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沙质海岸灌化黑松对蛀食胁迫的补偿性响应

The compensatory growth of shrubby *Pinus thunbergii* response to the boring stress in sandy coast

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中文摘要:

黑松(*Pinus thunbergii*)在特定的沙质海岸环境中形成了与之相适应的灌化树形。由蛀食胁迫诱发的黑松补偿性响应是其自我保护和适应不良环境的一种重要机制,目前尚缺乏相关研究。通过比较蛀食前后植株补偿性生长特征的变化来阐明补偿性响应的机理及其在灌化过程中的作用。结果表明:(1) 蛀食胁迫后,当年和次年枝的数量明显增加,且对当年枝的影响大于翌年枝,可见这种补偿响应具有持续性,但强度有减弱的趋势。同样,叶构件的补偿响应也具有持续性但强度差别不显著。(2) 当年枝和叶构件的补偿性生长与其在1年枝上的位置密切相关,蛀食后近顶端枝和叶长度分别为未蛀枝上同部位的1.75与1.43倍,而近底端补偿性生长不明显。(3) 在密度效应的影响下,蛀食枝的芽死亡率上升5.4倍,营养芽产量上升1.55倍,而生殖芽产量差异不显著,因此蛀食胁迫诱发的补偿性响应更倾向于投资营养生长。(4) 主枝遭蛀食胁迫停止生长后,分枝数增多,枝计盒维数增加25%。树冠计盒维数随枝条受害率的增加呈现"先增后减"的变化趋势。通过非线性回归分析表明,两者呈"后峰型"曲线函数关系。(5) 枝和叶构件的总生物量在两条件下差异不显著,属等量补偿性生长。本研究认为:灌化黑松响应蛀食胁迫的补偿性生长机理可用顶端优势去除理论解释,且具有持续效应,这种枝构型改变方式将最终导致黑松灌化形态的形成;同时,补偿性响应还包括芽命运和计盒维数的变化。因此,可将芽命运和计盒维数作为反映植物补偿性生长的指标。

English Summary:

Pinus thunbergii is one of the main tree species of the coastal forest in Shandong peninsula, China, and plays important roles in resisting natural perturbation and maintaining its ecological functions. Adapted to the sandy ocean coast habitats and the windy conditions, the species has developed shrubby crown due to compensatory response, an important mechanism to adapt the stress environments, induced by the insect boring wounds through still unknown mechanisms. For the purpose of sustainable management of *P. thunbergii* forests, this study elucidated the mechanism of compensatory response and its role in the formation process of crown architecture by comparing growth characteristics of the pre- and post-boring treatments. We randomly sampled 20 trees from the coastal pine forests for monitoring the morphological changes of buds and the crown dimension during March 2009 and May 2010, and identified the shoots into three age categories according to the morphological responses to the stressing perturbation. The results showed that 1) the current and next year shoots clearly increased by 1.56 and 1.4 times after the boring, while the treatment effect on the current shoots was higher than that of the next year. It indicated that the compensatory response was persistent but gradually decreased. The compensatory response of leaf module showed similar trend but was statistically insignificant among shoots of different ages. 2) A close relationship between the compensatory growth and the position of one year shoots was found, and the branch length and leaf module near the top was increased 1.75 and 1.43 times in average, respectively, after the boring, but the compensatory growth near the bottom was not tested significant. 3) The process of adapted architecture begun with the change of bud module quantity and forms. The mortality of bud increased by 5.4 times which could be explained by density effect, and the number of vegetative bud increase after boring. The production of vegetative bud increased by 1.55 times on average, but the production of generative bud had no significant difference. These results suggested that the boring induced compensatory response stimulates invest in vegetative growth. 4) The shoot leaders stopped growing after the boring and the number of bifurcation was increased resulting in a 25% improvement in the box-counting dimension (D_b) of shoot. There was a post-peak functional relationship between the crown dimension and damage rate of shoot: the crown dimension reached the maximum while the damage rate was also increased to about 70%. This compensatory response might enhance the competitive ability of the species for space. 5) The total shoot and leaf biomass did not have significant differences between pre- and post treatment indicating an equal-compensatory growth. This study revealed that apical dominance removal and the consequent compensatory responses to the boring wounds resulted in some drastic changes in crown architecture of *Pinus thunbergii* in the stressed coastal environments. The morphological changes of bud and their deviating normal development, as well as the crown dimension could be used as the indicators of this compensatory growth. Further studies should focus on the physiological mechanisms of the stress responses of the species.

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