Variations in C, N and P stoichiometry of leaf-litter-soil associated with Mongolian pine by stand origin, Northern China

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Abstract

Ecological stoichiometry is an important approach to understand the nutrient cycling and balance through the leaf-litter-soil system of Mongolian pine among different stand origins in desert regions. To reveal the variations in Mongolian pine carbon (C), nitrogen (N), and phosphorus (P) stoichiometry and stoichiometric homeostasis among different stand origins, we measured C, N, and P concentrations of leaves, litter, and soil, and analyzed the nutrient resorption efficiencies of leaves in differently aged plantations and natural forests from semi-arid and dry sub-humid regions. The results showed that (a) the stand origin had a significant effect on the C-N-P stoichiometry, and also significantly affected leaf N and P reabsorption efficiencies. Leaf N/P ratios indicated that Mongolian pine was co-limited by N and P in the NF, HB and HQ, and was mainly limited by P in MU. (2) With increasing stand age, C concentrations in the leaf-litter-soil system initially increased and then decreased, the N and P concentrations and reabsorption efficiencies in the leaf-litter-soil system were gradually increased. Overall, stand age had a significant effect on N concentrations, C/N and C/P ratios in the leaf-litter-soil system. (3) The C and N elements between the leaf-litter-soil system had a strong coupling relationship, and the P element between litter-soil had a strong coupling relationship. In addition, plantations exhibited greater N/P homeostasis than natural forests, and N/P exhibited greater homeostasis than N and P alone, which may be a nutrient utilization strategy for forests to alleviate N or P limitation. (4) Environmental factors have a significant influence on C-N-P stoichiometry in the leaf-litter-soil system, the most important soil properties and meteorological factors being soil water content and precipitation, respectively. These results will be essential to provide guidance for plantation restoration and management in desert regions.

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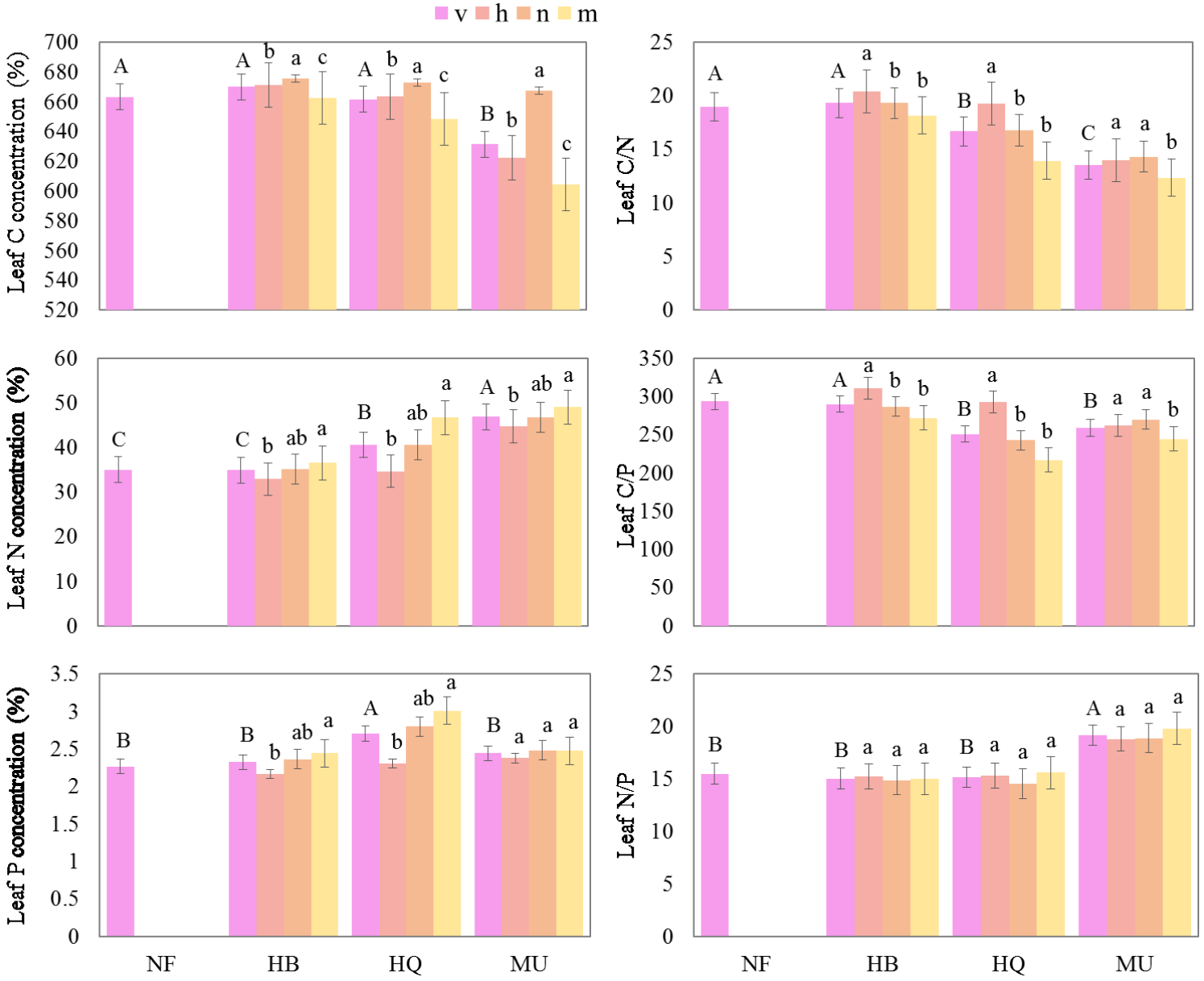

