红壤中光皮树的根际溶磷菌的分离、鉴定及功能注释

高壮壮[1,2]， 陈韵竹[2,*]

（1 中南林业科技大学，长沙市，410004；2 湖南省林业科学院，长沙市， 410004）

摘 要:【目的】解析光皮树根际微生物的群落组成，究阐明中国特有木本油料树种光皮树的根际微生物的组成与功能特点，并分离出具有菌肥潜力的高效解磷菌。【方法】以湘林 G1 号光皮树为研究材料，通过测定光皮树的表型差异结合土壤理化性质，采用微生物多样性与宏基因组分析方法，探究红壤中不同长势光皮树根际微生物群落组成与功能差异。通过解磷培养基进行分离高效解磷菌，并测定其解磷能力。通过盆栽实验检验 SwB16 的促生效果。【结果】在本研究中，对选取的具有代表性的光皮树优株（DTs）的树高、地径、冠幅和产量等农艺性状均低于非优株（RTs）。土壤理化性质结果表明，DTs 根际土的有效磷含量显著（$p \leq 0.001$）高于 RTs。根际微生物多样性测定表明，光皮树根际土壤中的优势门有 3 个，分别为 Proteobacteria，Actinobacteria 和 Acidobacteria。在根际微生物差异分析中，检测到细菌生物标志物丰度的显著差异。21 个生物标志物在 DTs 根际土壤中富集，9 个在 RTs 根际土壤中富集。根际微生物宏基因组测定表明，光皮树根际微生物的主要代谢途径有 14 种，其中 Metabolic pathways 的丰度最高，Biosynthesis of secondary metabolites 次之。DTs 根际微生物在代谢，合成，氧化磷酸化等多种生命活动高于 RTs。在环境因子关联分析中，涉及到 23 种代谢途径的 9 个微生物菌群与有效磷相关。通过解磷菌的分离纯化及鉴定，分离出 55 种具有解磷效果的菌，分布于 3 个门。其中，分离得到的高效解磷菌为放线菌，解磷效果为：347.23 $mg \cdot L^{-1}$。并通过盆栽实验进行验证该放线菌的促生能力。实验结果表明，该放线菌促进了光皮树苗子的生长发育。处理组的形态学参数和生物量均高于对照组。【结论】在本研究中，环境差异导致 DTs 与 RTs 根际微生物群落不同。DTs 根际土中的微生物多样性和物种总数都高于 RTs。在 DTs 富集的微生物中多种优势菌具有解磷功能，使土壤条件更适合光皮树的栽培。通过分离纯化，获得了 55 株解磷菌，其中，B16 具有较高的解磷效果，并且可以促进光皮树苗子的生长发育，所以具有成为光皮树林地生物肥料的潜力。

关键词：光皮树;根际微生物;有效磷;微生物多样性；宏基因组，植物生长促进。

Identification, functional annotation, and isolation of phosphorus-solubilizing rhizosphere bacteria of *Swida wilsoniana* (Wanger) Sojak grown in red soil

Abstract: 【Objective】To explore the reasons for the difference of growth potential and production, and to analyze the community composition in rhizosphere microorganisms of *S. wilsoniana*. The composition and functional characteristics of rhizosphere microorganisms of the Chinese endemic woody oil tree species were studied, and efficient phosphorus-solubilizing bacteria with bacterial fertilizer potential were isolated.【Method】In this study, Xianglin G1 was selected as a cultivar of S. *wilsoniana*, by measuring the phenotypic differences and soil physical and chemical properties of S. *wilsoniana*, microbial diversity and metagenomic analysis methods were used to investigate the composition of and functional differences among the rhizosphere microbial communities of trees with different growth potential in red soil. Efficient phosphorus solubilizing bacteria were isolated by phosphorus solubilizing medium, and their phosphorus solubilizing ability was determined. The growth promoting effect of SwB16 was tested by pot experim

ent.【Result】In this study, the tree height, ground diameter, crown width, production and other agronomic traits of selected dominant trees (DTs) were lower than those of recessive trees (RTs). The results of soil physicochemical properties showed that the available phosphorus content of DTs rhizosphere soil was significantly higher than that of RTs soil ($p \leq 0.001$). The determination of rhizosphere microbial diversity showed that there were three dominant phyla in the rhizosphere soil, namely Proteobacteria, Actinobacteria and Acidobacteria. We detected significant differences in the abundance of bacterial biomarkers in different populations and identified a total of 30 biomarkers across all rhizosphere soil samples. Among the 30 biomarkers, 21 were enriched in DTs rhizosphere soil, and 9 were enriched in RTs rhizosphere soil. Through the isolation, purification and identification of phosphorus-solubilizing bacteria, 55 kinds of phosphorus-solubilizing bacteria were isolated and distributed in 3 phyla. Among these bacteria, Actinomycetes were the most efficient phosphorus-solubilizing species, with a phosphorus solubilization capacity of up to 347.23 $mg \cdot L^{-1}$. The growth promoting ability of the actinomycetes was verified by pot experiment. The experimental results showed that the line bacterium promoted the growth and development of the bare bark seedlings. The dry weight and fresh weight of the treatment group were significantly higher than those of the blank group. The seedling height and ground diameter in the treatment group were significantly higher than those in the blank group.【Conclusion】In this study, the microbial community of *S. wilsoniana* is diverse, complex and dynamic. Environmental differences lead to different microbial communities in DT and RT rhizosphere. The microbial diversity and total number of species in DT rhizosphere soil were higher than RT. In the rhizosphere microorganisms of DT enrichment of various advantage bacterium has phosphate-solubilizing function, improve the content of available phosphate in soil, thus making up for the low content of available phosphorus in red soil and making soil conditions more suitable for the cultivation of *S. wilsoniana*. In order to investigate the phosphorus solving ability of rhizosphere phosphorus solubilizing bacteria, we isolated and purified the bacteria with phosphorus solubilizing function. In addition, 55 strains of phosphorus-solubilizing bacteria were obtained, among which, B16 had a high phosphorus solubilizing effect and could promote the growth and development of the seedlings of *S. wilsoniana*, so it had the potential to become a biological fertilizer in the forest of *S. wilsoniana*. The present study elucidated the composition and functional characteristics of rhizosphere microorganisms associated with the Chinese endemic oil plant *S. wilsoniana*, and efficient phosphorus solubilizing bacteria were obtained.