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Herbage Growth Models as Aids for Managing Intensively Grazed Grassland in Western Europe

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Summary: Estimates of variation in herbage growth are presented to demonstrate the problems which unforeseen variation can create for management of intensively grazed grassland in temperate Western Europe. The role of growth models in predicting herbage availability as a component in feed budgeting is described. Herbage growth models share a common structure and produce output in response to weather conditions; others also take account of soil properties. Growth models can be applied as aids to grassland management either as 'stand alone' models or can be an integral part of a decision support system and used to predict outcomes from whole farming systems. Although the reliability of models has been well demonstrated in many instances, their value to farmers as an aid to managing grassland intensively needs to be re-enforced.
Key words: grasslands, feed budgeting, herbage growth models, Western Europe

Introduction

Forage can be considered as a raw material in the 'manufacture' of ruminant products. However, unlike most industrial raw materials it is not possible to control with accuracy the amount which will be available. Consequently, any means of predicting growth and quality of herbage for a given set of conditions offers the farmer some control over forage as an input. Problems of variation apply to herbage grown either for forage conservation or grazing. However, it is more critical for management of grazing swards as grass is utilised more closely to the time that it has been produced than for forage grown for conservation and so there is less opportunity to make contingency plans when herbage is either scarce or is more plentiful than required by the grazing animals. Grass growth models, as a means of predicting production for a given set of conditions, can be used to help farmers plan their grazing strategy and as an early warning system of periods of excess or shortage before they arise.

Variation in Herbage Growth

Seasonal grass growth rate curves vary widely over western and northern Europe reflecting the range of climatic conditions (Fig. 1). So, while countries with short growing seasons, such as Finland and Iceland, rely heavily on conserved feed to meet the needs of ruminants, those with longer growing seasons have the opportunity to exploit fully the benefits of grazing.

However, even when grassland at the same site is managed consistently, herbage growth can vary widely from year to year, especially in intensively managed grassland systems. This variation is mainly due to year-to-year variation in weather and its interaction with other environmental conditions such as soil. Spring growth is important for grassland farms in which animals are housed over winter as a late spring extends the time the animals remain indoors and have to be fed expensive conserved forage and/or supplements. Grass growth rates for spring production in variety assessment trials of perennial ryegrass in Northern Ireland ranged from 21 to 100 kg DM/ha/day over 15 years.

Feed Budgeting

The concept of feed budgeting provides a basis for allocating grassland areas for short term and long term use (Mayne et al. 2000). In rotational grazing where the grassland area is divided into paddocks, a combination of a) knowing the daily feed requirements of the grazing animals, b) the current amount of herbage available and c) the anticipated growth allows the number of paddocks required for

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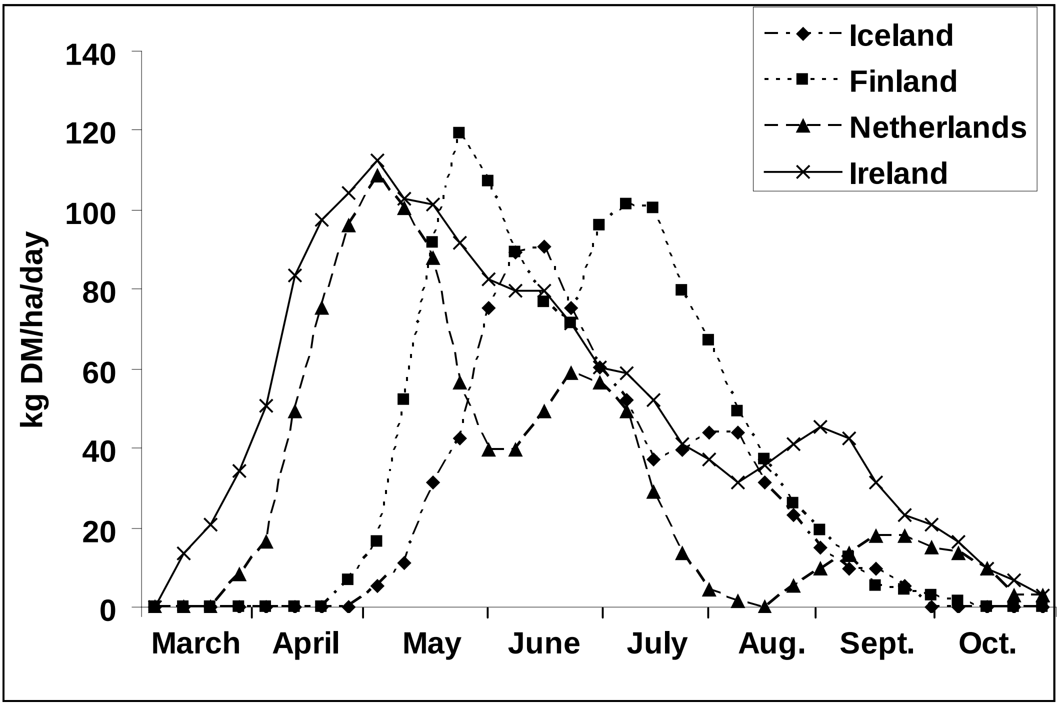

