A DYNAMIC MODEL FOR CHANGES IN NUTRITIONAL VALUE IN GRASS. AN APPROACH TO MODIFY THE MODEL TO A MIXED LEY WITH GRASS AND RED CLOVER

A.-M. Gustavsson

Department of Agricultural Science in Northern Sweden, Swedish University of Agricultural Sciences, P. O. Box 4097, S-904 03 Umeå, Sweden

ABSTRACT

The objective of this approach was to check the possibility to modify a dynamic model for simultaneous simulation of the above-ground dry matter growth (DM) and concentrations of crude protein CP) and metabolizable energy (ME) in stands of timothy (*Phleum pratense* L.) to a model for mixed leys with timothy and red clover (*Trifolium pratense* L.). DM growth is estimated in relation to intercepted radiation, air temperature, soil-water status and tissue-N concentration. CP is estimated in relation to plant uptake of N from soil mineralization, nitrogen fixation and applied fertilizer, and dilution of N during plant growth. ME is estimated in relation to plant development as influenced by genotype, temperature and day length.

KEYWORDS

Dynamic model, red clover, timothy, digestibility, crude protein, nitrogen *Trifolium pratense*, *Phleum pratense*

INTRODUCTION

The main feedstuff for dairy cows in Sweden is forage conserved on the farm from temporary grasslands (leys) that are cut for silage or hay on one or more occasions during summer and autumn. The leys are dominated by timothy (*Phleum pratense* L.), both in pure stands and in mixtures with red clover (*Trifolium pratense* L.) and meadow fescue (*Festuca pratensis* Huds.). The optimal forage production for livestock can be spcified in terms of dry matter yield (DM) and concentrations of metabolizable energy (ME) and crude protein (CP).

The managerial tactics available to producers for optimizing the quantity and quality of forage are to vary the proportion between grasses and legumes, the amount of N fertilizer (applied in early spring to first cut) and the time of harvest. In a pure grass ley, more N fertilizer normally increases growth and, depending on the time of cut, may increase the CP concentration. In a mixed grass-clover ley, more N fertilizer normally reduces the clover content and, depending on the clover content and time, may increase the CP concentration and growth. Delayed harvest leads to increased DM but decreased ME and CP in both a mixed grass-clover ley and ina pure grass ley. In a mixed ley, a higher proportion of legumes may increase the CP concentration.

The objective of this modelling approach is to develop a theoretical model to enhance our understanding of the interactions between growth and changes in nutritional value with time, and provide information to assist farmers in managing grasslands for optimal rations to dairy cows.

MATERIALS AND METHODS

The growth and quality of leys with pure timothy *cv*. Bottnia II and mixed leys with timothy *cv*. Bottnia II and red clover *cv*. Bjursele were measured on four sites in Sweden, 1981-1984. The experiments consisted of three blocks containing plots of 60 m^2, from which samples of 10 m^2 were harvested weekly to determine DM, CP and ME. Mean curves from all experiments are presented in Fig. 1. Above-ground dry matter were harvested on five occasions. The ley was cut at a height of 5 cm. The harvested DM was analysed for CP using 6.25 times the Kjeldahl-N concentration (Nordic committee on Food Analysis, 1976) for ash by combustion and for digestible organic matter (DOM) using the method of Tilley and Terry (1963) as modified by Lindgren (1979).

The grass model is an integrated dynamic model where DM growth and changes in ME and CP concentrations in timothy are simulated simultaneously (Gustavsson et al., 1995). The model accounts for the fact that the three processes are affected by the similar environmental factors and are physiological interdependent.

The digestible organic matter growth is mostly dependent on the phasic development, which is affected by photoperiod, temperature and genetic factors. The DM growth is dependent on temperature, soil moisture content, radiation, canopy cover and on the feedback mechanism between concentration of nitrogen in the plant and the DM growth. Increased internal nitrogen concentration enhances growth rate, which in turn tends to reduce the internal nitrogen concentration. The CP concentration is dependent on the nitrogen situation in the soil and the DM growth.

The botanical inputs to the model are the measured values for DM, CP and ME in a calibration sample taken early in the season. The measured values are used to estimate: (a) the initial canopy cover, which can vary because of different over-wintering conditions, (b) the nitrogen mineralization rate, which is dependent on the nitrogen situation in the field, and (c) the parameters affecting the non-digestible organic matter content. The parameters affecting the non-digestible organic matter content are calibrated at this stage of model development, but there are indications that standard parameters can be used in the future (Gustavsson, 1995).

The other inputs are nitrogen fertilization level, date for nitrogen fertilization, latitude for estimation of photoperiod, water holding capacity of the soil and daily weather from the nearest meteorological station (rainfall, global radiation, screen temperature, humidity and wind speed).

Attempts were made to make the approach for the model as simple as possible and that it should work with as few inputs as possible. The user should be able to apply the model on an ordinary field.

RESULTS AND DISCUSSION

The differences in DM, CP and ME between legumes and grasses depend on differences in morphological characteristics, chemical composition and on the fact that legumes live in symbiosis with nitrogen fixing bacteria (*Rhizobium*).

Metabolizable energy. The decrease curves for metabolizable energy of grasses and mixed leys intersect, showing higher digestibility for grasses than for mixed leys in early season (Fig. 1).

Crude protein concentration. The legumes are supplied with nitrogen as a result of the symbiosis with *Rhizobium* bacteria. The N fixation by the *Rhizobium* is affected by soil temperature, soil moisture, N content in the soil and of supply of carbohydrates from the host plant. The curves for mixed leys decrease more slowly than for pure timothy due to greater N supply (Fig. 1).

Clover content. The clover content is dependent on many environmental factors. Factors that reduce the fixation lead to reduced content of legumes. Clover is also more sensitive to damage by ice, water and pathogens which leads to variations in clover content between different parts of a field. At this stage of model development the clover content is handled as an input parameter. The user has to walk through the field and estimate the clover content. To fully describe the system a population model is needed.

REFERENCES

Gustavsson, A.-M. 1995. Predictions of growth and nutritional value of forage leys with a dynamic model. Agricultural Systems **47**, 93-105.

Gustavsson, A.-M., J.F. Angus and B.W.R. Torssell. 1995. An integrated model for growth and nutritional value of timothy. Agricultural Systems **47**, 73-92.

Lindgren, E. 1979. The nutritional value of roughages determined *in vivo* and by laboratory methods. Swedish University of Agricultural Sciences, Department of Animal Nutrition, Report **45**. Uppsala.

Nordic Committee on Food Analysis. 1976. Nitrogen. Determination in foods and feeds according to Kjeldahl. UDC 543.846. No. **6**.

Tilley, J.M.A. and R.A. Terry. 1963. A two-stage technique for the in vitro digestion of the forage crops. J. Brit. Grassl. Soc. **18**:104-111.

Figure 1
Metabolizable energy concentration (ME), crude protein concentration (CP) and dry matter yield (DM). Mean values from four sites. (° mixed ley, 0+0 kg N ha^{-1}, l mixed ley, 60+30 kg N ha^{-1}, ® timothy ley, 60+30 kg N ha^{-1}, æ timothy ley, 120+60 kg N ha^{-1}).