

黄土高原刺槐林根际和非根际土壤微生物元素利用效率的季节差异

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摘要: 为探究人工林根际和非根际土壤微生物元素利用效率的季节动态及影响因素, 在黄土高原安塞区五里湾流域选取 3 个季节 (春季、夏季、秋季) 刺槐人工林的根际和非根际土壤为研究对象, 测定其理化性质、微生物量和胞外酶活性等指标, 计算化学计量失衡、矢量特征及元素利用效率, 分析根际和非根际土壤微生物元素利用效率的季节变化特征及影响因素。结果表明 (1) 根际和非根际 C:N 失衡在季节上均表现为夏季 > 春季 > 秋季, 在夏季达到最大值 (0.91 和 3.22), 而 C:P 和 N:P 失衡呈现先降低后增加的趋势, 表明微生物在季节上受到底物不平衡的影响。(2) 矢量长度和矢量角度的变化表明根际与非根际土壤微生物均在夏季受到较强的碳、氮限制, 而在春、秋季受到较强的磷限制。(3) 根际和非根际土壤微生物碳利用效率在夏季最低 (0.18 和 0.10), 氮、磷利用效率在夏季最高 (分别为 0.83 和 0.93、0.93 和 0.96)。(4) 偏最小二乘路径模型结果表明, 根际和非根际土壤微生物均通过化学计量失衡特征和胞外酶活性间接地影响元素利用效率, 而非根际土壤微生物化学计量失衡对元素利用效率有直接影响。研究结果有助于深入理解人工林根际和非根际土壤微生物的营养利用机制, 为生态脆弱地区的人工林管理提供理论依据。

关键词: 根际和非根际; 化学计量失衡; 胞外酶; 资源限制; 元素利用效率

Seasonal differences of soil microbial element utilization efficiency in rhizosphere and bulk soil Robinia pseudoacacia forest on the Loess Plateau

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Abstract: To investigate the seasonal dynamics and influencing factors of microbial elements use efficiency in the rhizosphere and bulk soils, the rhizosphere and bulk soils of Robinia pseudoacacia plantations in three seasons (Spring, Summer, and Autumn) were selected as the study objects in Ansai area of the Loess Plateau. Soil physicochemical properties, microbial biomass were measured, and stoichiometric imbalance, vector characteristics,

and element use efficiency were calculated. The results showed that: (1) In rhizosphere and bulk soil, the variation of C: N imbalance showed summer > spring > autumn and reached a maximum value in summer (0.91 and 3.22), while C:P and N:P imbalance showed a trend of first decreasing and then increasing, suggesting that microorganisms were seasonally affected by substrate imbalance. (2) Changes in vector angle and vector length indicated that both rhizosphere and bulk soil microorganisms were affected by stronger carbon and nitrogen limitation in summer, and stronger phosphorus limitation in spring and autumn. (3) The soil microbial carbon use efficiency were the lowest in summer (0.18 and 0.10), and the nitrogen and phosphorus use efficiency were the highest in summer (0.83 and 0.93, 0.93 and 0.96) in rhizosphere and bulk soil. (4) Partial least squares path modeling results showed that microorganisms in rhizosphere and bulk soil indirectly influenced elemental use efficiency through stoichiometric imbalance characteristics and extracellular enzyme activities, while stoichiometric imbalance in bulk soil had a direct effect on microbial elemental use efficiency. The results of the study contribute to an in-depth understanding of the nutrient utilization mechanisms of rhizosphere and bulk soil microorganisms in plantation forests, and provide a theoretical basis for the management of plantation forests in ecologically fragile areas.

Keywords: rhizosphere and bulk; stoichiometric imbalance; extracellular enzymes; resource limitation; element use efficiency