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The multi-year cumulative effects of alternative stocking rate and grazing management practices on pasture productivity and utilization efficiency

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ABSTRACT

The production and utilization of increased quantities of high quality pasture is of paramount importance in pasture-based milk production systems. The objective of this study was to evaluate the cumulative effects of alternative integrated grazing strategies, incorporating alternative stocking rate (SR) and grazing severities, on pasture productivity and grazing efficiency over multiple years within farm systems using perennial ryegrass dominant pastures. Three whole-farm SR treatments were compared over 4 complete grazing seasons (2009 to 2012 inclusive): low (2.51 cows/ha; LSR), medium (2.92 cows/ha; MSR), and high (3.28 cows/ha; HSR). Each system had its own farmlet containing 18 paddocks and remained on the same treatment for the duration of the study. Stocking rate had a significant effect on all grazing variables with the exception of soil fertility status and sward density. Increased SR resulted in increased total annual net pasture accumulation, improved sward nutritive value, and increased grazed pasture utilization. Total annual net pasture accumulation was greatest in HSR [15,410 kg of dry matter (DM)/ha], intermediate for MSR (14,992 kg of DM/ha), and least for LSR (14,479 kg of DM/ha) during the 4-yr study period. A linear effect of SR on net pasture accumulation was detected with an increase in net pasture accumulation of 1,164.4 (SE = 432.7) kg of DM/ha for each 1 cow/ha increase in SR. Pregrazing pasture mass and height and postgrazing residual pasture mass and height were greatest for LSR, intermediate for the MSR, and lowest for the HSR. In comparison with the LSR, the imposition of a consistently increased grazing severity coupled with increased whole farm SR in MSR and HSR treatments arrested the decline in sward nutritive value, typically observed during mid-season. Incorporating the individual beneficial effects of SR on pasture accumulation, nutritive value, and utilization efficiency, total proportional energy (unité fourragère lait) utilization per hectare increased significantly with increasing SR (+0.026 and +0.081 for MSR and HSR, respectively). These results quantify the significant effect of grazing management practices on the feed production capability of modern perennial ryegrass pastures for intensive grazing dairy production systems. Furthermore, these results highlight the importance of consistently imposing grazing treatments over multiple years, and within integrated whole farm systems, to accurately assess the longer term effects of alternate grazing management practices on pasture productivity.
Key words: stocking rate, grazing severity, sward nutritive value, pasture production and utilization

INTRODUCTION

Worldwide demand for dairy products has been increasing rapidly as a result of projected population growth, urbanization, and increases in per capita disposable income (Rae, 2002; Delgado, 2005). Commensurate with the increased global food demand, increased competition for land, water, and energy resources necessitates that global agricultural production becomes more productive based on systems that are also more environmentally and socially sustainable. In this regard, awareness is increasing of the multifunctional character and benefits of pasture-based farming (Jeangros and Thomet, 2004) due to its capability to be both highly productive (Macdonald et al., 2008; McCarthy et al., 2013a), environmentally benign (Nosberger and Rodriguez, 1996; Jankowska-Huflejt, 2006; Peyraud et al., 2010), financially efficient (Dartt et al., 1999; Dillon et al., 2008), and socially sustainable (Dartt et al., 1999; White et al., 2002), while providing products with advantageous nutritional characteristics (O'Brien et al., 1999; Coakley et al., 2007). Both Taube et al. (2013) and Baumont et al. (2014) have suggested that systemic improvements in pasture-based food pro-

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duction efficiency can be ascertained by increasing pasture utilization and placing less emphasis on external supplementary feed and fertilizer inputs.