FIGURE 1 Differences in leaf C, N and P stoichiometric characteristics across the growth stage between natural forest and plantations. Error bars are the standard error (n=3). "h" for the half-mature forest, "n" for the near-mature forest, "m" for the mature forest, "v" for the mean value of h, n, and m. Different capital letters indicate significant differences in mean values among study areas, different litter letters indicate significant differences among stand ages.

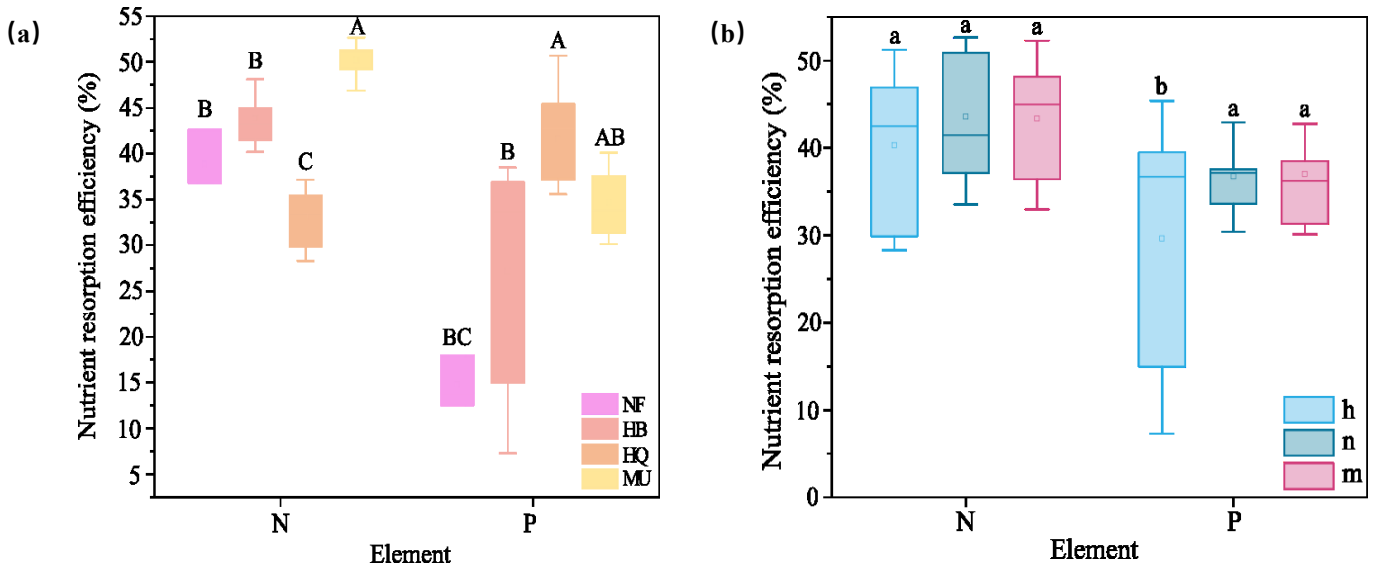

FIGURE 2 N and P resorption efficiencies of Mongolian pine in different stand origin (a) and stand age (b). Different capital letters indicate significant differences among study areas, different litter letters indicate significant differences among stand ages.

