Translating short-term environmental effects on leaf growth rate into differences in whole-plant profiles of maize leaf area: Impact of temperature, evaporative demand and soil water status

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1 Context

Leaf growth is one of the first processes affected by environmental changes. Physiological studies often concentrate on short-term mechanisms, thus increasing the gap with whole-plant models designed to predict biomass accumulation, transpiration and yield in field conditions. We propose here a model to bridge this gap for maize leaf growth in response to temperature, evaporative demand (VPD) and water deficit (estimated with the predawn leaf water potential, Ψ).

2 Stable patterns provide the experimental base of a development model

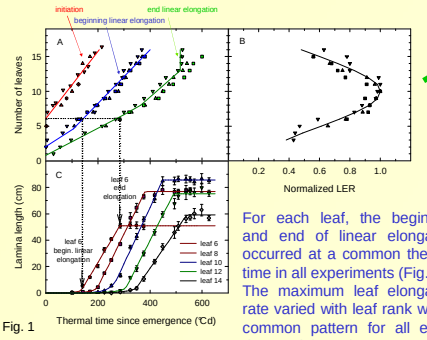


Fig. 1

For each leaf, the beginning and end of linear elongation occurred at a common thermal time in all experiments (Fig.1A). The maximum leaf elongation rate varied with leaf rank with a common pattern for all experiments (Fig. 1B).

3 Model

The model was calibrated with data performed in field, growth chamber and greenhouse experiments (first row). It combines (i) the estimation of key developmental stages (Fig. 2A) that fixes the period during which leaves grow, and (ii) environmental responses of leaf elongation rate (Fig. 2B-D) that are applied to every leaf (Fig. 2E). Each leaf thus expands during a fixed period at a rate determinate by the environmental factors (Fig. 2G).
This model of leaf growth and development was interfaced with the crop model APSIM for simulation of the leaf environmental variables (inputs of the leaf model) and for simulation at canopy level.

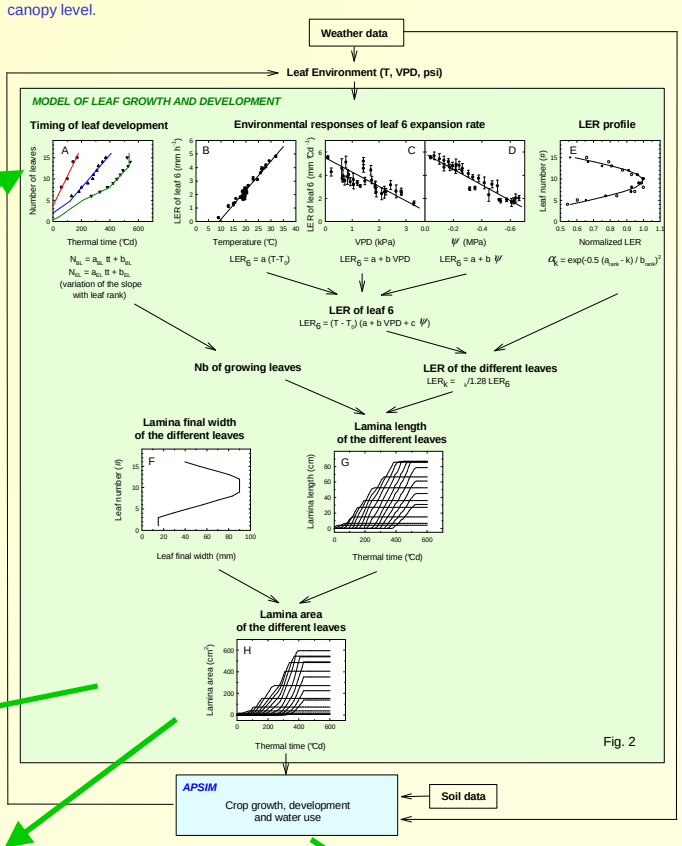
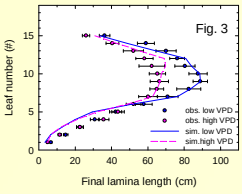


Fig. 2

4 Observed and simulated effect of evaporative demand, at whole-plant level



5 Observed and simulated effect of water deficit, at whole-plant level

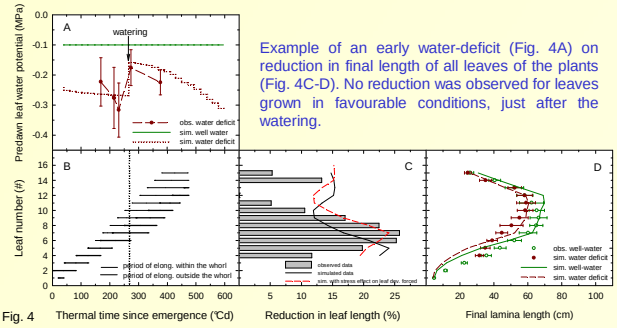
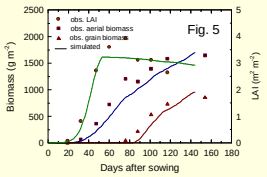


Fig. 4

Example of an early water-deficit (Fig. 4A) on reduction in final length of all leaves of the plants (Fig. 4C-D). No reduction was observed for leaves grown in favourable conditions, just after the watering.

6 Simulation at canopy level



7 Conclusion

This model extends existing physiological knowledge of leaf elongation responses to environmental conditions at the canopy level. Most of its parameters are stable characteristics of a genotype and can potentially be related to QTL. This model could thus be applied to determine how the genetic controls of leaf responses translate into yield differences in various set of environmental conditions.