Figure 1. Daily grass growth rates for a range of sites in western and northern Europe (Corrall 1984)
Slika 1. Dnevne količine proizvedene krme na većem broju lokaliteta u zapadnoj i severnoj Evropi

grazing in the near future to be determined and so the rest of the paddocks can be set aside to be cut for silage or hay. This ensures that maximum use is made of the herbage available. The excess conserved forage can be fed as a 'buffer' when grazing grass becomes scarce or can supplement the pool of winter fodder.

The farmer will know approximate intake requirements of animals either from experience or from tables of information. There are techniques available to help farmers estimate the amount of herbage currently in the paddocks. As it is not feasible to expect a farmer to take sample cuts to estimate herbage availability, indirect methods have been developed. A common method used is a 'rising plate' in which a disc or plate of specific weight slides on a graduated shaft. The assembly is placed vertically into the sward and the density and height of the sward determines how high the disc is above ground level. Equations are supplied with the equipment relating height above ground to herbage mass. So the estimated herbage mass (availability) can be calculated by the equation for a given sward height.

The third criterion for budgeting feed is anticipating growth. Grass growth models have a role to play in reducing uncertainly in intensive grassland management either as stand-alone aids or as integral components in decision support systems in which they are used in conjunction with whole-farm models which predict intake and animal or milk production.

Basis of Growth Models

A model is a representation of a real life system. So, a herbage growth model which represents herbage growth for a given set of conditions at a specific time of the year, is able to provide outcomes from a range of scenarios i.e. predictions.

Whether complex or a crude representation of reality, most grass growth models have a number of components in common i.e. a conversion of light (solar radiation) to dry matter, distribution of dry matter between plant parts, and loss of herbage due to utilisation or senescence and death (Fig. 2). The amount of solar radiation obviously influences the first component, while temperature, available soil moisture and nutrients (especially the major nutrients and nitrogen in particular) and stage of development influence all of these components. These components interact, such as the amount of leaf lamina produced has an affect on the interception of solar radiation. In

