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Research paper

Long-term banding modifies the changes to foliar coloration of *Acer rubrum* L. 'Brandywine'

Yan Yangyang[a,b], Liu Yumin[b,*], Liu Yamin[b], Li Li[b], Li Jiajia[b], Zhou Wenying[b]

[a] College of Resources and Environment, Southwest University, Chongqing 400715, China
[b] College of Resources and Environment, Key Laboratory of Eco-Environments in Three Gorges Region (Ministry of Education), Southwest University, Chongqing 400715, China

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ABSTRACT

To more thoroughly characterize the mechanism regulating the conversion of red maple tree (*Acer rubrum* L. 'Brandywine') foliar coloration in autumn, we analyzed the leaf coloration process using the Lab color space scale, and compared the anthocyanin concentrations, photosynthetic pigment contents, soluble sugar contents, and the phenylalanine ammonia lyase and polyphenol oxidase activities between control and band-treated red maple seedlings. We observed that stem banding enhanced the development of leaves exhibiting brilliant red coloration in the upper treated branches, and weakened the brightness of yellow leaves. Additionally, studies also revealed that leaf anthocyanin contents increased significantly. Moreover, carotenoid contents and polyphenol oxidase activity decreased considerably by banding. In contrast, the chlorophyll pigment, phenylalanine ammonia lyase activity and soluble sugar contents were only minimally affected by the long-term banding of trees. Our results indicate that the Lab color model is appropriate for quantifying leaf coloration changes, and for revealing the relationship between leaf coloration and internal physiological changes. Changes to leaf coloration are a consequence of the actions of photosynthetic pigments and anthocyanins. Our results also demonstrate that anthocyanin accumulation influences the underlying biochemical mechanism. The successful manipulation of leaf coloration changes highlights the significance of anthocyanins in this process, and is consistent with the possibility that anthocyanin accumulation influences the underlying biochemical activities.

1. Introduction

Acer rubrum L. 'Brandywine'the Northeastern America deciduous tree, it is not only has the beautiful and colorful leaves, but also the ecological characteristics, such as resistance to wet (Inman, 2007), cold (Bauerle et al., 2007), heavy metal (Silva et al., 2012; Tanentzap and Ryser, 2015) and drought tolerant (Abrams and Kubiske, 1990; O'Neill et al., 2003). More can adapt to a variety of soil types (Wheeler et al., 2016), and they have a certain capacity in taking in ozone and sulfur dioxide from the atmosphere (Carlson, 1979). Therefore, it was largely used to the landscaping of Chinese city. In order to better popularize the tree species, our group has engaged in researching its adaptation to the environment and coloration. Since October 2011, every year the leaf coloration has changed obviously and the colorful leaf stage can continue 30 d. Until the third year, the colored period was obviously shortened for the climate. The quality of leaf color has dropped, which seriously influences the popularization to the Southwestern city in China. Therefore, we tried to control the leaf coloration to modify conversion by artificial means. Original hypothesis was that by spraying sugar on the leaf, which was pree process to synthesis anthocyanin to influence the leaf color change (Murakami et al., 2008), but it turned out that was difficult to popularize for its high cost. One phenomenon was accidentally discovered in October 2014 that the leaf color of the trunk with raised callus section can change in advance, and the time of leaf coloration was up to 25 d. So we speculated that the section can affect plant material exchange, thereby we can change it early to increase the time of colorful leaf. Usually, girdling was used to study material exchange between the top and bottom of tree for its slowing phloem flow, which was filled with sugar, amino acids, mRNA, organic ions, and a series of proteins and plant hormone through the basic movement of the epidermis to cause the difference of leaf material between top and bottom (Dai et al., 2016), and the wound by girdled will be covered by generated callus section (Johnson and Edwards, 1979). But given the treatment will strongly influence on the growth, even lead to death (Percival and Smiley, 2015), we choose the new

* Corresponding author.
E-mail address: yuminliu@163.com (Y. Liu).