The efficient production of milk from grazing systems is dependent on the extensive use of cheap high-quality grazed pasture (Horan et al., 2005; Dillon et al., 2008). Previous studies have indicated that, in comparison with mechanically harvested or purchased feeds, grazed pastures provide a relatively inexpensive and energy efficient feed source for milk production (Dillon et al., 2008; Ramsbottom et al., 2015). The production performance of grazing systems is heavily reliant on the yield of utilizable energy and protein from grazed pastures and is consequently reliant on prevailing climatic conditions (Roche et al. 2009), which are beyond the control of the grassland farmer. Such inherent temporal variability necessitates the identification of grazing management practices that increase the yield and stability of high quality pasture to enhance the robustness and predictability of grazing systems in the future.

The agronomic objectives of technically efficient grazing management have been extensively studied and reviewed in the literature and the immediate influence of individual grazing management components on pasture accumulation, nutritive value, and utilization has been reported (Lee et al., 2007; Ganche et al., 2013b; Tuñon, 2013). Stocking rate (**SR**), defined as the number of animals per unit area of land used during a specified defined period of time (cows/ha, Allen et al., 2011) is widely acknowledged as the main driver of productivity from grazing systems (Hoden et al., 1991; Macdonald et al., 2008; Baudracco et al., 2010). Increasing SR is usually associated with an increase in grazing severity, and many studies have attributed the increased productivity of higher SR systems to an improvement in pasture utilization (Hoden et al., 1991; Macdonald et al., 2008). In contrast, the effect of increasing SR and defoliation severity on pasture production has been extensively studied but inconsistently reported (Donaghy and Fulkerson, 1998; Macdonald et al., 2008; Lee et al., 2009), and the evaluation of such effects is often complicated by alternative grazing decision rules (Clark et al., 2010) and the difficulties of extending the results of shorter term component-based or cutting experiments to field conditions (Anderson and Briske, 1995). Indeed, previous studies have also indicated that although variation in defoliation and plant regrowth patterns creates variability in sward structure and nutritive value (Possingham and Houston, 1990; Adler et al., 2001), the effects of such practices are frequently accentuated by the farm system SR (Laca and Demment, 1991). Despite the critical importance of grazing management practices to grazing science, and evidence of longer term conditioning effects of these practices (Hoogendoorn et al., 1992; Pulido and Leaver, 2003; Stakelum and Dillon, 2007), the integration and evaluation of alternative SR and grazing practice combinations over multiple years to evaluate the cumulative systemic effects on pasture productivity have seldom been undertaken.

Consequently, the objective of this study is to evaluate the cumulative effects of alternative integrated grazing strategies, incorporating alternative SR and grazing severities, on grassland productivity and grazing efficiency over multiple years within farm systems using perennial ryegrass dominant pastures.

MATERIALS AND METHODS

This study was undertaken at the Animal and Grassland Research and Innovation center, Teagasc Moorepark, Ireland (50°7 N; 8°16 W), over a 4-yr period (2009, 2010, 2011, and 2012). It formed part of a larger study designed to examine the biological and economic effects of alternative SR grassland systems, and a more detailed description of the animals, treatment, and experimental design has been reported previously (McCarthy et al., 2012). The on-site pastures used were predominantly perennial ryegrass (*Lolium perenne* L.) and had been reseeded over the previous 1 to 9 yr.

Experimental Design, Treatments, and Herd Management

In spring 2009, 138 high economic breeding index spring-calving Holstein-Friesian dairy cows were randomly assigned precalving based on parity, expected calving date, and economic breeding index to 1 of 3 whole farm SR treatments: low (2.51 cows/ha; **LSR**), medium (2.92 cows/ha; **MSR**), and high (3.28 cows/ha; **HSR**). Treatments were designed to represent alternative whole-farm SR that may be appropriate in a post-European Union milk quota, spring-calving, pasture-based milk production system. The experimental herd in the study was composed of elite animals (McCarthy et al., 2013b) and was managed with a compact spring-calving pattern that was closely aligned with the average pasture growth capacity of the site (50% of all animals calving in the first 2 wk of February, 90% calved by mid-March, and with a mean calving date of February 20). As a pasture-based production system, grazing commenced as cows calved in early February and the grazing season concluded in late November of each year. During December and January, all cows were dried off and housed on a diet of conserved pasture silage.