

柠檬醛型樟叶片单萜含量时间异质性分析

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摘要:【目的】明确柠檬醛型樟叶片基因表达与柠檬醛季节变化之间的相关性,深入研究柠檬醛型樟生长过程中单萜的合成规律及其影响因素,有助于建立科学的栽培管理技术,同时有助于确定最佳收割时期。【方法】采用 GC-MS 对野外大田樟树矮林栽培基地中 3 个品种柠檬醛型樟(C1、C2、C3)叶片整个生长周期的精油化学组成进行测定,同时通过 qRT-PCR 对柠檬醛合成相关基因香叶醇合成酶 *CoGES* 和醇脱氢酶 *CoADH* 表达进行定量研究。【结果】叶长、叶宽、叶面积均在 B-C 时期(抽叶后 3-5 周)快速升高,C-E 时期(抽叶后 5-9 周)增长速率降低,F 时期(抽叶后 12 周)后稳定,枝叶总生物量、叶枝比变化趋势相似,在 I 时期(8 月底)达到最大。不同生长期叶干重出油率为 0.53% - 2.79%,高于枝干重出油率 0.48% - 0.7%。不同生长期柠檬醛含量 C1 为 48.28% - 78.38%,C2 为 33.28% - 71.78%,C3 为 42.34% - 70.46%,在 G 时期最高。精油总产量 C1、C2、C3 均在 I 时期达到最高,分别为 20.19 ± 1.88 、 13.8 ± 0.61 、 16.47 ± 0.87 克/株,且方差分析 C1 显著高于 C2、C3。不同生长期柠檬醛含量与 *CoGES* 和 *CoADH* 基因表达量波动相一致,但相关性没有完全达到显著水平。*CoGES*、*CoADH* 酶蛋白活性与柠檬醛含量变化趋势一致,方差分析表明 *CoGES*、*CoADH* 酶蛋白活性与香叶醛、橙花醛含量显著相关,进一步证实 *CoGES* 和 *CoADH* 基因与柠檬醛合成相关。【结论】选择 C1 作为柠檬醛优良品种,综合柠檬醛含量、精油产量及生物量确定柠檬醛型樟最佳采收期为 7-8 月。

关键词:柠檬醛;樟树;单萜;最佳采收期;出油率

Differences in monoterpene synthesis in citral-type *Camphora officinarum* Nees ex Wall leaves during different growth periods

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Abstract: 【Objective】 The aim of this study was to clarify the correlation between gene expression and seasonal changes of citral in the leaves of citral-type *Camphora officinarum* (*C. officinarum*). The in-depth study of monoterpene synthesis law and its influencing factors in the growth process of citral-type *C. officinarum* would help to establish a scientific cultivation technology and determine the optimal harvesting period. 【Method】 GC-MS was used to determine the chemical composition of essential oils throughout the growth cycle of leaves of three varieties of citral-type *C. officinarum* (C1, C2 and C3) during *C. officinarum* coppice cultivation. The expression of citral synthesis-related genes geraniol synthase *CoGES* and alcohol dehydrogenase *CoADH* were quantified by qRT-PCR. 【Result】 Leaf length, leaf width and leaf area all increased rapidly in the B-C period (3-5 weeks after leaf extraction), the growth rate decreased in the C-E period (5-9 weeks after leaf extraction), and stabilised after the F

period (12 weeks after leaf extraction), and the total biomass of branches and leaves and leaf-to-branch ratio changed with similar trends, and reached the maximum in the I period (end of August). The leaf dry weight oil yield was 0.53%-2.79% at different growth periods, higher than the branch dry weight oil yield of 0.48%-0.7%. The citral content in different growth periods ranged from 48.28%-78.38% for C1, 33.28%-71.78% for C2, and 42.34%-70.46% for C3, which was the highest in G period. The total essential oil yield of C1, C2 and C3 were all highest at period I, 20.19 ± 1.88 , 13.8 ± 0.61 and 16.47 ± 0.87 g/plant, respectively, and C1 was significantly higher than that of C2 and C3 in the analysis of variance. The citral content of the different growth periods was consistent with the fluctuation of the expression of the *CoGES* and *CoADH* genes but the correlation did not reach the full significance level. The trend of *CoGES* and *CoADH* enzyme protein activities was consistent with that of citral content, and the variance analysis showed that *CoGES* and *CoADH* enzyme protein activities were significantly correlated with the content of geranial and neral, which further confirmed that *CoGES* and *CoADH* genes were related to citral synthesis. 【Conclusion】 Our results demonstrated that C1 was an excellent citral variety, and the best harvesting period for citral *C. officinarum* was July and August.

Key words: citral; *Camphora officinarum* Nees ex Wall; monoterpenes; harvesting period; oil yield.