Models for predicting effects of management factors on per-cow and per-hectare pasture intake by grazing dairy cows

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Abstract

Robust modelling of pasture herbage intake by grazing dairy cows under a wide range of grazing and supplementary feeding strategies allows the better combination of high rates of pasture utilisation and nutrition management in dairy systems. The GrazeIn model has been developed from 10 years at INRA (France) from extensive literature review and large experimental databases, and then validated at European level. It allows prediction of the effects of animal characteristics, sward nutritive value, grazing management (grazing system, pasture allowance, pasture mass, daily access time) and supplementation (concentrates and/or forages), along with their interactions, on daily pasture dry matter intake by grazing dairy cows. Grazing management and sward structural characteristics are, however, often unknown on farm. For that reason, a simplified version of the model describing sward state and management through only pre-grazing and post-grazing sward heights has also been developed, allowing easier use of the model for advising or teaching. After a brief description of the two versions of the model, the relative effects of the main factors affecting pasture intake are compared on a per-cow and on a per-hectare basis.

Keywords: grazing, intake, dairy cow, modelling

Introduction

Increased efficiency of grazing systems for dairy cattle production requires a better estimation of cow intake and performance according to management practices. Grazing management factors (pasture allowance, pre- and post-grazing sward height, daily access time), mostly depending on the farmer's decisions, are known to affect daily intake at pasture, in interaction with cow characteristics, pasture nutritive value and supplementation strategy. As pasture herbage intake at grazing is always difficult to measure, accurate predictive models may be used to help decisions, such as GrazeIn (Delagarde *et al.*, 2011a; Faverdin *et al.*, 2011), provided the required input information is available. However, at farm level, precise description of sward state is not available, and simplified models may be needed. After describing the complete and simplified version of GrazeIn, this paper will focus on the main factors determining per-cow and per-hectare intake at pasture and its use-efficiency.

Materials and methods

GrazeIn predicts pasture herbage intake through two steps. Firstly, sub-models for animal intake capacity and requirements, forage feed value and substitution rate between forages and concentrates through iterative calculations allow the calculation of the voluntary dry matter (DM) intake at pasture (as if the grazed pasture herbage was cut and given *ad libitum* indoors). Secondly, the relative intake at grazing is calculated, as a proportion of voluntary intake, taking into account the effects of pasture herbage allowance and pasture mass under strip- or rotational grazing, sward surface height under set-stocking, and daily access time to pasture under all grazing systems. Pasture herbage allowance and pasture mass effects are combined through the calculation of the relative pasture allowance above 2 cm from ground level, which allows the simulation of the positive or negative effects of pasture mass on intake in relation to cutting height as found in the literature (Pérez-Prieto and Delagarde, 2012). External validation with several datasets from Europe showed an average mean prediction error for pasture herbage intake of 10 to 16%, with no source of bias identified for sward or grazing management factors at herd and paddock level, whatever the season (Delagarde *et al.*, 2011b; O'Neill *et al.*, 2013).

The simplified version of the model was developed with the objective to use pre- and post-grazing sward heights as the sole descriptors of pasture availability, avoiding the need for estimating pasture herbage mass and allowance. Empirical multiple regressions were calibrated from thousands of grazing and feeding situations by using the complete GrazeIn model, in order to predict successively pasture DM intake without supplementation, the substitution rate of any conserved forage given as supplement, and the concentrate substitution rate if cows are fed concentrates (Faverdin *et al.*, 2007). Required daily area or paddock residency time to achieve the post-grazing sward height are also predicted. A single spreadsheet calculator allows a rapid calculation of pasture herbage intake per cow and per hectare in relation to cows, pasture, management and supplementation characteristics.

Results and discussion

This section focuses on key messages about the known effects of management factors affecting per-cow and per-hectare pasture intake and milk production, derived from literature review and using both versions of the GrazeIn model. High pasture quality (leafy swards, high organic matter (OM) digestibility, presence of legumes) has a major impact on milk production per cow due to its cumulative effect on pasture energy concentration and voluntary intake. As an example, increasing OM digestibility from 0.7 to 0.8 increases daily net energy (NE) intake by 20-25%.

Grazing severity may be viewed as the degree of restriction of pasture intake (at grazing) when expressed as a proportion of voluntary intake (indoors with no restriction). Relationships between pasture allowance and pasture intake show that grazing management strategy may be defined as lax, severe and very severe for relative intake restrictions of 1.0, 0.9 and 0.8, respectively. Grazing is called lax when cow intake is not restricted because it is achieved with high area per cow and low number of grazing days per hectare. During one grazing rotation, a severe grazing enables 45% increase in grazing days and 30% increase in milk production per hectare, when compared to lax grazing. During a grazing season (cumulated rotations), it may be estimated that pasture intake and milk production per cow varies 8 times less per cow than per hectare when stocking rate is affected (McCarthy *et al.*, 2011; Peyraud and Delagarde, 2013). In the current range, pre-grazing sward height (or pasture mass) or post-grazing sward height considered alone are bad indicators of pasture intake. However, the relative post-grazing sward height, when expressed as a proportion of pre-grazing sward height, is well related to pasture allowance and intake. Relative post-grazing sward height of 0.5, 0.4 and 0.3 are indicative of lax, severe and very severe grazing, respectively.

From lax to very severe grazing management, substitution rate between pasture and concentrates normally ranges from 0.5 to 0.0, and substitution rate between pasture and a forage supplement ranges from 1.0 to 0.5. Recommendations of supplementation level when daily access time to pasture is limited may also be given (Peyraud and Delagarde, 2013).

The complete GrazeIn model is currently used in INRAtion (www.inration.educagri.fr), a commercially available software for formulating diets of ruminants, in commercial tools of the French institute of performance control, in an INRA whole-farm model, and will be used after some adaptations in Irish grazing management tools by Teagasc. The simplified model is partially used in a pasture simulation model in France, and in several French experimental farms to estimate pasture DM intake at year level when platemeter heights are measured. Both versions of the model are also used for teaching in France.

Conclusions

Prediction of pasture intake by grazing dairy cows needs models sensitive to grazing system and grazing management factors. Several validated models adapted to the available grazing management information exist and may be used for advising, teaching and thinking on impacts of grazing management strategies.

The relatively low variation of intake per cow compared to that of intake per hectare when grazing pressure is changed shows that increasing efficiency of dairy cattle grazing systems should focus on pasture-use efficiency rather than on individual cow performance or on grazing system or sward state. In all situations, the quality of pasture herbage is a primary factor enabling high per cow performance at low use of concentrates.

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