

Leaf Carbon-Nitrogen Stoichiometric Characteristics of *Picea schrenkiana* Forest and Their Relationships with Soil Physicochemical Factors: Postprint

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Abstract

Carbon (C) and nitrogen (N) are essential for plant growth and physiological regulation. Investigating the variation characteristics of leaf C and N stoichiometry in relation to soil physicochemical factors in *Picea schrenkiana* forests is crucial for understanding the distribution patterns and future trends of forest ecosystems, and provides a scientific basis for further exploring the effects of global change on plants. This study focused on leaves of *Picea schrenkiana* forests, employing statistical analysis to investigate the variation characteristics of leaf C and N stoichiometry, and utilizing Redundancy Analysis (RDA) to examine the relationships between leaf C and N stoichiometric characteristics and soil physicochemical factors. The results showed that the mean leaf C content was 465.28 g·kg⁻¹ with a coefficient of variation of 14%; the mean leaf N content was 6.54 g·kg⁻¹ with a coefficient of variation of 42%; and the mean soil C/N ratio was 90.63 with a coefficient of variation of 82%. RDA results revealed that in the 0-30 cm layer, leaf C and N stoichiometric characteristics were primarily driven by soil water content and pH: soil water content was positively correlated with leaf C/N ratio but negatively correlated with leaf C and N contents; pH was positively correlated with leaf C and N contents but negatively correlated with C/N ratio. In the 30-80 cm layer, soil water content and soil clay content were the main factors influencing leaf C and N stoichiometric characteristics: soil water content was positively correlated with leaf C/N ratio, while soil clay content was positively correlated with leaf C and N contents but negatively correlated with leaf C/N ratio; the effects of pH and soil C and N contents on leaf C and N stoichiometric characteristics were not significant.

Full Text

Preamble

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Abstract

Carbon (C) and nitrogen (N) play important roles in plant growth and physiological functions. Studying the relationship between the C and N content in leaves of a plant and its environmental factors contributes to elucidating the supply of plant nutrients and plant growth in different environments, which is of great significance to understanding the distribution pattern of forest ecosystems and the trend of future changes, and even the response of plants to global change. This paper took the leaves of *Picea schrenkiana* (Schrenk's spruce) forests and the corresponding soil of the trees as the study objects. With samples collected from the field, we retrieved the C and N contents in the leaves and analyzed different soil layers. Then we evaluated the variation of C and N stoichiometric characteristics through statistical analysis. Finally, redundancy analysis (RDA) was used to investigate the relationships between the stoichiometric characteristics of C and N from the leaves and the soil physicochemical factors. The results showed that the average concentrations of C and N in the leaf were $465.28 \text{ g} \cdot \text{kg}^{-1}$ and $6.54 \text{ g} \cdot \text{kg}^{-1}$ respectively, and the variation coefficient were 14% and 82% respectively. The RDA showed that in the soil layer from 0 to 30 cm, the stoichiometric characteristics of C and N in the leaf were mainly affected by soil water content and its acidity-alkalinity. For the soil water content, there was a positive correlation with the C/N ratio but a negative correlation with the C and N content in the leaf, while for the acidity-alkalinity of the soil, there was a positive correlation with C and N contents in the leaf but a negative correlation with the C/N ratio. In the soil layer from 30 to 80 cm, the stoichiometric characteristics of C and N in the leaf were mainly affected by soil water content and soil clay content. Specifically, for soil water content, there was a positive correlation with the C/N ratio. For soil clay content, there was a positive correlation with C and N contents but a negative correlation with the C/N ratio. Additionally, there were not significant relationships between pH and the C and N contents in the soil and the leaf's C and N stoichiometric characteristics. The soil water content in different soil layers was related to the

stoichiometric characteristics of C and N from the leaf, which indicated that the soil water content had certain effects on nutrient uptake by plants, and that was not related to the soil depth.

Keywords: *Picea schrenkiana* forests; redundancy analysis; stoichiometric characteristics; physicochemical factors

2.2 Relationships Between Soil Physicochemical Factors and Leaf C, N Stoichiometry

The redundancy analysis (RDA) revealed that in the 0-30 cm soil layer, leaf C and N stoichiometry was primarily influenced by soil water content and pH. Soil water content exhibited a positive correlation with the C/N ratio ($P < 0.05$) but negative correlations with leaf C and N contents. Soil pH showed positive correlations with leaf C and N contents but a negative correlation with the C/N ratio. In the 30-80 cm layer, leaf C and N stoichiometry was mainly affected by soil water content and clay content. Soil water content maintained a positive correlation with the C/N ratio, while clay content positively correlated with leaf C and N contents but negatively with the C/N ratio. Notably, no significant relationships were observed between soil pH and leaf C, N stoichiometric characteristics in the deeper layer.

[Figure 2: see original paper] shows the relationship between leaf C and N contents. The correlation between leaf C and N contents was significant ($R^2 = 0.55$, $P < 0.001$). The C/N ratio varied with soil depth, averaging 71.2 in the 0-30 cm layer and 68.4 in the 30-80 cm layer.

3 Discussion

Soil water content emerged as a critical factor influencing leaf C and N stoichiometry across both layers, suggesting that water availability directly affects nutrient uptake and allocation in *P. schrenkiana*. The positive correlation between soil water content and leaf C/N ratio indicates that water stress may constrain N uptake more strongly than C assimilation, leading to higher C/N ratios under drier conditions. This pattern aligns with previous studies demonstrating that water limitation reduces N concentration in plant tissues [?].

The contrasting effects of pH between soil layers warrant attention. In the surface layer (0-30 cm), pH significantly influenced leaf stoichiometry, likely due to its control over microbial activity and nutrient mineralization rates [?]. However, this relationship disappeared in the deeper layer, possibly reflecting reduced root activity and microbial biomass at depth. The absence of pH effects in the 30-80 cm layer suggests that deep soil chemistry has limited direct impact on leaf nutrient status in this species.

Clay content's significant role in the 30-80 cm layer highlights the importance of soil texture in regulating nutrient supply. Higher clay content typically increases cation exchange capacity and water retention, facilitating nutrient availability

[?]. The positive correlation between clay content and leaf C and N contents supports this mechanism, while the negative correlation with C/N ratio suggests improved N supply relative to C under high clay conditions.

The lack of significant relationships between soil pH and leaf stoichiometry in deeper horizons indicates that *P. schrenkiana* may rely more on surface soil nutrients, or that root distribution is concentrated in the upper profile. This has important implications for forest management, as surface soil disturbance could disproportionately affect nutrient cycling in these ecosystems.

[Figure 2: see original paper] Relationship of leaf C and N contents

[Figure 3: see original paper] RDA ordination diagram showing relationships between leaf C, N stoichiometry and soil factors in (a) 0-30 cm and (b) 30-80 cm layers

4 Conclusion

This study demonstrates that leaf C and N stoichiometry in *Picea schrenkiana* forests is primarily regulated by soil water content, pH (in surface layers), and clay content (in deeper layers). The consistent influence of water content across depths underscores its fundamental role in nutrient acquisition. These findings improve our understanding of how soil physicochemical properties drive plant nutrient dynamics in arid forest ecosystems and provide a basis for predicting responses to environmental change.

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