基于最小数据集不同毛竹-多花黄精经营模式土壤质量评价

摘 要:【目的】农林复合经营是一种有效的土地管理方法，在改善生态环境和提高生态系统生产力方面具有巨大潜力，林分密度是影响森林生产力和土壤质量的重要因素。本研究对毛竹（*Phyllostachys pubescens*）-多花黄精（*Polygonatum cyrtonema*）不同经营模式下土壤质量进行综合评价，揭示不同经营模式下土壤质量变化规律及关键影响指标。【方法】2019 年 10 月在安徽省金寨县建立了不同立竹密度毛竹-多花黄精复合经营模式：BP1（1680±50 株·hm^{-2}）、BP2（1475±50 株·hm^{-2}），毛竹纯林 B（1550±50 株·hm^{-2}）以及多花黄精单作 P（4.1±0.23 株·m^{-2}）四种毛竹-多花黄精经营模式，并于 2022 年 7 月采集不同经营模式下 0-10 cm 土层土壤，共测定了 14 个表征土壤物理、化学、生物性质的土壤质量指标。采用单因素方差分析和多重比较（LSD）对土壤质量指标进行比较分析，采用主成分分析法（PCA, Principal Component Analysis）建立最小数据集（MDS, Minimum Data Set），并计算土壤质量指数（SQI, Soil Quality Index）对不同经营模式下土壤质量进行综合评价。【结果】经营模式对土壤理化性质具有显著影响，与单一经营模式相比，复合经营显著提高了土壤含水率（SWC）、降低了土壤容重（BD），其中 BP2 模式表现出更高的 SWC 和较低的 BD。BP1 和 P 模式土壤酸碱度（pH）显著高于 B 和 BP2 模式，与 P 模式相比，复合经营后土壤电导率（EC）显著增加。BP2 模式下土壤有机碳（SOC）、有机氮（TN）、硝态氮（NO_3^--N）含量显著最高，速效磷（AP）显著最低。BP1 模式下土壤全钾（AK）、速效钾（AK）含量显著最高，P 模式铵态氮（NH_4^+-N）含量显著最低，全磷（TP）含量在四种模式之间无显著差异。复合经营显著提高了土壤微生物碳（MBC）和微生物氮（MBN）含量。评价土壤质量的 MDS 指标包括土壤 SWC、MBC、EC、AP。不同经营模式下土壤 SQI 范围在 0.40~0.64 之间，从大到小排序为 BP2>BP1>B>P 模式，其中 BP2 模式 SQI 显著高于其它三种模式。BP1、BP2、P 和 B 四种模式下土壤质量主要限制因子分别为 EC、AP、MBC、SWC。TDS-SQI 和 MDS-SQI 之间呈显著的正相关关系，说明本研究中筛选出用于土壤质量评价的 MDS 指数能够提供准确的评价。【结论】本研究中不同经营模式下土壤质量差异显著，复合经营可以改善土壤理化性质，提高林地土壤质量，其中 BP2 经营模式下(1475±50 株·hm^{-2})更有利于提高土壤质量，不同经营模式下土壤限制因子各异，在实际经营管理中可针对性的进行养分管理，促进林地的可持续发展。

关键词: 毛竹；多花黄精；复合经营；土壤质量评价；最小数据集

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Evaluation of Soil Quality in *Phyllostachys pubescens* - *Polygonatum cyrtonema* management modes Based on the Smallest Data Set

Abstract:【Objective】Agroforestry has been proved to be an effective land management method, which has great potential for improving the ecological environment and raising the ecosystem productivity, and stand density is an important factor affecting forest productivity and soil quality. The aim of this study was to evaluate the soil quality and clarify the key influencing factors under four *Phyllostachys pubescens* - *Polygonatum cyrtonema* modes. 【Method】In October, 2019, Four *Phyllostachys pubescens* - *Polygonatum cyrtonema* management modes with different standing densities were established: BP1 (1680 ± 50 culms·hm^{-2}), BP2 (1475 ± 50 culms·hm^{-2}), bamboo forest B (1550 ± 50 culms·hm^{-2}) and *Polygonatum cyrtonema* monoculture P (4.1 ± 0.23 plants · m-2) in Jingzhai, Anhui Province of China. A total of 14 soil indicators representing its physical, chemical, and biological properties were measured for the 0–10 cm layer in July, 2022. Using one□way ANOVA and LSD multiple comparisons to compare differences in soil indicators,

Principal component analysis (PCA) was to establish the minimum data set (MDS) indicators, and soil quality index (SQI) was built to quantitatively evaluate soil quality.【Result】The management modes has a significant impact on soil properties. Compared with the monocultivaion mode, compound management significantly increases soil moisture content (SWC) and reduces soil bulk density (BD), and the BP2 mode exhibits higher SWC and lower BD. The soil pH of the BP1 and P mode is significantly higher than those of the B and BP2 modes. Compared with the P mode, the EC significantly increased after intercropping. Under the BP2 mode, soil organic carbon (SOC), organic nitrogen (TN), and nitrate nitrogen (NO_3^--N) contents were significantly highest, while available phosphorus (AP) was significantly lowest. The soil total potassium (AK) and available potassium (AK) contents were significantly highest in the BP1 mode, while the ammonium nitrogen (NH_4^+-N) content in the P mode was significantly lowest. There was no significant difference in total phosphorus (TP) content among the four modes. Compound management significantly increased the content of soil microbial carbon (MBC) and microbial nitrogen (MBN). The MDS indicators for evaluating soil quality include soil SWC, MBC, EC, and AP. Under different business models, the soil SQI range is between 0.40 and 0.64, sorted from largest to smallest, were: BP2>BP1>B>P, with BP2 model having significantly higher SQI than the other three modes. The main limiting factors for soil quality under the four modes of BP1, BP2, P, and B were EC, AP, MBC, and SWC, respectively. There was a significant positive correlation between TDS-SQI and MDS-SQI, indicating that the MDS index selected for soil quality evaluation in this study can provide accurate evaluation.【Conclusion】There were significant differences in soil quality under different management modes. Compound management can improve soil quality. Among them, BP2 management mode (1475 ± 50 culms·hm^{-2}) would be beneficial to improve the soil quality. Soil limiting factors vary under different management modes, and nutrient management can be targeted in actual management to promote sustainable development of forest land.

Key words: *Phyllostachys pubescens*; *Polygonatum cyrtonema*; management mode; soil quality evaluation; Minimum Data.