Acid Rain

Title	**Effects of rare earth and acid rain pollution on plant chloroplast ATP synthase and element contents at different growth stages**
Author Name	Fan Zhang, Huiqing Hu, Lihong Wang, Qing Zhou & Xiaohua Huang
Journal Name	Chemosphere
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Volume and Issue	194
Pages	441-449
Abstracts	Combined rare earth and acid rain pollution has become a new environmental problem, seriously affecting plant survival. The effects of these two kinds of pollutants on plant photosynthesis have been reported, but the micro mechanisms are not very clear. In this research, we studied the effects of lanthanum [La(III), 0.08, 1.20 and 2.40 mM] and acid rain (pH value = 2.5, 3.5 and 4.5) on the ATPase activity and gene transcription level and the functional element contents in rice leaf chloroplasts. The results showed that the combined 0.08 mM La(III) and pH 4.5 acid rain increased the ATPase activity and gene transcription level as well as contents of some functional elements. But other combined treatments of acid rain and La(III) reduced the ATPase activity and gene transcription level as well as functional element contents. The change magnitude of the above indexes at rice booting stage was greater than that in seedling stage or grain filling stage. These results reveal that effects of La(III) and acid rain on ATPase activity and functional element contents in rice leaf chloroplasts are related to the combination of La(III) dose and acid rain intensity and the plant growth stage. In addition, the changes in the ATPase activity were related to ATPase gene transcription level. This study would provide a reference for understanding the microcosmic mechanism of rare earth and acid rain pollution on plant photosynthesis and contribute to evaluate the possible environmental risks associated with combined La(III) and acid rain pollution.
Keywords	Lanthanum; Acid rain; Rice; ATP synthase; Functional elements

Title	**Comparative effects of simulated acid rain of different ratios of SO_4^{2-} to NO_3^- on fine root in subtropical plantation of China**
Author Name	Xin Liu, Wenrui Zhao, Miaojing Meng, Zhiyuan Fu, Linhao Xu, Yan Zha, Jianmin Yue, Shuifeng Zhang & Jinchi Zhang
Journal Name	Science of The Total Environment
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Abstracts	The influence of acid rain on forest trees includes direct effects on foliage as well as indirect soil-mediated effects that cause a reduction in fine-root growth. In addition, the concentration of NO_3^- in acid rain increases with the rapidly growing of nitrogen deposition. In this study, we investigated the impact of simulated acid rain with different SO_4^{2-}/NO_3^- (S/N) ratios, which were 5:1 (S), 1:1 (SN) and 1:5 (N), on fine-root growth from March 2015 to February 2016. Results showed that fine roots were more sensitive to the effects of acid rain than soils in the short-term. Both soil pH and fine root biomass (FRB) significantly decreased as acid rain pH decreased, and also decreased with the percentage of NO_3^- increased in acid rain. Acid rain pH significantly influenced soil total carbon and available potassium in summer. Higher acidity level (pH = 2.5), especially of the N treatments, had the strongest inhibitory impact on soil microbial activity after summer. The structural equation modelling results showed that acid rain S/N ratio and pH had stronger direct effects on FRB than indirect effects via changed soil and fine root properties. Fine-root element contents and antioxidant enzymes activities were significantly affected by acid rain S/N ratio and pH during most seasons. Fine-root Al ion content, Ca/Al, Mg/Al ratios and catalase activity were used as better indicators than soil parameters for evaluating the effects of different acid rain S/N ratios and pH on forests. Our results suggest that the ratio of SO_4^{2-} to NO_3^- in acid rain is an important factor which could affect fine-root growth in subtropical forests of China.
Keywords	Acid rain; Fine root biomass; Fine root element; SO_4^{2-}/NO_3^-; Soil acidification

Title	**Direct effect of acid rain on leaf chlorophyll content of terrestrial plants in China**
Author Name	Enzai Du, Dan Dong, Xuetong Zeng, Zhengzhong Sun, Xiaofei Jiang, Wim de Vries
Journal Name	Science of The Total Environment
Year	2017
Volume and Issue	605-606
Pages	Pages 764-769
Abstracts	Anthropogenic emissions of acid precursors in China have resulted in widespread acid rain since the 1980s. Although efforts have been made to assess the indirect, soil mediated ecological effects of acid rain, a systematic assessment of the direct foliage injury by acid rain across terrestrial plants is lacking. Leaf chlorophyll content is an important indicator of direct foliage damage and strongly related to plant productivity. We synthesized data from published literature on experiments of simulated acid rain, by directly exposing plants to acid solutions with varying pH levels, to assess the direct effect of acid rain on leaf chlorophyll content across 67 terrestrial plants in China. Our results indicate that acid rain substantially reduces leaf chlorophyll content by 6.71% per pH unit across the recorded plant species. The direct reduction of leaf chlorophyll content due to acid rain exposure showed no significant difference across calcicole, ubiquist or calcifuge species, implying that soil acidity preference does not influence the sensitivity to leaf injury by acid rain. On average, the direct effects of acid rain on leaf chlorophyll on trees, shrubs and herbs were comparable. The effects however varied across functional groups and economic use types. Specifically, leaf chlorophyll content of deciduous species was more sensitive to acid rain in comparison to evergreen species. Moreover, vegetables and fruit trees were more sensitive to acid rain than other economically used plants. Our findings imply a potential production reduction and economic loss due to the direct foliage damage by acid rain.
Keywords	Acid rain; Chlorophyll; Functional group; Economic use type; Calcicole; Calcifuge

Title	**Effects of simulated acid rain on soil respiration and its components in a subtropical mixed conifer and broadleaf forest in southern China**
Author Name	Guohua Liang, Dafeng Hui, Xiaoying Wu, Jianping Wu, Juxiu Liu, Guoyi Zhou Deqiang Zhang
Journal Name	Environ. Sci.: Processes Impacts
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Abstracts	Soil respiration is a major pathway in the global carbon cycle and its response to environmental changes is an increasing concern. Here we explored how total soil respiration (RT) and its components respond to elevated acid rain in a mixed conifer and broadleaf forest, one of the major forest types in southern China. RT was measured twice a month in the first year under four treatment levels of simulated acid rain (SAR: CK, the local lake water, pH 4.7; T1, water pH 4.0; T2, water pH 3.25; and T3, water pH 2.5), and in the second year, RT, litter-free soil respiration (RS), and litter respiration (RL) were measured simultaneously. The results indicated that the mean rate of RT was 2.84 ± 0.20 μmol CO_2 m^{-2} s^{-1} in the CK plots, and RS and RL contributed 60.7% and 39.3% to RT, respectively. SAR marginally reduced ($P = 0.08$) RT in the first year, but significantly reduced RT and its two components in the second year ($P < 0.05$). The negative effects were correlated with the decrease in soil microbial biomass and fine root biomass due to soil acidification under the SAR. The temperature coefficients (Q10) of RT and its two components generally decreased with increasing levels of the SAR, but only the decrease of RT and RL was significant ($P < 0.05$). In addition, the contribution of RL to RT decreased significantly under the SAR, indicating that RL was more sensitive to the SAR than RS. In the context of elevated acid rain, the decline trend of RT in the forests in southern China appears to be attributable to the decline of soil respiration in the litter layer.
Keywords	Soil respiration; southern China; microbial biomass; temperature coefficients; soil acidification