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Effects of Perennial Ryegrass Cultivars on Milk Yield and Nitrogen Utilization in Grazing Dairy Cows

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ABSTRACT

The effects of 4 diploid perennial ryegrass cultivars that differed in water-soluble carbohydrate (WSC) concentrations on milk yield and nitrogen (N) utilization in dairy cows were evaluated in a 2-yr grazing experiment. Twelve lactating dairy cows were assigned to 1 cultivar for a 2-wk period in a 4 × 4 Latin square design with 3 replicates. Each year, the experiment lasted 8 wk. Swards were in a vegetative stage throughout the experiment. Herbage constituents were determined, and DM intake was estimated with the *n*-alkane technique. Nitrogen utilization was calculated as N excreted in milk divided by N intake, assuming a zero N retention. Two cultivars had consistently higher WSC concentrations and slightly lower neutral detergent fiber concentrations than the other 2 cultivars. The ranking of the cultivars in chemical composition traits in both years was rather consistent. Cows grazing the cultivar with the lowest concentration of WSC had the lowest herbage DM intake, N intake, milk yield, and milk N yield in 2002, but with a similar difference in WSC concentration, no differences among cultivars were found in 2003. In both years, milk urea N concentration was slightly higher for cows grazing the cultivar with the lowest WSC concentration, although it was significant only in 2003. Nitrogen utilization (N milk:N intake, g/g) varied between 0.241 and 0.246 in 2002 and between 0.190 and 0.209 in 2003, and in both years there was no effect of cultivar. At relatively high N concentrations in grass and only small differences among cultivars in neutral detergent fiber concentrations, cultivars with an elevated WSC concentration did not increase N utilization in grazing dairy cows.
Key words: perennial ryegrass, cultivar, grazing, nitrogen utilization

INTRODUCTION

In temperate areas of the world, high-quality forages, notably fresh grass, are among the cheaper components in dairy diets. Grazing systems should aim at maximizing herbage DMI while maintaining a high quality and quantity of the sward over the grazing season (Peyraud et al., 2004). Dairy cows with a high proportion of forages in their diet (Veerkamp et al., 1994), or those grazing intensively managed grassland (Kolver and Muller, 1998; Peyraud et al., 2004), have a lower milk yield (**MY**) than cows fed concentrate-supplemented diets. The lower MY could be attributed partly to a lower DMI and partly to an imbalance among absorbed nutrients (Kolver and Muller, 1998). Another aim of modern grassland-based dairy farming is to improve the low nitrogen (N) utilization and to reduce N losses to the environment. Intensive use of fertilizer N and selection by the cows of young and leafy grass not only result in the intake of highly digestible herbage with a relatively high energy concentration, but also with a high CP concentration. At a high CP concentration, the supply of N often exceeds the supply of energy from carbohydrates required for microbial growth in the rumen. Almost 80% of this excess N is excreted in urine (van Vuuren, 1993).

Differences among perennial ryegrass cultivars in their concentrations of water-soluble carbohydrates (**WSC**) were consistent and heritable (Humphreys, 1989). A comparison of 2 ryegrass cultivars showed an increased digestible DMI, MY, and N utilization in the cultivar with an increased WSC concentration (Miller et al., 2001). Miller et al. (2001) speculated that the efficiency of microbial protein synthesis was increased because of the higher WSC concentration, and this was confirmed by infusing sugars into perennial ryegrass in an in vitro fermentation system (Lee et al., 2003), but could not be demonstrated in vivo in the rumen of steers (Lee et al., 2002). However, in the studies of Miller et al. (2001) and Lee et al. (2002), the CP concentration in grass was low (92 to 107 g/kg of DM) and the NDF concentration was high (>540 g/kg of DM) because

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of a relatively long regrowth period of 6 wk and low N fertilization levels, and this may have influenced their results. In a 2-yr stall-feeding experiment, cultivars with an elevated WSC concentration did not increase the DMI and MY (Tas et al., 2005), nor was the N utilization in dairy cows improved (Taweel et al., 2005; Tas et al., 2006). The aim of this study was to evaluate the effects of 4 diploid perennial ryegrass cultivars, differing in WSC concentration, on MY and N utilization in grazing dairy cows.

