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Production and economic responses to intensification of pasture-based dairy production systems

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ABSTRACT

Production from pasture-based dairy farms can be increased through using N fertilizer to increase pasture grown, increasing stocking rate, importing feeds from off farm (i.e., supplementary feeds, such as cereal silages, grains, or co-product feeds), or through a combination of these strategies. Increased production can improve profitability, provided the marginal cost of the additional milk produced is less than the milk price received. A multiyear production system experiment was established to investigate the biological and economic responses to intensification on pasture-based dairy farms; 7 experimental farmlets were established and managed independently for 3 yr. Paddocks and cows were randomly allocated to farmlet, such that 3 farmlets had stocking rates of 3.35 cows/ha (LSR) and 4 farmlets had stocking rates of 4.41 cows/ha (HSR). Of the LSR farmlets, 1 treatment received no N fertilizer, whereas the other 2 received either 200 or 400 kg of N/ha per year (200N and 400N, respectively). No feed was imported from off-farm for the LSR farmlets. Of the 4 HSR farmlets, 3 treatments received 200N and the fourth treatment received 400N; cows on 2 of the HSR-200N farmlet treatments also received 1.3 or 1.1 t of DM/cow per year of either cracked corn grain or corn silage, respectively. Data were analyzed for consistency of farmlet response over years using mixed models, with year and farmlet as fixed effects and the interaction of farmlet with year as a random effect. The biological data and financial data extracted from a national economic database were used to model the statement of financial performance for the farmlets and determine the economic implications of increasing milk production/cow and per ha (i.e., farm intensification). Applying 200N or 400N increased pasture grown per hectare and milk production per cow and per hectare, whereas increasing stocking rate did not affect pasture grown or milk production per hectare, but reduced milk production per cow. Importing feed in the HSR farmlets increased milk production per cow and per hectare. Marginal milk production responses to additional feed (i.e., either pasture or imported supplementary feed) were between 0.8 and 1.2 kg of milk/kg of DM offered (73 to 97 g of fat and protein/kg of feed DM) and marginal response differences between feeds were explained by metabolizable energy content differences (0.08 kg of milk/MJ of metabolizable energy offered). The marginal milk production response to additional feed was quadratic, with the greatest milk production generated from the initial investment in feed; 119, 99, and 55 g of fat and protein were produced per kilogram of feed DM by reducing the annual feed deficit from 1.6 to 1.0, 1.0 to 0.5, and 0.5 to 0 t of DM, respectively. Economic modeling indicated that the marginal cost of milk produced from pasture resulting from applied N fertilizer was less than the milk price; therefore, strategic use of N fertilizer to increase pasture grown increased farm operating profit per hectare. In comparison, operating profit declined with purchased feed, despite high marginal milk production responses. The results have implications for the strategic direction of grazing dairy farms, particularly in export-oriented industries, where the prices of milk and feed inputs are subject to the considerable volatility of commodity markets.
Key words: profitability, marginal response, supplementary feed, marginal economics

INTRODUCTION

Dairy production systems have achieved major productivity increases through improvements in cow genetics and animal husbandry practices. For example, Capper et al. (2009) estimated that 21% of animals, 23% of feedstuffs, 35% of the water, and only 10% of the land were required to produce 1 billion kilograms of milk in a modern housed dairy system in the United States when compared with the prevalent system of farming in the 1940s. Similarly, in grazing systems, Macdonald et al.

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(2008b) reported that over 30 yr, genetic improvements alone resulted in a 16% increase in milk yield, a 21% increase in milk fat production, and a 26% increase in milk protein, with only a 2% increase in maintenance requirements. These production increases resulted from greater milk production responses to additional feed, as there was a linear increase in the yield of milk components when the modern genetic strain was allocated additional feed, up to an allowance of 7 t of DM/cow per year (63 g of fat and protein for each kilogram of DM of additional feed allowance). In comparison, the 1970 dairy cow genetic strain produced no additional milk when offered a feed allowance above 5,700 kg of DM/cow per year (Macdonald et al., 2008b).