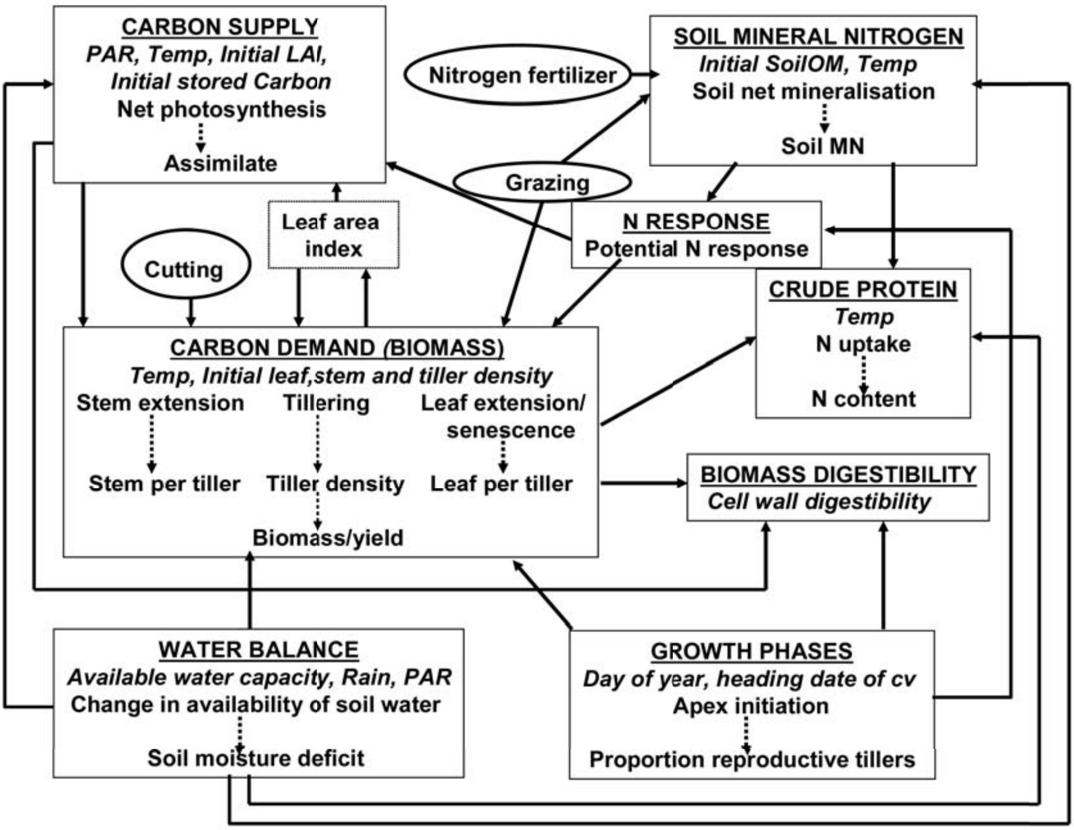

Figure 2. Schematic representation of an herbage growth model
Slika 2. Shematizovani prikaz modela proizvodnje krme

addition some models include herbage quality as an output, especially digestibility and crude protein content (Groot & Lantinga 2004).

Probably the most comprehensive grass growth model is that of Thornley (1998) which is based on the Hurley Pasture Model. The model is complex but routines and sub-models within it can be isolated and applied to specific aspects of grassland growth and herbage species development. Due to its complexity, the Hurley model is often used more as a research tool.

Some advanced models include more than one species e.g. grass and white clover and so the interaction between the species both above and below ground is considered (e.g. Thornley et al. 1995). So the model is extended to take account of soil factors which influence growth. Inclusion of the grazing animal embraces the interaction between different species in the mixture and intake, including selection by the animal (e.g. Parsons et al. 1991). These plant-animal-soil models form the basis of decision support systems in which the next step is to frame the model to fit specific production systems. This is considered in the next section.

Other grass growth models have been developed to take account of different semi-natural grassland communities. For example, the model of Jouven et al. (2006) includes differences in grassland species, classified as different functional groups, and their adaptation to different grassland conditions. The most productive functional group contains species which are adapted to fertile sites and frequent defoliation (with high specific leaf area, high digestibility, short leaf lifespan and early reproductive growth). In contrast, the least productive contains those which are adapted to poor sites and infrequent defoliation (with low specific leaf area, low digestibility, very long leaf life span and very late reproductive growth).

Application of Herbage Growth Models in Grassland Management

A herbage growth model can be used as a management aid either as a stand-alone method

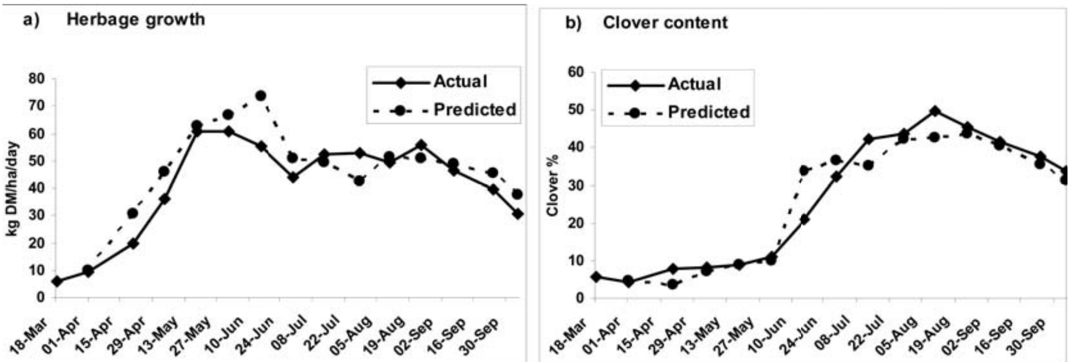

Figure 3. Actual and predicted a) daily growth rate and b) white clover content in dry harvested dry matter in two series of plots at each of 7 CloverCheck sites in Northern Ireland in 2009

Slika 3. Trenutne i predviđene vrednosti a) dnevnih proizvedenih količina i b) udela bele dateline u pokošenoj suvoj materiji u dva niza parcela na svakom od sedam CloverCheck lokaliteta u Severnoj Irskoj 2009. godine

to predict growth, and so can be used as an input to grass budgeting calculations, or as an integral component of a decision support system. In the latter, the growth model is linked to a herbage intake model which in turn can predict animal production.

