking account of the effects of period, N fertilization and regrowth interval, as well as period x N fertilization, period x regrowth interval, N fertilization x regrowth interval and period x N fertilization x regrowth interval. Moreover, regression analyses were conducted between chemical variables and FA concentrations to establish overall relationships based on measured plant characteristics.

Results and discussion

The most distinct differences in all analyzed herbage chemical characteristics were reported between material collected in *May – June* (reproductive development stage), *Aug. – Sept.*, and *Oct.* (vegetative development stage). The highest WSC and lowest N and FA concentrations occurred in the first period, while during the following months the WSC concentrations decreased, and N and FA concentrations increased ($P < 0.05$; Figure 1 and 2) (Hawke, 1973).

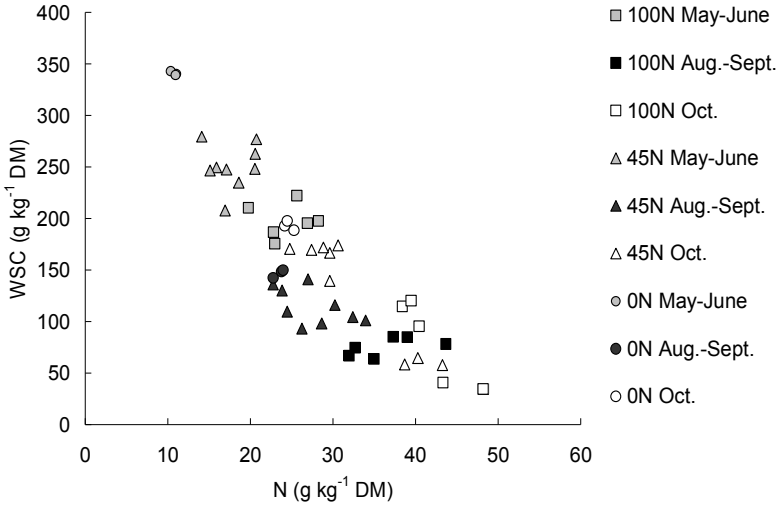

Figure 1. The relation between WSC and N (g kg^{-1} DM) of *Lolium perenne* during three periods in 2004; N = 367.44 – 7.49 * WSC; $R^2 = 0.79$.

The differences in the herbage nutritive value observed during the entire experiment might be explained in three ways. Firstly, the nutritive value of morphological forage fractions and their proportions derives the nutritive value of the forage. Since, in *May – June* the leaf blade proportion was smallest, the concentrations of N and FA were lower, and WSC higher than in the following months. Secondly, an accumulation of DM with the regrowth interval negatively influences the nutritive value of the herbage. High herbage yields coupled with a considerable increase in the yield with an extended regrowth interval (45N-20d: 1.9 ± 0.2 t ha^{-1} vs. 45N-32d: 4.2 ± 0.8 t ha^{-1}) were only reported in *May – June*, when weather conditions were favourable for herbage growth. In subsequent periods, the yields were approximately 50% lower, as the growth was limited by either high temperature (*Aug. – Sept.*) or low solar radiation (*Oct.*). Thirdly, the photosynthetic rate decreases with the herbage age, leading to reduced synthesis of metabolic components, such as proteins, chlorophyll, and FA (Hawke, 1973). Therefore, with the extended regrowth interval, the concentrations of N, total major FA and C18:3 decreased ($P < 0.01$), while the concentrations of WSC, C16:0 and C18:2 increased ($P < 0.001$). Besides, higher N fertilization levels increased concentrations of FA ($P < 0.01$). The N fertilization promotes photosynthesis, by increasing the leaf area (light harvesting part of the plant) and the synthesis of metabolic components, such as chloroplast and proteins. Pigment-protein complexes, composed of proteins, chlorophylls, and FA are constituents of chloroplast thylakoid membranes (Evans, 1996), and are directly responsible for the harvesting of the solar radiation. We can speculate, based on the previously reported positive relationship between chlorophyll and FA (Hawke, 1973), that this relationship should be valid for all main constituents of these complexes. This might be an explanation for the positive correlation between N and C18:3 concentrations established throughout the entire experiment (Figure 2).

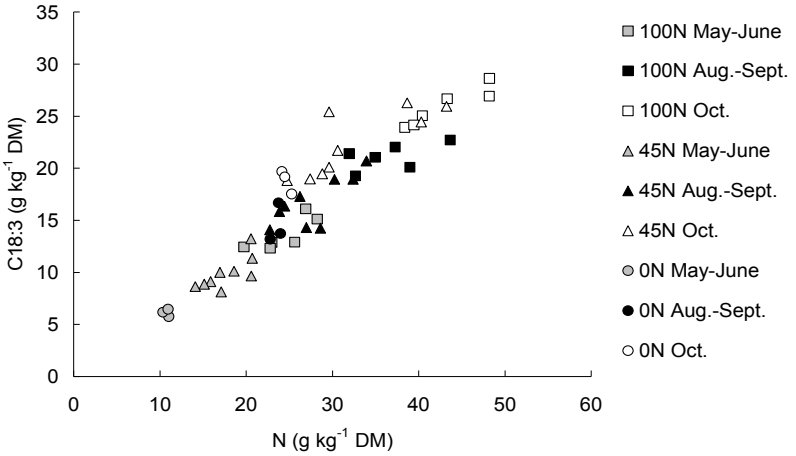

Figure 2. The relation between N and C18:3 concentration (g kg^{-1} DM) of *Lolium perenne* during three periods in 2004; C18:3 concentration = 0.49 + 0.59 * N; R^2 = 0.87.

Conclusions

Grassland management can enhance levels of important FA in herbage. Frequent cutting of the sward results not only in a higher nutritive value of forage, but also in higher levels of FA. It seems to be especially important in spring, when the rate of herbage growth is highest. N fertilization also seems to be an attractive way for enhancing levels of FA in herbage. Nonetheless, large seasonal variations in the concentrations of WSC, N, and FA in the herbage exist. Further research is required to explore these relationships on more fundamental plant level.

Referentes

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