

不同林龄柳杉人工林土壤有机碳和根际效应的变化特征

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摘要:【目的】人工林具有巨大的固碳潜力, 在减缓全球气候变化方面发挥着重要作用。复杂的根土相互作用可能导致土壤有机碳在林分发育过程中发生变化。然而, 林分发育如何影响根际和非根际土壤有机碳含量以及根际效应仍需进一步研究。分析不同林龄阶段下碳组分变化和根际效应的影响机制, 可为全球变化背景下的人工林科学经营和管理提供理论依据。【方法】以华西雨屏区柳杉人工林为研究对象, 采用空间代替时间的方法, 选取幼龄林(9年)、中龄林(15年)、近熟林(25年)、成熟林(35年)和过熟林(55年)五个龄组的林龄序列样地。采集柳杉1-5级根系、根际土与非根际土样品, 测定根系性状、土壤碳组分、养分含量、微生物活性等指标, 探讨不同林龄柳杉人工林土壤有机碳(SOC)及其组分(颗粒态有机碳, POC和矿物结合态有机碳, MAOC)和根际效应的变化特征。【结果】(1)在林分发育过程中, 根际和非根际土壤中的SOC和POC含量均先增加后趋于稳定, 但在55年过熟林中MAOC含量有所下降; (2)从幼龄林到成熟林的发育过程中, 非根际土壤中POC/SOC比值降低, MAOC/SOC比值升高, 而在根际土壤中呈现出相反的趋势; (3)相对于非根际土壤, 根际土壤中的SOC和POC含量分别高出83.0%和232.2%, 而MAOC在两者之间无显著差异; (4)林龄可以通过直接或间接影响根系性状、土壤性质和微生物特性, 从而影响POC和MAOC的根际效应, 并且SOC的根际效应主要由MAOC的根际效应解释。【结论】我们的研究表明, 过熟人工林仍能促进SOC的固持, 并强调了同时研究根际对POC和MAOC的影响有助于阐明人工林发育过程中根诱导的有机碳封存机制。

关键词: 土壤颗粒态有机碳; 矿物结合态有机碳; 根际效应; 碳固持; 根系性状; 林龄

The variation characteristics of soil organic carbon and rhizosphere effects during the development of *Cryptomeria japonica* plantations

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Abstract: 【Objective】Complex root-soil interactions may cause variations in rhizosphere soil organic carbon (SOC) dynamics with stand development that differ from those in bulk soil. However, how stand age affects particulate organic C (POC) and mineral-associated organic C (MAOC) in the rhizosphere and bulk soil, as well as the rhizosphere effects on SOC pools, remains to be elucidated. 【Method】Here, we investigated the contents of total SOC and its components (POC vs MAOC) in the rhizosphere and bulk soils and further assessed the patterns of the rhizosphere effects on SOC pools along a chronosequence (6, 15, 25, 35, and 55 years) of *Cryptomeria japonica* var. *sinensis* plantations. 【Result】(1)The total SOC and POC contents in both compartments initially increased and then stabilized during stand development, despite a decrease in MAOC content in the 55-year-old

stand, as the soil environment of the over-mature plantation slightly inhibited microbial growth and activity.(2) The POC/SOC decreased and MAOC/SOC ratios increased in bulk soil from 9-year-old to 35-year-old plantation, while contrasting trends were common in rhizosphere soil. (3) The total SOC content was 83.0% significantly higher in the rhizosphere compared to bulk soil while the rhizosphere effect on total SOC decreased with stand age, indicating substantial but diminishing rhizosphere capacity for organic C formation and accumulation during stand development. Moreover, the rhizosphere effects on POC and MAOC, mediated by root traits (related to chemistry and morphology), were directly related to soil and microbial properties, respectively, with the rhizosphere effect on total SOC primarily determined by the effect on MAOC. **【Conclusion】** Collectively, our findings indicate that over-mature plantations still promote SOC sequestration, and underscore that simultaneous tracking of the rhizosphere effects on POC and MAOC helps elucidate the mechanisms of root-induced organic C sequestration during plantation development.

Key words: POC and MAOC; rhizosphere effect; soil carbon sequestration; root traits; stand age.