

美洲黑杨不同生长势子代及其亲本叶片淀粉和蔗糖代谢特征差异分析*

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摘要:【目的】研究美洲黑杨不同生长势 F1 子代及其亲本在不同林龄生长关键时期的叶片淀粉、蔗糖代谢关键指标差异, 解析淀粉、蔗糖代谢在美洲黑杨生长优势形成和维持中的作用, 明确杨树生长性状优势杂交子代的糖代谢特征。【方法】采用空间替代时间方法, 以生长旺季(6、7、8、9月)1、3年林龄的美洲黑杨高生长势子代(H1、H2、H3), 低生长势子代(L3、L4)及其父(MP)、母(FP)本为研究对象, 采用微量法测定不同时间点叶片淀粉(Starch)、蔗糖(Sucrose)含量及 ADP-葡聚糖焦磷酸化酶(AGPase)、蔗糖磷酸合酶(SPS)、 β -淀粉酶(BAM)和蔗糖合成酶(分解方向, SS-I)活性, 通过亲子代间的各指标差异比较、相关性、回归和通径分析, 解析淀粉、蔗糖代谢关键指标对不同生长势形成作用规律。

【结果】生长旺季1、3年生的高生长势子代的树高、地径、胸径均表现出明显超亲优势, 并显著高于低生长势子代($p<0.05$); 8、9月高生长势子代的夜间淀粉、蔗糖分解能力和日间合成能力的中亲或超亲优势明显, 其中淀粉夜间消耗量、AGPase活性、BAM活性中亲优势率 MPH 分别为1.24%~12.20%、0.42%~18.40%和0.54%~5.20%, 蔗糖夜间消耗量和 SPS活性超亲优势率 HPH 分别为0.29%~26.05%和0.61%~16.03%, 且上述指标在低生长势子代中具相反趋势; 但低生长势子代 SS-I活性为超亲优势(HPH: 0.87%~11.81%), 并高于高生长势子代。美洲黑杨在生长旺季的树高、胸径(地径)单月净增长量主要与 AGPase活性、SPS活性和淀粉夜间消耗量显著正相关; 此外, SPS、AGPase和BAM酶活性对生长旺季美洲黑杨的树高、胸径(地径)单月净增长量的直接正影响效应显著。【结论】美洲黑杨高生长势子代具有稳定的生长优势, 高生长势子代淀粉、蔗糖的夜间分解能力和日间合成能力中亲和超亲优势明显, SPS、AGPase和BAM酶活性的提高能有效促进和维持美洲黑杨高生长势形成。研究结果为解析淀粉、蔗糖代谢对林木杂交子代生长优势形成的作用机制和超高产育种提供有益参考。

关键词: 美洲黑杨; 淀粉代谢; 蔗糖代谢; 生长性状; 杂种优势

Differences in Metabolism Characteristics of Starch and Sucrose in Leaves of *Populus deltoides* Hybrids with Different Growth Potential and their parents*

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Abstract: This study aimed to investigate the differences in key indicators of starch and sucrose metabolism in the leaves of F1 hybrids with different growth potentials and their parents *Populus deltoides* at different forest ages during critical growth periods, analyze the role of starch and sucrose metabolism in the formation and maintenance of growth heterosis of *P. deltoides*, and clarify the sugar metabolism characteristics of hybrids with superior growth-trait in *Populus*. Utilizing the space-for-time substitution method, the high-growth potential hybrids (H1, H2, H3) and low-growth potential hybrids (L3, L4), along with their male (MP) and female (FP) parents of *P. deltoides* in 1- and 3-year-old during the peak growth season (June, July, August, September), were selected as the research materials. The content of starch and sucrose in the leaves at different time points, as well as the activities of ADP glucan pyrophosphate synthase (AGPase), sucrose phosphate synthase (SPS), β -amylase (BAM), and sucrose synthase (decomposition direction, SS-I), were measured using micro-methods. The study compared the differences of various indicators among hybrids and parents, conducted correlation, regression equations, and path analysis, to elucidate the regulatory patterns of key indicators in starch and sucrose metabolism that contributed to formation of different growth potential. During the peak growth season, high-growth potential hybrids in 1- and 3-year-old exhibited significant high-parent heterosis (HPH) for tree height, ground diameter (GD), and diameter at breast height (DBH), and were significantly higher than those of low-growth potential hybrids ($p < 0.05$); In August and September, high-growth potential hybrids demonstrated notable mid-parent (MPH) or high-parent heterosis in starch and sucrose breakdown capacity at night and synthesis capacity during the day. Specifically, the MPH for nighttime starch consumption, AGPase activity, and BAM activity were 1.24%–12.20%, 0.42%–18.40%, and 0.54%–5.20%, respectively, and the HPH for nighttime sucrose consumption and SPS activity were 0.29%–26.05% and 0.61%–16.03%, respectively, while these indicators showed opposite trends in low-growth potential hybrids. However, SS-I activity in low-growth potential hybrids showed high-parent heterosis (HPH: 0.87%–11.81%) and was higher than in those with high-growth potential hybrids. The net monthly growth in tree height and DBH (GD) of *P. deltoides* during the peak growing season was significantly positively correlated with AGPase activity, SPS activity, and nighttime starch consumption. Additionally, the direct positive effects of SPS, AGPase, and BAM enzyme activities on the net monthly growth in tree height and DBH (GD) of *P. deltoides* during the peak growth season were significant. High-growth potential hybrids of *P. deltoides* exhibited stable growth heterosis, and they showed significant MPH and HPH in the nighttime decomposition capabilities and daytime synthesis abilities of starch and sucrose. Enhanced activities of SPS, AGPase, and BAM enzymes could effectively promote and sustain the formation of high-growth potential in *P. deltoides*. The results provide useful references for elucidating the mechanism by which starch and sucrose metabolism contribute to the formation of growth heterosis in hybrids of trees and breeding for super high yield.

Key words: *Populus deltoides*; Starch metabolism; Sucrose metabolism; Growth traits; Heterosis.