分类号：_____ 学校代码：10269

密　级：_____ 工　　号：20164003

華東師範大學

博士后研究工作报告

氮添加对亚热带常绿林土壤微生物量和酶活性的影响

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研究工作开始时间：2016 年 1 月

研究工作完成时间：2019 年 10 月

华东师范大学（上海）

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EFFECTS OF NITROGEN ADDITION ON SOIL MICROBIAL BIOMASS AND EXTRACELLULAR ENZYME ACTIVIRY IN A SUBTROPICAL EVERGREEN FOREST

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研究工作期满时间　2019 年 10 月

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内 容 摘 要

由于工业化和大量人为活动导致的氮沉降，造成许多亚热带生态系统中氮（N）沉积迅速增加，但土壤重要元素碳（C），氮，磷（P）以及微生物活性对 N 沉降的响应，无论在方向还是程度上都还不一致。尽管表层土和深层土在很多特性非常不同，大量研究主要基于表层土壤，而对深层土壤的研究很有限。

土壤胞外酶是土壤质量评价的重要指标，在森林生态系统的生物地球化学循环中起着重要作用。特别是，对土壤微生物如何对热带和亚热带森林中的氮（N）沉积作出反应非常重要，因为在热带森林和亚热带森林土壤 N 利用率通常会增加。本研究阐释了氮沉降对中国细东部亚热带常绿阔叶林土壤养分、微生物和胞外酶活性的影响是否对着土壤深度的变化而产生差异。

在对照（0 kg N ha^{-1} yr^{-1}），低氮（50 kg N ha^{-1} yr^{-1}）和高氮（100 kg N ha^{-1} yr^{-1}）三种 N 添加水平的样地，分别在表层土（0-10 cm），中层土（10-30 cm）和深层土（30-50 cm）采集土壤样品。本研究测定了土壤微生物量碳（C）、N 和磷（P）（MBC, MBN and MBP），以及与 C、N and P-循环有关的胞外酶活性。结果表明，除了土壤 C:P 和 N:P 大多数土壤养分及其生态化学计量比都随着土壤深度的增加而降低。尽管 N 添加整体上对土壤 C, N, P 及其生态化学计量比没有显著影响，N 添加提高了表层土壤 C:N 和 N:P。另外，研究结果显示 N 添加对土壤微生物量没有显著影响。与之相反，N 添加整体上显著影响了与 C 和 N 循环有关的酶活性，但对 P 循环有关的酶活性和氧化酶活性没有显著影响。N 添加随着土壤深度的增加，提高了 C 和 N 循环有关的酶活性，在上层土壤降低了氧化酶活性，但 N 添加与 P 循环有关的酶活性的影响随着土壤深度没有显著变化。

总之，土壤酶活性比微生物量对 N 添加的响应更敏感，它们都和土壤养分有相关性。本研究为研究土壤生物地球化学循环和微生物活性对于 N 沉降的响应提供了数据支持。今后，长期 N 添加对亚热带常绿林土壤微生物特性的研究显得更为重要。

关键词：氮沉降；微生物活性；土壤剖面；亚热带森林；化学计量学

Abstract

Despite rapid increases in nitrogen (N) deposition in many subtropical ecosystems as a result of industrialization and greater anthropogenic N deposition, there have been still no consistent responses of soil key elements of carbon (C), N and phosphorus (P) and soil microbial activities to N addition in both direction and magnitude. However, the majority studies focused on the surface soil and few attempts have made to the deeper soil, despite in pedological and physicochemical features differed between the upper and deeper soils.

Soil extracellular enzymes are important indicators of soil quality, and play an important role in the biogeochemical cycling of forest ecosystems. Particularly, it is important to know how soil microbes respond to N deposition in tropical and subtropical forests, where an increase in soil N availability is typically observed. We examined whether the effects of N addition on soil nutrients, microbial biomass, extracellular enzyme activity (EEA) changes with soil depth in a subtropical evergreen forest in eastern China.

Soil samples were collected from three depths: top soil (0-10 cm), midsoil (10-30 cm) and subsoil (30-50 cm), and from three N addition levels: ambient (0 kg N ha^{-1} yr^{-1}), low (50 kg N ha^{-1} yr^{-1}) and high (100 kg N ha^{-1} yr^{-1}). We measured microbial biomass C, N and P (MBC, MBN and MBP), and EEAs of six enzymes involved in C-, N- and P-cycling. The results clearly demonstrate that most of soil nutrients and their stoichiometry decreased with soil depth, except for C:P and N:P. Although N addition totally had no effects on soil C, N, P and stoichiometry, we found N addition increased C:N and N:P in the topsoil. N additions did not affect soil microbial biomass. In contrast, N addition totally affected EEAs involved in C- and N-cycling, except for their ratios, and P-acquisition and oxidative enzymes. However, the interaction between N addition and soil depth increased EEAs related to C- and N-acquisition enzymes, and suppressed oxidative enzymes in the upper soil. This was not the case for P-acquisition enzymes.

Taken together, we demonstrate that soil EEA is more sensitive than microbial biomass to over 6-years N additions, and both of these were correlated with soil nutrients among treatments. Our studies have provided useful information about the biogeochemical cycle and microbial activities under N deposition. Further study is needed to appropriately assess and clarify the long-term effects of N addition on soil microbial biomass and EEAs

with soil depth in subtropical forests.

Keywords: N deposition; microbial activity; soil profile; subtropical forest; stoichiometry