

格氏栲幼苗根系性状的生长权衡对氮磷添加的响应

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摘要:【目的】由于我国亚热带地区长期受氮沉降影响, 导致植物生长主要受到磷限制。为理解格氏栲幼苗在磷限制严重的亚热带地区的地下生长权衡策略, 探究格氏栲幼苗根系性状对氮磷添加的响应, 以期为格氏栲种群的可持续发展提供理论参考。【方法】以格氏栲 (*Castanopsis kawakamii*) 幼苗为研究对象, 依据当地氮磷水平设置氮 (低氮 (N_1)、中氮 (N_2)、高氮 (N_3))、磷 (低磷 (P_1)、中磷 (P_2)、高磷 (P_3)), 并依据氮磷比设置交互试验, 即 N_0P_0 、 N_1P_1 、 N_1P_2 、 N_1P_3 、 N_2P_1 、 N_2P_2 、 N_2P_3 、 N_3P_1 、 N_3P_2 和 N_3P_3 共 16 个处理, 其中以 N_0P_0 (无氮磷添加处理) 作为对照, 测定幼苗总根长、根表面积、根生物量、比根长、根体积、根系平均直径等根系性状指标对不同氮磷浓度的响应策略, 分析氮磷添加对格氏栲幼苗根系性状的影响。【结果】1) 氮磷养分添加显著促进了格氏栲幼苗根系总根长、根系平均直径和根系表面积等形态指标的生长, 且各根系指标对不同氮磷浓度的响应不同。2) 总根长、比根长、根尖数、分支数以及根表面积之间具有极显著正相关关系 ($p<0.001$); 根生物量和根体积具有显著正相关根系 ($p<0.001$), 与根比表面积具有极显著负相关 ($p<0.001$)。3) 主成分结果表明根系形态指标基本分布在两条正交轴上, 总累积方差解释率为 55.1%, 第一主成分轴与根表面积、根尖数、分支数、总根长、比根长、根比表面积和根体积之间具有显著相关性。第二主成分轴与根系平均直径、根生物量和根氮含量具有较强的相关性。4) 层次聚类分析将 16 个处理划分为 3 个类群, 其中 N_0P_3 、 N_1P_3 和 N_2P_1 划分为同一类群, N_1P_0 、 N_1P_2 、 N_2P_3 、 N_0P_1 、 N_1P_1 划分为同一类群, 其他处理单独划分为同一个类群。【结论】氮磷养分添加显著促进了格氏栲幼苗根系的生长, 其中, N_0P_3 、 N_1P_3 和 N_2P_1 处理下格氏栲幼苗的各根系指标生长的综合效果最佳。在未来森林经营过程中, 可通过氮磷交互添加的方式促进格氏栲幼苗根系快速生长发育。

关键词: 氮磷添加; 根系性状; 根系养分; 权衡策略; 格氏栲

Growth Trade-offs of Root Traits in *Castanopsis kawakamii* Seedlings in Response to Nitrogen and Phosphorus Addition

Abstract: 【Objective】Due to the long-term impact of nitrogen deposition in subtropical regions of China, plant growth is mainly limited by phosphorus. To understand the underground growth trade-off strategy of *Castanopsis kawakamii* seedlings in subtropical areas with severe phosphorus limitations, and to explore the response of root traits of *Castanopsis kawakamii* seedlings to nitrogen and phosphorus addition, in order to provide theoretical reference for the sustainable development of *Castanopsis kawakamii* populations. 【Method】Taking *Castanopsis kawakamii* seedlings as the research object, nitrogen (low nitrogen (N_1), medium nitrogen (N_2), high nitrogen (N_3)), phosphorus (low phosphorus (P_1), medium phosphorus (P_2), high phosphorus (P_3)) were set according to the local nitrogen and phosphorus levels, and interaction experiments were set up based on the nitrogen phosphorus ratio, namely N_0P_0 , N_1P_1 , N_1P_2 , N_1P_3 , N_2P_1 , N_2P_2 , N_2P_3 , N_3P_1 , N_3P_2 , and N_3P_3 totaling 16 treatments, Among them, N_0P_0

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(non nitrogen and phosphorus addition treatment) was used as a control to determine the response strategies of root traits such as total root length, root surface area, root biomass, specific root length, root volume, and average root diameter of seedlings to different nitrogen and phosphorus concentrations. The effects of nitrogen and phosphorus addition on the root traits of *Castanopsis kawakamii* seedlings were analyzed. 【Result】 1) The addition of nitrogen and phosphorus nutrients significantly promoted the growth of morphological indicators such as total root length, average root diameter, and root surface area of *Castanopsis kawakamii* seedlings, and the response of each root indicator to different nitrogen and phosphorus concentrations was different. 2) There is a highly significant positive correlation between total root length, specific root length, number of root tips, number of branches, and root surface area ($p<0.001$); There is a significant positive correlation between root biomass and root volume in the root system ($p<0.001$), and a highly significant negative correlation with root specific surface area ($p<0.001$). 3) The principal component results showed that the root morphology indicators were basically distributed on two orthogonal axes, with a total cumulative variance interpretation rate of 55.1%. The first principal component axis had a significant correlation with root surface area, root tip number, branch number, total root length, specific root length, root specific surface area, and root volume. The second principal component axis has a strong correlation with the average root diameter, root biomass, and root nitrogen content. 4) Hierarchical clustering analysis divided 16 treatments into 3 groups, in which N_0P_3 , N_1P_3 and N_2P_1 were divided into the same group, N_1P_0 , N_1P_2 , N_2P_3 , N_0P_1 and N_1P_1 were divided into the same group, and other treatments were divided into the same group separately.

【Conclusion】 The addition of nitrogen and phosphorus nutrients significantly promoted the root growth of *Castanopsis kawakamii* seedlings, among which the comprehensive effects of various root indicators of *Castanopsis kawakamii* seedlings under N_0P_3 , N_1P_3 , and N_2P_1 treatments were the best. In the future forest management process, the rapid growth and development of the root system of *Castanopsis kawakamii* seedlings can be promoted through the interactive addition of nitrogen and phosphorus.

Key words: nitrogen and phosphorus addition; root traits; root nutrients; balancing strategies; *Castanopsis kawakamii*