MATERIALS AND METHODS

Cows, Cultivars, and Experimental Design

In July and August of 2002 and 2003, 2 grazing experiments were conducted with 12 dairy cows. Both experiments lasted 8 wk, divided in four 2-wk periods. For 3 wk before the experiments started, cows grazed a perennial ryegrass sward. In 2002, the cows were in their second to fourth lactation, 67 ± 4.2 DIM at the start of the experiment, BW was 528 ± 7.1 kg, and MY was 32.7 ± 0.9 kg/d in the adaptation period. The cows used in 2003 were in their second to fifth lactation, 79 ± 3.7 DIM at the start of the experiment, BW was 549 ± 6.7 kg, and MY was 30.7 ± 0.9 kg/d in the adaptation period.

The cows grazed 4 diploid perennial ryegrass cultivars (cultivars 1 to 4): 2 intermediate-heading types (May 27; Abergold and Agri) and 2 late-heading types (June 10; Barezane and Barnhem). Two cultivars (1 and 4) had a higher WSC concentration than the other 2 cultivars (2 and 3) in a stall-feeding experiment conducted in 2000 and 2001 (Tas et al., 2005). The 4 cultivars were sown on 2 paddocks in Wageningen, The Netherlands, according to a randomized complete block design with 3 replicates. At all times, the cutting and fertilizing regimen was similar for all cultivars. Prior to the experiment and after each grazing event, the sward was cut at 6 cm above ground level and herbage was removed. Pasture management aimed at an herbage mass at 4 cm above ground level of 2,000 kg of DM/ha. Herbage mass was estimated by cutting strips of at least 5% of the total area with a mowing machine (Agria 3200; Agria-Werke, Möckmuhl, Germany) at a stubble height of 4 cm. Grass was collected and weighed, and duplicate samples were oven-dried at 70°C for 24 h. Grass morphology was determined by hand-separating a plucked sample into stem, leaf blade, pseudostem, and dead material. Initially, the fertilization level was 55 kg of N/ha per cut. However, during the first 2 periods in 2002, the grass growth was lower than expected; therefore, the fertilization level was increased to 75 kg of N/ha per cut in the last 2 periods in 2002 and in 2003. The regrowth period was approximately 23 d in 2002 and 29 d in 2003. In 2003, more regrowth days were necessary owing to retarded grass growth because of warm and dry weather conditions. Each paddock was therefore irrigated 6 times with 15 mm in July and August. See Smit et al. (2005a) for a detailed description of pasture management.

Each paddock was divided into 12 strips of 22 × 84 m, and each strip was sown with one of the 4 cultivars. Mobile fences were established every 6 m across the 12 strips, to obtain daily plots of 132 m^2 per cow. With an herbage mass of approximately 2,000 kg of DM/ha, this would result in an herbage allowance of 25 kg of DM/cow per d, enough to ensure an unrestricted access to fresh grass. A strip-grazing system was applied, and each plot was grazed by a cow for 24 h. Cows were moved at 1200 h to a new plot. Cows grazed in periods 1 and 3 on one paddock and in periods 2 and 4 on the other paddock. All cows were assigned for a 2-wk period to 1 cultivar in a 4 × 4 Latin square design.

Cows were milked twice a day at 0600 and 1600 h, and diets were supplemented with 2.7 kg of DM/d of concentrate feed in 2 equal portions at milking. Dotriacontane (C_{32}) n-alkane marker was added to the concentrate feed to estimate DMI (Mayes et al., 1986; Smit et al., 2005a,b). The MY of each cows was recorded at each milking.

Sampling, Analyses, and Measurements

On d 8 to 13 in each period, herbage samples were plucked by hand at 0700, 1330, and 2000 h. After cows were moved to a new plot, all dung patches on each plot that were excreted after 24 h of grazing were sampled and stored at −20°C. Sample handling and chemical analyses of herbage, feces, and concentrate feed are described by Smit et al. (2005a).

Two composite milk samples in the evening and consecutive morning (1:1, vol:vol) were taken from each cow. One sample was analyzed for milk fat and protein concentration by near-infrared reflectance spectroscopy according to ISO Standard 9622 (ISO, 1999), and the other for MUN concentration with the pH difference method according to ISO Standard 14637 (ISO, 2004); Melkcontrolestation, Zutphen, The Netherlands).

Calculations and Statistical Analyses

The efficiency of N utilization was calculated as N excretion in milk (protein yield/6.38) divided by total N intake ([N concentration in grass (N = CP/6.25) × herbage DMI] + concentrate feed N intake), assuming a zero N retention in the body, which, when taking