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Modeling and analyzing the topology development of young *Michelia chapensis*

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Highlights: *Michelia chapensis* is one of the most important landscape trees and it is important to study the plant topology structure. We measured the 2 years old michelia tree through one year, study the tree topology structure, well fit and simulate the tree with the new GreenLab version.

INTRODUCTION

Michelia chapensis is one of the most important landscape trees which are more and more broadly bred in the nursery garden in the South of China. When the plant topology structure is well studied and the dynamic plant structure model is used, the landscape designer can use the model to make the dynamic landscape design. It is important to study the plant topology structure.

For many studies about the plant structural model or functional-structural model, the plant was studied with one year as the time step, such as LIGNUM (Perttunen *et al.*, 1996, 1998) or GreenLab pine (Wang *et al*., 2012). It was enough to study the forestry trees, but it is not available to arrange the management strategies or landscape design for the garden trees.

In this study, we measured the 2 years old michelia trees, study the tree topology structure, fit and simulate the tree with the new GreenLab version.

MATERIAL AND METHODS

Field experiment

The field experiments were conducted in the nursery garden of Tengtou Landscape Company (29°42' N, 121°22' E) in Zhejiang province. The plant were sown in spring of 2010 by seeds and transplanted to the nursery garden in autumn. Plant grew at a spacing of 0.5 × 0.5 m. The branches which were below the 8th phytomer were pruned in the beginning of 2011. Fertilizer inputs and irrigation were conducted so as to avoid any mineral and water limitations to plant growth.

From 21 April,2011 to 13 March,almost every month, 20 plants were sampled and counted the phytomer number of the main stem. And at the same time 12 plants were sampled and the topology structure were recorded, as well as the branch level and position, the phytomer number of the branches, the blade living time and expansion time.

Brief description of GREENLAB model

Detailed descriptions of the model were presented in some previous studies (Yan *et al*., 2004; Guo *et al*., 2006) and we just recall its main principles and the new features. In the model, the plant architecture is described hierarchically according to their physiological age (PA), as presented in a review paper by Barthélémy and Caraglio (2007). The time step, called growth cycle (GC), is the time elapsed between emergences of two successive phytomers expressed in thermal time.

GL2 is a stochastic functional-structural model, where the plant topology development depends on probabilities related to bud functioning (e.g., branching probabilities, buds survival probabilities, rhythm ratio between different PAs). In the new version GL5, the topology and biomass production were fitted separately. We fitted the topology first and got the topology development for the plant. Then the biomass will be fitted for the total biomass and the allometry based on common pool and basic GreenLab principle.

In this study, we just considered the following probabilities , such as the growth probabilities of all the PAs, the delay growth cycle of the PA2 and PA3, the rhythm ratio between different Pas, the delay and growth in the winter, etc. The branch death was not considered in this study. All the probabilities were described with the binomial distribution and fitted and simulated in Matlab software produced by the Mathworks Inc.

RESULTS

Descriptions on michelia structure

There was almost 1 branch, which were the 1st level branch (PA2), at each phytomer rank along the main stem (PA1). To these branches, there were about 4 growth cycles delay. The growth rate of PA2 is almost the same with PA1, sepecially for the new branches. At the beginning of the year 2011, there were about 14-19 phytomers in the michelia tree. Through the main stem there was no branch or there are little branches at the position from 15-23, maybecause the bud were dead in the winter.

There were the 2nd level branches (PA3) on the 1st level branch (PA2), but the PA3 didn't come out until the phytomer of PA2 is more than 6. And also there was 2 or 3 growth cycle delay in the PA3 compared to PA2.

The plant growth fast in the summer and early autumn, there was one new phytomer about three to five days from April to Octomer in 2011 (Fig.2a), but keep almost constantly from Octomer, 2011 to March, 2012. Almost all the plants grew in the same rate and the variability is small for the main stem of all the sampled trees.

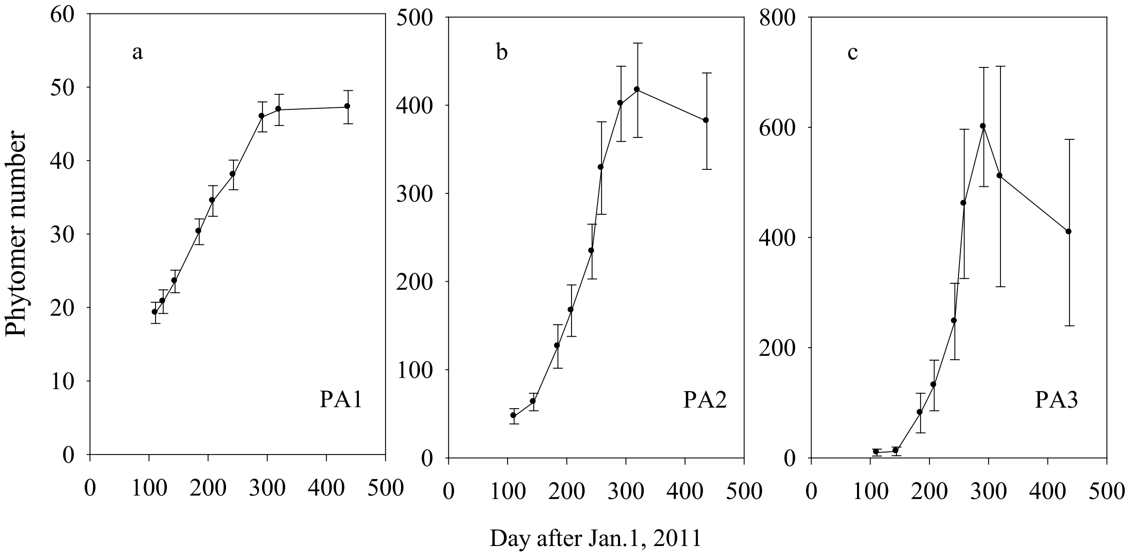

Fig. 2. Total phytomer number of the main stem and branches. Fig. 2a represents the phytomer number of the main stem (PA1) changing with time, Fig. 2b denotes the phytomer number of all the first level branches (PA2) varying with time and Fig. 2c represents the phytomer number of the total PA3s in one tree.

To PA2 and PA3, the total phytomer number decreased because some of the branches died in the autumn and winter. Also the variability is larger than PA1.

Fitting and simulating results

The phytomer number of different PAs was fitted separately and well simulated. The rhythm ratio was almost one for all PAs, that means the main stem grew one growth unit, the children branch could grew a growth unit, too. But the probability of growth for PA1 was larger than PA2 and probability of PA3 was the smallest. At the same time, the probability of branch death for PA1 was the smallest (nearly to zero) and probability of PA3 was biggest (data were not shown in this paper). The delay of year 2011 and the Inhibition control could also be modeled (Fig.3).

DISCUSSION

Trees can grow for many years, so many researchers study the tree growth using 1 year as the time step. Some information of the tree growth will be lost (Sievänen *et al*, 2000) and most of the information is very important especially for the young garden tree which grew in the nursery garden. In this study we observed, measured and simulated the young Michelia grown in one year, studied the growth rate of the main stem and branches. The gardener can decide their irrigating, fertilizing strategies and also they can deciede when to prune and transplant the plant through the model.

We also found when the plants were pruned, the new branches grew in a very similar way as the young trees. And the model was also important to the big trees. So we can also use the model to show the influence of pruning and landscape design.

In the future, the climate factors, the biomass production and allocation will be considered in this model, which is then more useful in the management strategies.

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