

抚育间伐对华北平原毛白杨人工林各器官化学计量特征和叶片养分重吸收的影响¹³

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摘 要:【目的】通过对抚育间伐后不同时期毛白杨各器官养分含量、化学计量特征和养分重吸收的监测, 解释林木器官尺度对不同间伐强度下光照、水、养资源的响应状况, 同时对该区域毛白杨人工林培育管理提供理论支撑。【方法】以华北平原 8 年生三倍体毛白杨 S86 人工林为研究对象, 设置三种间伐强度: 不间伐 (NT)、隔行间伐 (间伐 50%, T50)、隔行隔株间伐 (间伐 75%, T75)。通过对林木叶、枝、干、根进行取样, 分析毛白杨年内生长旺盛期和生长末期的各器官养分含量、化学计量比、叶片重吸收效率和相对重吸收率, 从而探究不同时期叶片养分含量、化学计量特征和重吸收之间的耦联关系。【结果】1) 两个时期综合来看, 间伐强度仅对叶片磷含量和树干碳含量存在显著影响; 而在生长末期, 间伐能够显著提高钾在叶片中的积累, T50 和 T75 相较于 NT 分别提高了 33.43% 和 35.74%。2) C/N、C/P、C/K 表示在碳稳定作用下吸收氮、磷、钾养分的能力, 可作为判断植物养分吸收速率和利用效率的指标, 生长旺盛期和生长末期两个时期叶片 C/N、C/P、C/K、N/P 差异显著; 此外相比于枝、干、根, 叶片的化学计量特征更易受到时期、间伐及其交互作用的影响, 其中间伐强度对毛白杨叶片的 C/P 和 N/P 影响显著。3) 不同间伐强度下毛白杨叶片氮的重吸收效率 (NRE) 为 14.64%~24.55%, 磷的重吸收效率 (PRE) 为 18.87%~34.97%, 钾的重吸收效率 (KRE) 为 7.00%~33.59%; 随着间伐强度的增加, 叶片钾回流效率降低, 间伐 50% 和间伐 75% 分别使林木钾重吸收效率显著降低 53.56% 和 79.16%。4) 养分含量和养分重吸收效率之间存在显著的相关关系, 成熟时期叶片为正相关关系, 凋落叶片多呈负相关关系; 凋落叶片 N/K (N/K_{sen})、成熟叶片 N/K (N/K_{gr})、凋落叶片磷含量 (LP_{sen}) 对养分重吸收的贡献率排在前三, 分别为 40.8%, 17.6%, 12.8%, 其中 N/K_{sen} 对养分重吸收影响显著。【结论】不同时期毛白杨各器官养分吸收和利用策略不同, 毛白杨生长旺盛期和生长末期间叶片碳、氮、磷、钾含量均存在显著差异。抚育间伐主要对叶片和树干存在影响, 间伐强度改变了叶片磷含量和树干碳含量, 同时对叶片的 C/P、N/P 产生显著作用。间伐后, 毛白杨叶片 KRE 发生改变, 但间伐强度对 NRE、PRE 和相对重吸收率无调控作用, 其中 N/K_{sen} 是影响养分重吸收的关键指标。此外, 基于“N/P 阈值假说”, N/P<14 预示植物生长受到氮限制, 而不同间伐强度下 N/P 范围为 10.05~11.06, 表明该区域毛白杨林木生长受到氮素限制, 建议在抚育间伐后的林分管理中增施氮肥; 其次, 结果显示 NRE/PRE<1, 基于“相对重吸收假说”, 在增施氮肥中配以适量磷肥, 能够促进林木生理代谢, 提高林木的生长潜力。

关键词: 毛白杨、间伐效应、树木各器官、生态化学计量、养分重吸收

Effects of tending thinning on stoichiometric characteristics of various organs and leaf nutrient reabsorption in *Populus tomentosa* plantations in the North China Plain.