Grazing production systems are popular because of the simplicity of establishment and low operating costs compared with housed systems (Dillon et al., 2005; Macdonald et al., 2008a; Ramsbottom et al., 2015). However, despite low operating production costs, the capital cost of land is considerable and is fixed. In theory, therefore, it would be economically prudent to dilute the cost of land through greater production per hectare (McLaren et al., 2005), provided the cost of marginal production is less than the price received for milk. Greater milk production on efficient grazing dairy farms occurs through the provision of additional feed to increase production (Ramsbottom et al., 2015). The additional feed can be provided from within the dairy platform, for example, by using N fertilizer to increase pasture production (Whitehead, 1995), through planting a proportion of the farm in high-yielding crops (e.g., corn for silage), or through the importation of feed from sources external to the dairy platform (i.e., supplementary feed; Bargo et al., 2003). The greater response to additional feed in modern cows compared with previous generations would support the intensification of grazing systems through increasing feed allocation per cow and per hectare to improve profitability through the dilution of fixed costs.

Little has been published on milk production responses to applied nitrogenous (N) fertilizer within the context of the full farm system, despite a wealth of publications on the pasture production response to this input variable (see Whitehead, 1995). Nevertheless, it is a valid technology for increasing the availability of feed per cow and per hectare. In comparison, marginal milk production responses (**MMPR**) to supplementary feeds have been extensively explored in short-term component experiments (see reviews by Stockdale, 2000; Bargo et al., 2003), longer-term full lactation or multiyear farm system experiments (Kennedy et al., 2002; Horan et al., 2005; Roche et al., 2006, 2013), and from commercial farm databases (Ramsbottom et al., 2015; DairyCo, 2013). Published responses range from 0.8 kg of milk/kg of DM concentrate fed on commercial farms (Ramsbottom et al., 2015), to 1 kg of milk/kg of DM concentrate fed in component experiments (Stockdale, 2000; Bargo et al., 2003), and 1.2 kg of milk/kg of concentrate DM fed in whole-lactation farm systems experiments (Horan et al., 2005; Roche et al., 2013). However, very little published information exists on the marginal cost of the additional milk relative to the marginal production response.

As profit is linearly related to pasture utilization per hectare (Ramsbottom et al., 2015), grazing systems that use imported feeds are designed to use supplementary feeds to fill feed deficits per cow that are generated through increasing the stocking rate beyond what is optimal in a system that does not import supplementary feed (Macdonald et al., 2008a). As a result, substitution rate is minimized and biological responses to supplementary feeds are likely to be ≥1 kg of milk/kg of supplement DM. However, the intricacies of the interactions between stocking rate, N fertilizer, and imported supplementary feeds have not been investigated within the context of the total farm system, where (a) longer-term effects of supplementary feeds on late-lactation BCS, lactation length, and milk production across years could result in greater than anticipated MMPR to the supplementary feeds provided, but (b) the fixed costs associated with additional cows could undermine, at least in part, the benefits of the increased revenue from milk production per hectare (Macdonald et al., 2011).

The objective of the current experiment was to determine, in a multiyear farm systems context, the biological and economic responses to increasing the milk production output from a grazing dairy system (i.e., intensification). Milk production was increased (a) by using N fertilizer to grow more pasture on the dairy farm, (b) by increasing stocking rate, (c) through the importation of corn grain or corn silage, or (d) through a combination of increased stocking rate, N fertilizer, and corn grain or corn silage. The experiment was undertaken over 3 yr and the consistency of farmlet response to treatment was assessed.

MATERIALS AND METHODS

This experiment was undertaken at No. 2 Dairy Farm, DairyNZ, Hamilton, New Zealand (37°47′S, 175°19′E; 40 m above sea level) over 3 yr. The experimental area was a permanent grassland site and pastures were predominantly ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.), on a Te Rapa peaty silt loam soil, a Humic Aquic Haplorthod in soil taxonomy or a Humose Groundwater-Gley Podzol in the New Zealand classification.