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Impact of decomposing *Cinnamomum septentrionale* leaf litter on the growth of *Eucalyptus grandis* saplings

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ABSTRACT

A pot experiment was performed to study the impact of decomposing *Cinnamomum septentrionale* leaf litter on the growth of *Eucalyptus grandis* saplings. The experimental design scheme was 0 (CK), 40 (A_1), 80 (A_2) and 120 g pot^{-1} (A_3) of *E. grandis* leaves, and changes in the volatile oil chemical composition during litter decomposition were assessed in the present study. The results showed that *C. septentrionale* leaf litter inhibited the growth of *E. grandis* saplings, as determined by the height, basal diameter and chlorophyll content, after 69 d (T1). Five months after transplantation (T2), the height growth rate of the *E. grandis* saplings increased and then gradually reduced (A_1: 40 g pot^{-1} > A_2: 80 g pot^{-1} > A_3: 120 g pot^{-1} > CK: 0 g pot^{-1}). After eleven months (T3), the variations in the height and basal diameter were the same as observed at T2, and the inhibition on leaf, branch, root and stem biomass increased with increasing leaf litter content. Gas chromatography–mass spectrometry (GC–MS) was used to identify the volatile compound composition. The results indicated that the *C. septentrionale* original leaf litter (S1) contained thirty-one volatile compounds, but the treated leaf litter S2 (which was mixed with soil for eleven months to simultaneously plant *E. grandis* saplings) only possessed fourteen volatile compounds, releasing many secondary metabolites in the soil during decomposition. Most of the volatile compounds were alcohols, monoterpenoids, sesquiterpenes, alkanes, alkene, esters and ketones. Most of the allelochemicals of *C. septentrionale* might be released during the initial decomposing process, inhibiting the growth of other plants, whereas some nutrients might be released later, promoting the height growth of plants. In conclusion, decomposing *C. septentrionale* leaf litter release of many allelochemicals in the soil that significantly inhibit the growth of *E. grandis*.

1. Introduction

Cinnamomum septentrionale Hand. Mazz is a member of the Lauraceae family, an evergreen broadleaf tree species, which primarily grow to distracting heights in areas with an average temperature of 14 °C and precipitation over 800 mm, such as Sichuan basin, south Shanxi province, south Gansu province, Hunan province, China, et al. [1]. Because of its exuberant branches and leaves, beautiful tree appearance, sweet fragrance, *C. septentrionale* has been widely used as rural four sides gardening trees and landscape (e.g., planted surrounding villages or alongside gardens and vegetable fields) in China [2]. *C. septentrionale* leaves have camphor and fragrance [3]. *Cinnamomum* is a large genus, many species of which yield a volatile oil during distillation [4]. Many studies have shown that *Cinnamomum camphora* (L.) Presl [5,6], *Cinnamomum zeylanicum* Blume [7,8], *Cinnamomum cassia* Presl [9], *Cinnamomum tamala* (Buch.-Ham.) Nees et Eberm. [10]., *Cinnamomum pauciflorum* Nees [10], *Cinnamomun burmannii* (C.G.& Th. Nees) Blume [10], *Cinnamomum osmophloeum* Kaneh. [4]. and *Cinnamomum kanehirae* Hay. [11] possess large amounts of volatile allelopathic chemicals in essential oils. Most of the chemical components of essential oils are terpenoids, including monoterpenes, sesquiterpenes and their oxygenated derivatives [4]. Tworkoski [12] showed that essential oils from *C. zeylanicum* Blume induced electrolyte leakage, resulting in the death of *Taraxacum officinale* Weber in Wiggers cells. Liu et al. [5] reported that the essential oils from *C. camphora* seeds showed notable toxicity on wheat seed germination, but the phytotoxicity was reduced over time. The volatile allelopathic chemicals of *C. camphora* trees inhibited the growth of turfgrass under the crowns of camphor trees [13], and the associated rhizosphere soil contained allelochemicals, which inhibited the germination and growth of *Raphanus sativus* L. seedlings at

Abbreviations: GC–MS, gas chromatography–mass spectrometry; RI, rate of inhibition; NIST, National Institute of Standards and Technology.

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higher concentrations, but promoted growth at lower concentrations [14]. 1,8-Cineole and 1,4-cineole are typical components of essential oils from aromatic plants, such as *C. osmophloeum* [4], *Cinnamomum glaucescens* Nees [15], *Eucalyptus* spp. [16], and *C. zeylanicum* [7], the former inhibits all stages of mitosis, whereas the latter only inhibits the earlier stages of mitosis [17]. These volatile compounds influence seedling and shoot growth, leaf photosynthesis and leaf physiology [18], and *C. septentrionale* leaf litter significantly inhibits the growth of *Brassica rapa* L. [19]. However, there are few studies concerning the allelopathy of *C. septentrionale*.

Eucalyptus grandis Hill ex Maid, the most cultivated species for industrial purposes [20], was introduced into China from Australia by the late 19th century and became the main tree species in the southern industrial construction plantations in China [21]. Because of its fast growth, high yield and quality, well adaptability and wide-range in application, *E. grandis* has been widely introduced and planted, which has effectively promoted the timber production in China [21]. But most *Eucalyptus* plantations are currently grown as monocultures [22,23] and bring in many ecological problems, such as the reduction of biological diversity (mainly due to allelopathy), woodland soil degradation, productivity decline, etc [24–26]. Proper mixed-species plantation could increase the light efficiency, water and nutrient uptake, and overall stand productivity [27,28], and in recent years, *E. grandis* plantations have been rapidly developed and some of them were planted largely under or near *C. septentrionale* forest. Therefore, in this study, we used a pot experiment to transplant *E. grandis* in soil containing *C. septentrionale* leaf litter to analyse whether the decomposing leaf litter could affect the growth of *E. grandis* saplings, furthermore to examine the possibility of planting *E. grandis* near the edge and cut-over land of forests containing *C. septentrionale* and other Lauraceae species. In addition, we used GC–MS to analyse the release of volatile compounds in soil during decomposition of *C. septentrionale* leaf litter and identify the underlying allelopathic mechanism.

2. Results

2.1. Effects of *C. septentrionale* leaf litter on the chlorophyll content, height, basal diameter and biomass of *E. grandis* saplings

Changes in the height and basal diameter of *E. grandis* saplings were observed (Figs. 1–3). The relative height and basal diameter growth of *E. grandis* saplings was significantly reduced ($P < 0.05$) with increasing *C. septentrionale* leaf litter contents by the 30th of June, 2011 (T1); the relative basal diameter growth dramatically decreased ($P < 0.05$) by September 30, 2011 (T2) and March 15, 2012 (T3), while the relative height growth increased (A_1) and gradually reduced (A_2, A_3).

The chlorophyll content of *E. grandis* showed a sharp decline with increasing *C. septentrionale* leaf litter content after 69 d (RI: $A_1 = -0.257 > A_2 = -0.275 > A_3 = -0.311$), and the carotenoid

Fig. 1. Effects of different leaf litter treatments on the growth of *E. grandis* saplings at different stages: May 11, 2011 (A), June 22, 2011 (B), July 22, 2011 (C), August 6, 2011 (D) and March 15, 2012 (E), and one lengthwise row represents a treatment, from left to right 120 g pot^{-1} (A_3), 80 g pot^{-1} (A_2), 40 g pot^{-1} (A_1) and 0 g pot^{-1} (CK).