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More milk from forage: Milk production, blood metabolites, and forage intake of dairy cows grazing pasture mixtures and spatially adjacent monocultures

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ABSTRACT

There is interest in the reincorporation of legumes and forbs into pasture-based dairy production systems as a means of increasing milk production through addressing the nutritive value limitations of grass pastures. The experiments reported in this paper were undertaken to evaluate milk production, blood metabolite concentrations, and forage intake levels of cows grazing either pasture mixtures or spatially adjacent monocultures containing perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*), and plantain (*Plantago lanceolata*) compared with cows grazing monocultures of perennial ryegrass. Four replicate herds, each containing 4 spring-calving, cross-bred dairy cows, grazed 4 different forage treatments over the periods of early, mid, and late lactation. Forage treatments were perennial ryegrass monoculture (PRG), a mixture of white clover and plantain (CPM), a mixture of perennial ryegrass, white clover, and plantain (RCPM), and spatially adjacent monocultures (SAM) of perennial ryegrass, white clover, and plantain. Milk volume, milk composition, blood fatty acids, blood β-hydroxybutyrate, blood urea N concentrations, live weight change, and estimated forage intake were monitored over a 5-d response period occurring after acclimation to each of the forage treatments. The acclimation period for the early, mid, and late lactation experiments were 13, 13, and 10 d, respectively. Milk yield (volume and milk protein) increased for cows grazing the RCPM and SAM in the early lactation experiment compared with cows grazing the PRG, whereas in the mid lactation experiment, milk fat increased for the cows grazing the RCPM and SAM when compared with the PRG treatments. Improvements in milk production from grazing the RCPM and SAM treatments are attributed to improved nutritive value (particularly lower neutral detergent fiber concentrations) and a potential increase in forage intake. Pasture mixtures or SAM containing plantain and white clover could be a strategy for alleviating the nutritive limitations of perennial ryegrass monocultures, leading to an increase in milk production for spring calving dairy cows during early and mid lactation.
Key words: pasture-based dairy systems, species mixtures, monocultures, forage intake, novel forage species

INTRODUCTION

Perennial ryegrass (*Lolium perenne*) is the major pasture species grown on dairy farms in the southern dairy regions of Australia and in New Zealand (Doyle et al., 2000; Holmes, 2007). Ryegrass is highly productive, has efficient responses to irrigation (Rawnsley et al., 2009) and N inputs (Pembleton et al., 2013), and is easy to establish and manage. However, 70% of annual growth occurs during spring (Rawnsley et al., 2007), which is associated with the transition from high-nutritive value vegetative growth to low-nutritive value reproductive development. The resulting oversupply of lower-nutritive value forage in spring presents a management challenge to producers. Management options currently employed to address this include conserving excess forage as silage, pre- or postgrazing topping (mechanical mowing) to achieve the desired postgrazing residual, or forcing cows to graze to the desired residual (Irvine et al., 2010). Whereas all of these options are considered appropriate management strategies, they limit efficient conversion of forage to milk, through either reduced forage intakes, reduced forage nutritive values, or increased wastage levels during forage conservation and feeding.

The inclusion of nongrass pasture species within the forage base may provide a complementary forage op-

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tion that improves overall pasture nutritive value and helps alleviate the spring surplus by pushing growth into the pre- and postspring periods. Although legumes have long been recognized as important components of pastoral systems (Penning et al., 1995; Frame and Laidlaw, 2005), the increased use of N fertilizer to improve pasture productivity has led to a botanical composition shift from a legume grass mixture to a grass monoculture (Feyter et al., 1985; Bolland and Guthridge, 2007).

