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Using models to establish the financially optimum strategy for Irish dairy farms

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ABSTRACT

Determining the effect of a change in management on farm with differing characteristics is a significant challenge in the evaluation of dairy systems due to the interacting components of complex biological systems. In Ireland, milk production is increasing substantially following the abolition of the European Union milk quota regime in 2015. There are 2 main ways to increase the milk production on farm (within a fixed land base): either increase the number of animals (thus increasing the stocking rate) or increase the milk production per animal through increased feeding or increased lactation length. In this study, the effect of increased concentrate feeding or an increase in grazing intensity was simulated to determine the effect on the farm system and its economic performance. Four stocking rates (2.3, 2.6, 2.9, and 3.2 cow/ha) and 5 different concentrate supplementation strategies (0, 180, 360, 600, and 900 kg of dry matter/lactation) resulting in 20 different scenarios were evaluated across different milk, concentrate, and silage purchase prices. Each simulation was run across 10 yr of meteorological data, which had been recorded over the period 2004 to 2013. Three models—the Moorepark and St Gilles grass growth model, the pasture-based herd dynamic milk model, and the Moorepark dairy systems model—were integrated and applied to simulate the different scenarios. Overall, this study has demonstrated that the most profitable scenario was a stocking rate of 2.6 cow/ha with a concentrate supplementation of 600 kg of dry matter/cow. The factor that had the greatest influence on profitability was variability of milk price.
Key words: grazing intensity, concentrate supplementation, models, economic

INTRODUCTION

With the end of the European Union milk quota regime in 2015, dairy farmers have an opportunity to expand their dairy enterprises unhindered for the first time in a generation. For most farmers, restrictions at a farm level moved from a scenario in which they are limited by milk quotas to a scenario in which some other features of the farm will be limiting. For most farmers, this will be land. Research has demonstrated that increasing stocking rate (**SR**) will result in an increase in milk production per hectare and at the same time will be associated with a reduction in postgrazing height, thus decreasing grass intake per cow and ultimately reducing milk production per cow (McCarthy et al., 2013) if not associated with an increase in grass growth or concentrate supplementation. Conversely, increasing the amount of concentrate fed will result in an increase in milk production per cow at any given SR. The increase is dependent on the level of initial underfeeding in the herd, mainly driven by the overall farm SR (McEvoy et al., 2008) as well as dairy cow genetics. For dairy farmers, the effect on performance of various strategies needs to be evaluated at farm level in terms of overall farm performance and, ultimately, economic performance. Indeed, the effect of SR and concentrate supplementation is highly dependent on the type of animal and the overall grass growth on the farm (Dillon et al., 2003). Dairy farms in Ireland in general have a type of animal that has been selected for a balance of milk production and fertility traits that are adapted to the Irish grazing system (e.g., compact spring calving, extended grazing season; Berry et al., 2014).

Farms are complex, and there is no easy way to calculate the perfect economic system due to the presence of many interactions. For example, optimal economic performance can change with variations in grass growth, differing SR, and variation in prices of milk and concentrates. To investigate the economically optimum strategies for a farm under various SR and for different amounts of concentrate feeding, the use of

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mechanistic models is beneficial. The models used must be capable of simulating the complex interactions of the system, including the effect of increasing fertilizer levels on grass growth; the effect of grazing severity on animal intake, milk production, and BCS; and the effect of all of these characteristics on farm profitability. Several models and scenarios have been developed and used in the dairy industry all over the world to answer complex industry questions in recent years (Schils et al., 2007; McDonald et al., 2013). Examples of such research in Ireland include investigating the effect of soil type and climatic conditions on overall farm profitability (Shalloo et al., 2004a), the effect of genotype and feed system on system profitability (McCarthy et al., 2007), the effect on profitability of introducing sexed semen technologies in cows and in heifers (Hutchinson et al., 2013a, b), and the effect on profitability of expansion of the dairy industry (McDonald et al., 2013). All of those studies used an Irish whole-farm model to evaluate different options with data obtained from empirical studies (Shalloo et al., 2004b). Models have been used in other countries to simulate the long-term effects of a technology or a strategy on a farm by simulating the technology over many years (Rotz et al., 1989). Schils et al. (2007) used the model DairyWise to explore future farm strategies for individual farms and for study groups of farmers working under similar environmental conditions.

In this study, 3 previously described models were used to evaluate 20 different options across different grazing systems and concentrate feeding levels. The models included a grass growth model, the Moorepark and St Gilles grass growth model (**MoSt GG**; Ruelle and Delaby, 2016; Ruelle et al., 2016b), which has been merged with an animal intake and performance model (Ruelle et al., 2015, 2016a). The outputs from those models have been combined into the Moorepark dairy systems model (**MDSM**; Shalloo et al., 2004b) to evaluate the overall effect of 20 options on the economic performance of the farm. The analysis was conducted with a cow that had been selected for a balance of traits encompassing both milk production and fertility over a 14-yr period (Berry et al., 2014).

The objective of this study was to evaluate the economics of expansion across different system options for dairy farmers in a post–European Union quota environment. Four different SR and 5 concentrate supplementation strategies were examined across a range of different milk and concentrate price scenarios.

MATERIALS AND METHODS

Three separate models were integrated to simulate the production system (Figure 1).

Description of the 3 Models

MoSt GG Model. The MoSt GG model is a dynamic model developed in C++ (Ruelle and Delaby, 2016; Ruelle et al., 2016b) and based on the Jouven grass growth model (Jouven et al., 2006). A nitrogen submodel as well as a water submodel have been added to the Jouven grass growth model to create the MoSt GG model. The model simulates grass growth with a daily time step taking into account soil water and soil N dynamics. The model uses weather (temperature, solar radiation, and rainfall) and farm management (fertilization, harvesting, and grazing) information as inputs to complete the simulations.

Pasture-Based Herd Dynamic Milk Model. The pasture-based herd dynamic milk (**PBHDM**) model is a dynamic, stochastic agent–based model developed in C++ (Ruelle et al., 2015). The PBHDM model comprises the herd dynamic milk model (Ruelle et al., 2016a) adapted for grazing conditions and management. Each animal and paddock are described and simulated individually on a daily basis. The model simulates all aspects of the life of an animal from birth to culling and death through several different submodels. The submodels included in the PBHDM model include fertility, intake, animal growth, BCS change, and milk production. The model simulates each individual animal at grazing and is dependent on the animal characteristics but also on grass availability and quality, with a decrease in animal intake during the defoliation process included in the model. Within the model, grassland management-based decision rules are included to ensure realistic simulations. Animals move from one paddock to another based on a fixed residency time in the paddocks or based on an objective postgrazing height that can be either fixed or dependent on the pregrazing height. The farm cover is evaluated daily and is compared with the requirement of the cattle. In situations in which there is an excess of farm cover on the overall farm, some paddocks can be allocated for silage conservation rather than grazed and vice versa if paddocks are closed for silage. In the case of grass deficit (subject to the management rules defined by the user), forage or concentrate supplementation can be added to the diet. The PBHDM model has been evaluated in terms of milk production, weekly BCS, grass harvested per hectare, pre- and postgrazing height, and residence time across 2 data sets in Ireland and France (Ruelle et al., 2015). The MoSt GG model has been incorporated within the PBHDM to predict directly the grass growth for each paddock in the model, thus reacting to the management and interacting with the animals.

MDSM. The MDSM (Shalloo et al., 2004b) is a stochastic budgetary simulation model with the objective