Visualizing reaction of chrysanthemum to temperature and light: model calibration and validation

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Introduction

The external quality of chrysanthemum includes morphology (number and size) of stem, leaf and flower (Carvalho and Heuvelink, 2001). Each character is influenced by several growth conditions interacting with each other. Higher temperature increases internode elongation rate and number of flowers per plant, and reduces individual flower size (Carvalho et al., 2005); light intensity increases assimilate availability, and consequently the weight of the plant and number of flowers, whereas the size of the flowers is hardly influenced (Carvalho and Heuvelink, 2003).

Descriptive models for chrysanthemum have been developed for some quality aspects. However, several important quality aspects like flower characteristics and leaf size are absent, and the mentioned characteristics were never integrated in a single model. Functional-structural plant models (FSPMs) aim at modelling plant development and growth and their interactions. It is potentially a suitable tool for evaluating the external quality of ornamental crops. For chrysanthemum FSPMs have been developed based on L-systems (de Visser et al., 2006) and GreenLab methodology (Kang et al., 2006, Fig. 1). In the latter study, all the external quality aspects mentioned above, were computed by the model based on sink-source relations.

Fig.1. Virtual chrysanthemum (Kang et al., 2006)

The aim of the current study is modelling of the external quality of chrysanthemum in reaction to different combinations of temperature and light with the GreenLab model. The new feature is the feedback of plant production on plant development in order to simulate the architecture plasticity of chrysanthemum.

Material and Methods

Experiment setup and data collection

The experiment was conducted in growth chambers using block–rooted cuttings of Chrysanthemum 'Reagan Splendid'. 16 treatments were achieved, being combinations of four temperature (15^{o}C, 18^{o}C, 21^{o}C, 24^{o}C) and four light levels obtained with shading screens (100%; 297 µmol $m^{-2} s^{-1}$), (65%; 194 µmol $m^{-2} s^{-1}$), (51%; 152 µmol $m^{-2} s^{-1}$) and (40%; 118 µmol $m^{-2} s^{-1}$). Plants were1 placed at a density of 69 plants m^{-2}. CO_2 concentration was maintained at ambient level.

The first destructive measurement was carried out at planting and was followed by eight destructive measurements (every 7-10 days) on five plants per treatment, starting at the beginning of the short day (SD) period (15 days after planting). For each plant collected data (at plant level) includes the number of leaves on the main stem (MS), the length of MS, the area and weight of leaves on MS and side shoots (SS) respectively, the weight of MS and SS respectively, the number and weight of flowers and flower buds. In four extreme treatments (combinations of temperature 15^{o}C and 24^{o}C with light level 40% and 100%), detailed measurements were conducted on individual organs (leaf blades, petioles, internodes, flowers) at three plants per treatment three weeks after visible bud stage and at final harvest.

GreenLab model with interaction between plant production and development

GreenLab model has been described in previous publications (de Reffye et al, 2003; Yan et al., 2004). In previous applications of GreenLab (Guo et al., 2006, Kang et al., 2006), the plant development follows a predefined pattern without being influenced by the assimilate availability. It is suitable mostly for a fixed environment. In current study, not only the size and weight of organs, but also the plant development change with climate condition. Thus GreenLab model with feedback of plant production on the plant topological structure (Mattieu, 2006) is used in this study. With this new feature, the varying branching order and number of flowers along the stem according to environment can be simulated through parameters (*a* and *b*) linked to assimilate demand and supply, as shown in Eqn. (1).

$$v_B = a + b \cdot \frac{Q}{D}(n) \qquad (1)$$

v_B is a coefficient describing speed of top-down flowering as described in (Kang et al., 2006). Q and D are assimilate supply and demand at plant age (in cycles) n.

The model is first calibrated using data from the four extreme treatments and four intermediate treatments. The calibrated model is to be validated with independent data set from other eight intermediate treatments. The model output can be visualized with 3D virtual chrysanthemum, showing the effect of climate conditions on chrysanthemum external quality.

Outlook

The experimental results show that the branching order, number of flowers, as well as organ weight changes with the different combinations. It is promising to predict such behaviour with a model with feedback. As the current work is still ongoing, the full results are to be presented in coming article.

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