Phenology of grasslands: a new model

Simon Rouet, Leclercq Denis, Marie-Hélène Bernicot, Didier Combes, Romain Barillot, Jean-Louis Durand

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Rouet Simon[1] (simon.rouet@inrae.fr), Leclercq Denis[2], Bernicot Marie-Hélène[2], Combes Didier[1], Barillot Romain[1], Durand Jean-Louis[1]

[1] *INRA, Lusignan, France*; [2] *GEVES, Lusignan, France*

Introduction

Understanding the phenology of grasses is crucial for grasslands management as it strongly affects the quantity and quality of the biomass. The floral transition (FT) of the apex is induced by the exposition to specific conditions of temperature and photoperiod. Under non-inductive climatic conditions, the apex is vegetative and continually produces leaves. After exposure to cold temperature and long photoperiod, the meristem completes its floral induction and starts floral development. Heading date (HD) constitutes a main marker of the reproductive development. Determinants of the HD identified are the advancement of floral induction, the final number of leaves and the development of the leaves and the spike. The aim of the present work is to present a model of FT for perennial grasses driven by environmental conditions. The HD is simulated from the phyllochrone and organ size, given by a functional-structural model of ryegrass. Model behaviour is assessed using a dataset of HD.

Material and Methods

The model of FT is based on an obligatory dual induction where the second phase follows the first one without any overlapping (Heide, 1994). Primary induction is achieved by a function of low temperature accumulation adapted from Sirius-wheat (He et al., 2012). Secondary induction is achieved after a given number of days with a minimum daylength. During the secondary induction phase, we assumed the plastochrone to decrease (leaves are initiated at a higher rate). When the secondary induction is completed, the apex produces spikelets instead of leaves. Until the start of the flag leaf growth, spikelet production stops. The model of FT is coupled with the L-grass structural-functional plant model (Verdenal, 2009) that describes leaf growth for ryegrass based on a self-regulation approach of architecture development. The growth of internodes and spike was implemented in the model based on coordination rules. After appearance of all leaves, the HD is then achieved when the cumulated length of the spike and the peduncle exceeds the length of the flag leaf sheath.
Calibration and validation of the model are realised with the HD of perennial ryegrass cultivars in seven sites in France over seventeen years.

Result and Discussion

Fig.1 presents intermediary demonstrative results of our model functioning. Finally, it provides the HD of the tiller. The model allows a dynamic calculation of the final leaf number in relation to environment. It shows the great importance of the climatic windows of tiller development on the final number. The tiller appears before the cold period (1st Oct.) produces more leaves than later tillers, mainly due to its longer vegetative period. Tillers appeared during the cold period (1st Dec. and 1st Feb.) reach their FT later than the previous one because of the need to complete primary induction. For these two cases, convergence of the final number of leaves can be explain by higher temperature between the two inductions for the tiller appeared on the 1st February. The tiller produced after the cold period (1st Apr.) produces an indefinite number of leaves due to the deficit of low temperature to complete primary induction.
This new model combined with a model of tillering and tiller mortality will help to study grassland dynamics (seed yields, perenniality).

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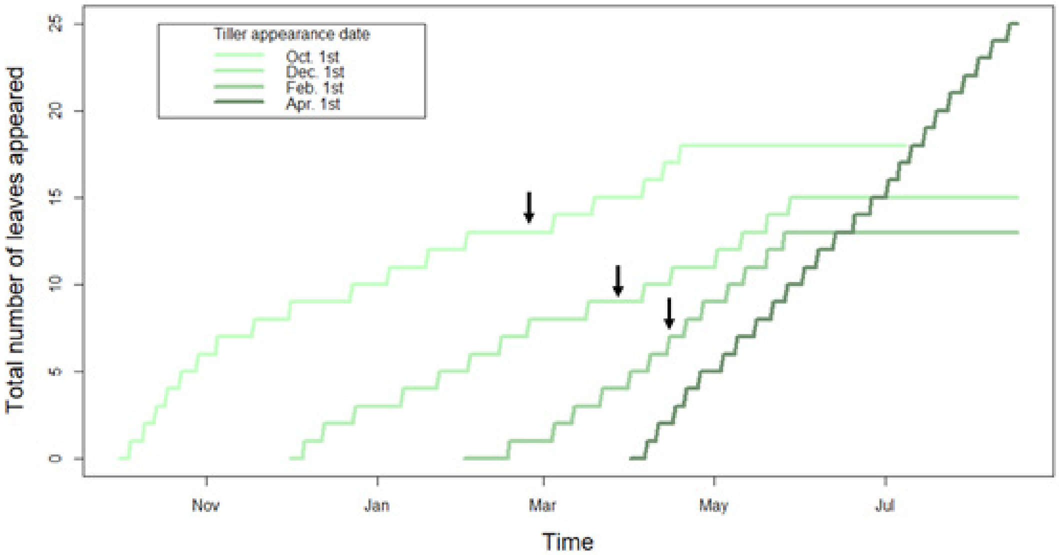

Figure 1. Simulated cumulated leaf on a tiller in relation to climate depending tiller appearance date. Arrows indicates dates of FT. Climatic data correspond to the year 2017-2018 in Lusignan, France.

Keywords: heading date, flowering, ryegrass, leaf number.

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