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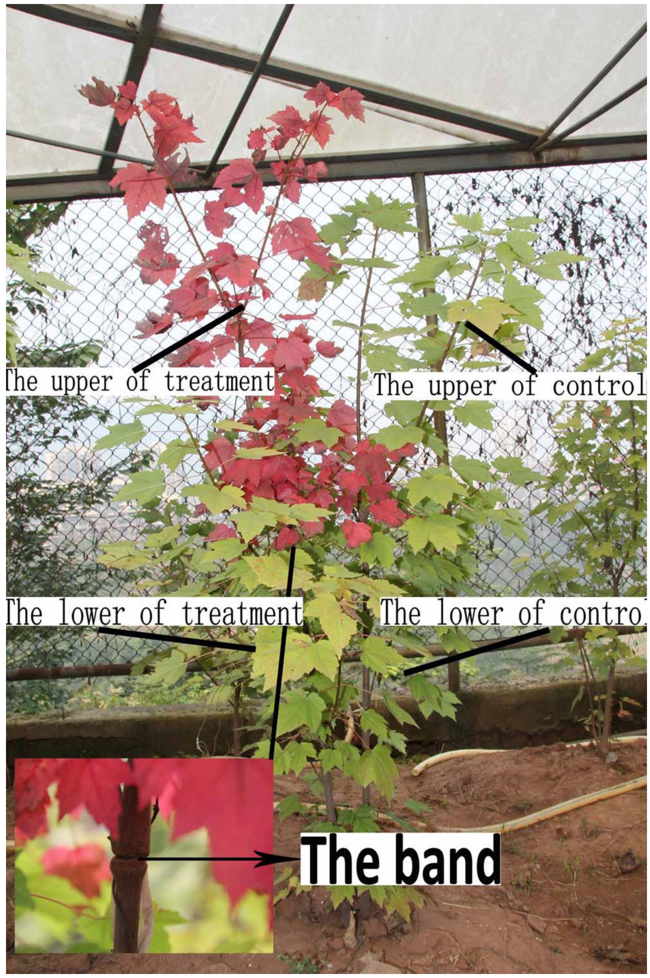

Fig. 1. Eight red maples were selected that has two branches only as experimental material, just like this picture. Based on the selection, a branch from the tree was ligated tightly with plastic strip in middle part of the branch and tagged on each tree. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

method to replace girdling. At present, the method has not yet been reported in the research of the plant physiological character. We hypothesis that the banded tree can change the material internal exchange, just like increasing the accumulation of anthocyanin, to achieve the effect of regulated leaf color. Based on the hypothesis, we have measured the difference of leaf color, flower pigment glycosides, chlorophyll, PAL, PPO, the change of soluble sugar, soluble protein between upper and bottom leaves. It was repoted that PPO has a functional decomposition on anthocyanin (Kader et al., 1999). And in the anthocyanin biosynthesis pathway catalytic reaction, PAL not only provides precursors for the synthesis of anthocyanin, but also for the synthesis of other substances (Boss et al., 1996). It aimed at characterizing biological mechanisms regulating autumnal leaf pigmentation in trees that produce colored leaves to provide theoretical basis for the North American maple garden promotion in China.

2. Materials and methods

This study involved 32 red maple trees (*Acer rubrum* L. 'Brandywine') that originated from the United States of America (March 2014). They were grown at the Little Experimental Forest of the Southwest University Research Station (106° 25′45″ E, 29° 49′18″ N), Chongqing, China. This region is characterized by a humid subtropical climate, and experiences monsoons. The mean annual temperature is approximately 18 °C, while the mean winter temperatures are 6–8 °C. July is the warmest month, with high temperatures above 35 °C. Trees were planted in the field (separation distance: 1 m × 1 m) with purplish soil underneath the canopy. The trees were periodically irrigated. Eight red maple trees with only two branches were selected for subsequent analyses (Fig. 1). In December 2013, the middle part of a branch from each tree was tightly wrapped around three times as treatmented branches with a plastic strip that is non-alkali glass fiber rope with a width of 5 mm, and the other is control branche. By 2016, the trees had adapted to the stress induced by the plastic band. Twenty leaves were collected from each tree when the leaves on the treated branch turned red from October 2 to October 6, 2016, other leaf of the control and the lower of treatmented did not change. Meanwhile, the collected leaves were immediately ground in liquid nitrogen, and stored at −80 °C until analyzed.