Forbs have long been considered important components of pasture (Foster, 1988), providing benefits of improved mineral nutrition (Stewart, 1996; Pirhofer-Walzl et al., 2011) and overall nutritive value (Woodward et al., 2008) of forage during periods when ryegrass growth rates are low. However, many dairy pastures' contain little or no forb component. The development of improved cultivars of the forbs plantain (*Plantago lanceolata*) and chicory (*Cichorium intybus*) coupled with increasing environmental concerns, in regard to high levels of N fertilizer inputs into pastoral systems in general, has renewed interest in the forb and legume components of pastures. This interest centers on reduced N fertilizer requirements (Frame et al., 1998; Brown et al., 2005; Labreveux et al., 2006) and improved stress tolerance of forbs when compared with perennial ryegrass (Stewart, 1996; Neal et al., 2011). Campling (1984), Thomson et al. (1985), and Derrick et al. (1993) have demonstrated increased voluntary intake in dairy cows grazing forbs, whereas Conrad et al. (1982) , Kusmartono et al. (1996), Barry (1998), Harris et al. (1998), Woodward et al. (2008), and Sun et al. (2012) demonstrated their potential to increase animal production.

Several approaches exist to incorporate forb and legume species into dairy pastures without sacrificing the ease of management and input responsiveness that make ryegrass so favored. These include forage mixtures of legumes and forbs, with or without a grass component, or spatially adjacent monocultures. Whereas mixtures present an opportunity for each species to exploit suitable niches within the pasture (Sanderson et al., 2005; Picasso et al., 2011), maximizing complementary aspects of the species, they do present limited herbicide options and careful management of grazing pressure and N inputs that are required to maintain the desired botanical composition. Spatially adjacent monocultures, where each species is sown as a monoculture within the boundaries of the same field, offer the opportunity to manage each species' individual requirements. Experimental evidence from rotationally grazed dairy sheep suggests spatially adjacent monocultures of annual ryegrass (*Lolium multiflorum*) and sulla (*Hedysarum coronarium*) can improve animal production above that of grass monocultures (Molle et al., 2007). Similarly, spatially adjacent monocultures of perennial ryegrass and white clover improved animal performance compared with mixtures of the 2 species (Champion et al., 2004), as they allow animals to efficiently select a diet higher in legumes (Rook et al., 2002). As yet, no evaluation of forbs as a component of spatially adjacent monocultures in livestock production systems has occurred.

The aim of our experiments were to determine if species mixtures or spatially adjacent monocultures are able to increase milk production of pasture-based dairy systems. Over the states of lactation (early, mid, and late lactation), milk production, key blood metabolites, and forage intake of dairy cows grazing mixtures containing perennial ryegrass, white clover, and plantain or spatially adjacent monocultures were evaluated in comparison to perennial ryegrass monocultures.

MATERIALS AND METHODS

Site Description

The experiments were done at the Tasmanian Dairy Research Facility at Elliott, Tasmania, Australia (41′08″S, 145′77″E). This location has a mean daily maximum temperature of 15°C, a mean daily minimum temperature of 7°C, and an annual total rainfall of 1,200 mm (65% distributed between May and October, inclusive). The soil is classified as a clay loam red ferrosol soil (Isbell, 2002; Soil Survey Staff, 1990).

Experimental Design

The experimental design, treatments, and all animal procedures were approved by the University of Tasmania's Animal Ethics committee (Approval A0012629). Three experiments were undertaken, covering mid (January 2013), late (May 2013), and early lactation (September/October 2013). In each experiment, 4 replicate herds of 4 lactating spring-calving, cross-bred dairy cows were grazed continuously on 4 forage treatments (a total of 64 cows). Each herd was balanced for age, milk production, DIM, and live weight (Table 1). The forage treatments were a monoculture of perennial ryegrass (cultivar 'Base'; **PRG**); a mixture of perennial ryegrass ('Base'), white clover ('Kopu II'), and plantain ('Tonic'; **RCPM**); a mixture of white clover ('Kopu II') and plantain ('Tonic'; **CPM**); and spatially adjacent monocultures (**SAM**) of perennial ryegrass ('Base'), white clover ('Kopu II'), and plantain ('Tonic'; Figure 1). Cows were offered an equal area of each species monoculture.