Application of 'stand-alone' grass growth models

In the herbage growth monitoring and forecasting system in Northern Ireland, called GrassCheck, the model originally developed as GrazeGro (Barret & Laidlaw 2005), is used to predict growth while the network of monitoring plots provides information on growth and quality of herbage up to a specific date. The monitored and forecasted growth information is publicised weekly in farming press and on appropriate websites for farmer to use in their grass budgeting calculations. The model is specifically built for intensive grassland management and so inputs to drive the model include N fertiliser application, and forecasted daily air temperature, photosynthetically active radiation and rainfall.

In contrast, a grass/white clover monitoring and forecasting system in the Province, CloverCheck, has been developed for farmers who are applying no (e.g. organic dairy and beef farmers) or very low levels of nitrogen fertiliser and so are relying heavily on white clover as a source of nitrogen (Laidlaw et al. 2007). CloverCheck bulletins are published fortnightly and emphasis is on herbage growth and clover content. Plots are in two series at each site, harvested every 4 weeks 2 weeks apart. Actual and predicted herbage growth and clover content from the 7 monitor sites in 2009 are presented in figure 3.

Despite the sites ranging from upland beef farms to lowland organic dairy farms agreement between actual and predicted outputs is reasonably good. Although the data from cut plots are applied to grazed swards, the disadvantage of grazing plots instead of cutting them is that high variation is introduced and it is not practical to manage a network of grazed plots widely distributed. While grazing has a relatively small effect on grass swards compared with cutting, especially those receiving relatively high rates of nitrogen fertiliser, the difference between cut and grazed swards is high for grass/clover swards. In CloverCheck the data have to be converted when applied to grazed swards. Growth in grazed swards is about 75% of that of plots and clover content relative to that of cut plots declines to 40%, or less, that of plots in summer (Laidlaw 2008).

While a model may be capable of predicting growth with sufficient accuracy when the inputs are known, relying on forecasted weather as a set of inputs introduces an additional source of variation in the prediction. So limitations to forecasting weather, especially one to two weeks ahead, may limit the effectiveness of application of a model

Use of models in decision support systems for grassland management

When a growth model is linked to other models, especially animal intake and production models, and represent complete systems of production, they can function as decision support systems. The whole farm model SEPATOU in France (Cros et al. 2003) and Dairy-sim in Ireland (Fitzgerald et al. 2008) each incorporate a grass-growth sub-model which predicts herbage growth and, in the case of SEPATOU, herbage quality. Dairy-sim, having been tested against output data from different climatic areas in Ireland, was used to simulate and predict outcomes on dairy farms on wet heavy soils. Contrasts were drawn between these farms and those on light free draining soils, with the model predicting lower practicable stocking rates and higher housing requirements than on farms on the drier soils.

The model developed by Jouven et al. (2006) already discussed, has been built into a full systems model simulating suckler cow and calf production in permanent grassland in France, called SEBIEN (Jouven & Baumont 2008). They have used the model to determine the extent to which acceptable animal production can be achieved using biodiversity-friendly management. The output of the model has shown that, overall, balance between animal production and biodiversity is possible but while some paddocks had a high level of floristic diversity, others were adversely affected, emphasising the need for whole farm simulation rather than simulating events in only one paddock.

Conclusions

The herbage growth models cited are only a small selection of those either being developed or are currently being applied to grassland farming in Europe. While models can be effective aids to understanding complex interactions between components in the sward-animal-soil system, more effort is required to educate farmers in the value of output of herbage growth models. Formal courses are unlikely to be effective but repeated demonstration of the reliability of prediction of herbage growth models, particularly in periods where weather has resulted in forage shortages, may convince farmers of their value.

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Modeli proizvodnje krme za negu intenzivno korišćenih travnjaka zapadne Evrope

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Izvod: Procene variranja proizvodnje krme izložene su u svrhu ukazivanja na probleme koje mogu da izazovu nepredviđena variranja u nezi intenzivno korišćenih travnjaka u oblastima zapadne Evrope sa umerenom klimom. Opisana je uloga modela proizvodnje u predviđanju raspoloživosti krme kao činioca krmnog budžeta. Modeli proizvodnje krme poseduju zajedničku strukturu i ostvaruju proizvode u zavisnosti od vremenskih uslova, dok drugi, pak, uzimaju u obzir i zemljišne uslove. Modeli proizvodnje mogu da se primene u nezi travnjaka bilo kao pojedinačni modeli, bilo kao integralni deo sistema odlučivanja i u svrhu predviđanja ishoda čitavih sistema poljoprivredne proizvodnje. Iako je isplativost modela dokazana na više načina, potrebno je potvrditi vrednost koju imaju za farmere prilikom nege intenzivno korišćenih travnjaka.

Ključne reči: krmni budžet, modeli proizvodnje krme, travnjaci, zapadna Evropa