Abstract: 【Objective】By monitoring the nutrient content, stoichiometric characteristics and nutrient r

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reabsorption of various organs of *Populus tomentosa* at different stages after tending and thinning, the response of forest organ scale to environmental changes in light, water and nutrient resources under different thinning intensities was explained, provide theoretical support for the cultivation and management of *Populus tomentosa* plantations in the region. **【Method】** Taking the 8-year-old triploid *Populus tomentosa* S86 plantation in the North China Plain as the research object, three thinning intensities were set: no thinning (NT), alternate row thinning (50% thinning, T50), and alternate row and alternate plant thinning (75% thinning, T75), by sampling the leaves, branches, trunks and roots of forest trees, analyzing each organ nutrient content, each organ stoichiometric ratio, leaf reabsorption efficiency and relative reabsorption rate of *Populus tomentosa* during the vigorous growth period and the end of growth period of the year, so as to explore the leaves of *Populus tomentosa* in different periods. Coupling relationships between nutrient content, stoichiometry and reabsorption. **【Results】** 1) Taking the two periods together, thinning intensity only has a significant impact on leaf phosphorus content and trunk carbon content; at the end of the growth period, thinning can significantly increase the accumulation of potassium in leaves, and T50 and T75 respectively increase compared with NT 33.43% and 35.74%. 2) C/N, C/P, and C/K represent the ability to absorb nitrogen, phosphorus, and potassium nutrients under the effect of carbon stabilization, and can be used as indicators to judge plant nutrient absorption rate and utilization efficiency. There are significant differences in leaf C/N, C/P, C/K, and N/P between the vigorous growth period and the late growth period. In addition, compared with branches, trunks and roots, the stoichiometric characteristics of leaves are more susceptible to the influence of period, thinning and their interactions. Among them, the intensity of thinning has a significant impact on the C/P and N/P of *Populus tomentosa* leaves. 3) The nitrogen reabsorption efficiency (NRE) of *Populus tomentosa* leaves under different thinning intensities is 14.64%~24.55%, the phosphorus reabsorption efficiency (PRE) is 18.87%~34.97%, and the potassium reabsorption efficiency (KRE) is 7.00%~33.59%. As the thinning intensity increases, the potassium return efficiency of leaves decreases. Thinning by 50% and 75% significantly reduces the potassium reabsorption efficiency of forest trees by 53.56% and 79.16%, respectively. 4) There is a significant correlation between nutrient content and nutrient reabsorption efficiency. There is a positive correlation for mature leaves, and a negative correlation for litter leaves. The contribution rates of litter leaf N/K(N/Ksen), mature leaf N/K (N/Kgr), and leaf phosphorus content (LPsen) to nutrient reabsorption rank in the top three, 40.8%, 17.6%, and 12.8% respectively. Among them, N/Ksen has a significant impact on nutrient reabsorption. **【Conclusion】** The nutrient absorption and utilization strategies of various organs of *Populus tomentosa* are different in different periods. There are significant differences in the carbon, nitrogen, phosphorus and potassium contents of leaf during the vigorous growth period and the end of growth of *Populus tomentosa*. Tending thinning mainly affects leaves and trunks. Thinning intensity changes leaf phosphorus content and trunk carbon content, and also has a significant effect on leaf C/P and N/P. After thinning, the KRE of *Populus tomentosa* changed, but the thinning intensity had no regulatory effect on NRE, PRE and relative reabsorption rate, among which N/Ksen is the key indicator affecting nutrient reabsorption. In addition, based on the “N/P threshold hypothesis”, $N/P < 14$ indicates that plant growth is nitrogen limited, wh

ile the N/P range is 10.05~11.06 under different thinning intensities, indicating that the growth of *Populus tomentosa* in this area is limited by nitrogen, and it is recommended to apply more nitrogen fertilizer in stand management after thinning. At the same time, the results show that $NRE/PRE < 1$. Based on the “relative reabsorption hypothesis”, adding an appropriate amount of phosphorus fertilizer to the increased nitrogen fertilizer can promote the physiological metabolism of forest trees and improve the growth potential of forest trees.

Keywords: *Populus tomentosa*, thinning effect, tree organs, ecological stoichiometry, nutrient reabsorption.