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氮沉降对杉木人工林土壤有机碳矿化和土壤酶活性的影响

Effects of elevated nitrogen deposition on soil organic carbon mineralization and soil enzyme activities in a Chinese fir plantation

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中文摘要:

为探讨氮沉降对亚热带森林土壤有机碳矿化及土壤酶活性的影响规律,在杉木人工林中开展了野外模拟N沉降试验。试验设计为4种处理,分别为N0(对照)、N1(60 kg N·hm^{-2}·a^{-1})、N2(120 kg N·hm^{-2}·a^{-1})和N3(240 kg N·hm^{-2}·a^{-1}),每处理重复3次。通过28 d的培养后发现,各土层有机碳日均矿化量随培养时间的延长呈下降趋势,而有机碳累计矿化量则逐步增加。不同氮沉降处理下各土层有机碳累计矿化量总体趋势表现为:随着氮沉降量的增加而降低,日均矿化量降低幅度以N1最大,其次是N0和N2,N3降幅最小。相同N沉降处理下,参与土壤碳循环的6种主要酶(蔗糖酶、纤维素酶、淀粉酶、β-葡糖苷酶、多酚氧化酶、过氧化物酶)活性、土壤有机碳日均矿化量和有机碳累计矿化量均随土层加深而降低。氮沉降对6种土壤酶活性的影响存在差异,对纤维素酶和多酚氧化酶具有促进作用,而对淀粉酶和过氧化物酶表现出一定的抑制作用;中-低氮沉降(N1、N2)对蔗糖酶无影响,而对β-葡糖苷酶具有促进作用,高氮沉降(N3)促进了蔗糖酶活性,但抑制了β-葡糖苷酶活性。表层土壤中,土壤有机碳累积矿化量与土壤纤维素酶、β-葡糖苷酶、过氧化物酶活性呈显著正相关。因此,氮沉降促进了表层土壤纤维素酶、多酚氧化酶和蔗糖酶的活性,但在一定程度上抑制了淀粉酶和过氧化物酶,对土壤有机碳矿化也表现出明显的抑制作用。

English Summary:

Human activities have dramatically increased the quantity of nitrogen fixed in terrestrial ecosystems, due to fossil fuel combustion, production and use of chemical fertilizers, and livestock ranching. Increased N supply can have a fertilization effect on forest ecosystems, but in the long-term, excess N can negatively impact biogeochemical cycling, soil chemistry, and productivity. Most research to date has focused on aggregate effects of N deposition on soil chemistry and N cycling. However, very little is known about the response of the microbial activities that are responsible for soil nutrient cycling and decomposition to these environmental changes. To investigate the response of soil organic carbon mineralization and soil enzyme activities to elevated nitrogen deposition, a field experiment was conducted in a Chinese fir plantation at Shaxian State Forest Farm of Fujian Province, China. Nitrogen loadings were designed at 4 levels as N0 (control), N1, N2 and N3 at the doses of 0, 60, 120 and 240 kg·hm^{-2}·a^{-1}N, respectively. Each treatment comprised three replicate plots of 20m×20m which were sprayed with $CO(NH_2)_2$ solutions on the forest floor at the beginning of each month, lasting from January 2004 to the sampling time, March 2010. Soil samples were incubated in the laboratory at 28 °C for 28 days, and the alkali absorption method was applied to measure soil respiration. The carbon that mineralized as CO_2 evolved was measured on the third day and once every week thereafter, and determined on the 28th day for the last time. Soil invertase, cellulose and amylase were detected by 3, 5- dinitrosalicylic acid assay, β-glucosidase by nitrophenol colorimetric method, and polyphenol oxidase and peroxidase by iodometric titration. During the incubation period, the daily mineralization of soil organic carbon decreased, but the cumulative mineralization of soil organic carbon increased with increasing time. Generally, the cumulative mineralization of soil organic carbon decreased with increasing doses of nitrogen deposition. The daily mineralization of soil organic carbon decreased in the sequence of N1>N0>N2>N3. At the same level of nitrogen deposition, the activities of the six soil enzymes involving carbon cycle (invertase, cellulose, amylase, β-glucosidase, polyphenol oxidase and peroxidase),the daily mineralization of soil organic carbon and the cumulative mineralization of soil organic carbon all decreased with the increasing soil depth. The activities of six soil enzymes responded differently to nitrogen treatments. At the soil depth of 0-20 cm, nitrogen additions promoted cellulose and polyphenol oxidase activities, but inhibited amylase and peroxidase to some extents. High level of nitrogen loading (N3) showed significant positive impact on invertase, but negative on β-glucosidase. Significant correlation was established between some soil enzymes, with cellulose being positively related with invertase and amylase, polyphenol oxidase with amylase and cellulose, peroxidase with invertase, amylase, cellulose and polyphenol oxidase. Soil organic carbon mineralization was also found to be positively correlated with β-glucosidase and peroxidase, but negatively with invertase and cellulose at the surface soil (0-20 cm). Hence, nitrogen deposition in this experiment accelerated the activities of surface soil cellulose, polyphenol oxidase and invertase, but inhibited amylase and peroxide to some extents, and suppressed soil organic carbon mineralization.

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