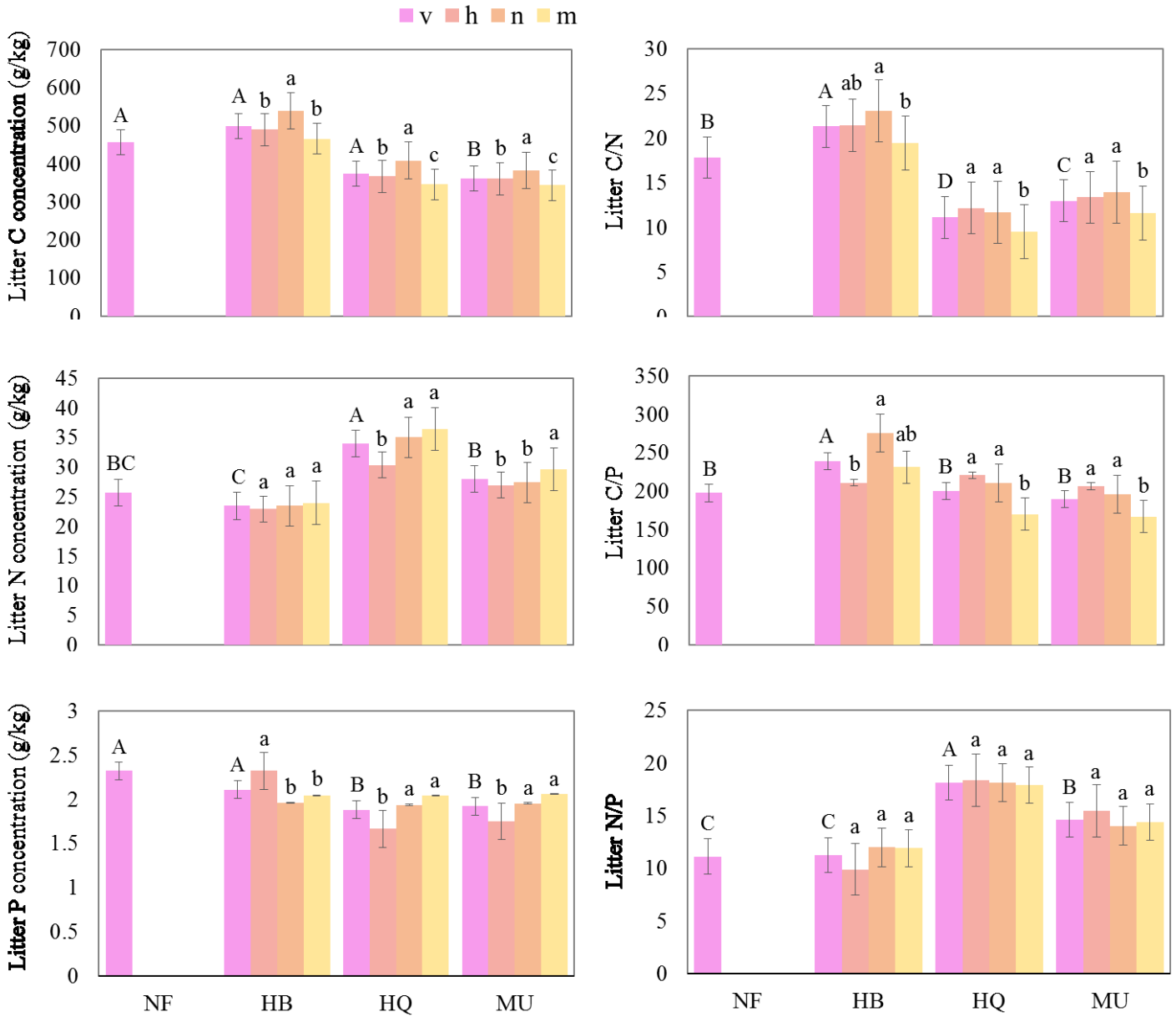

FIGURE 3 Differences in litter C, N and P stoichiometric characteristics across the growth stage between natural forest and plantations. Error bars are the standard error (n=3). "h" for the half-mature forest, "n" for the near-mature forest, "m" for the mature forest, "v" for the mean value of h, n, and m. Different capital letters indicate significant differences in mean values among study areas, different litter letters indicate significant differences among stand ages.

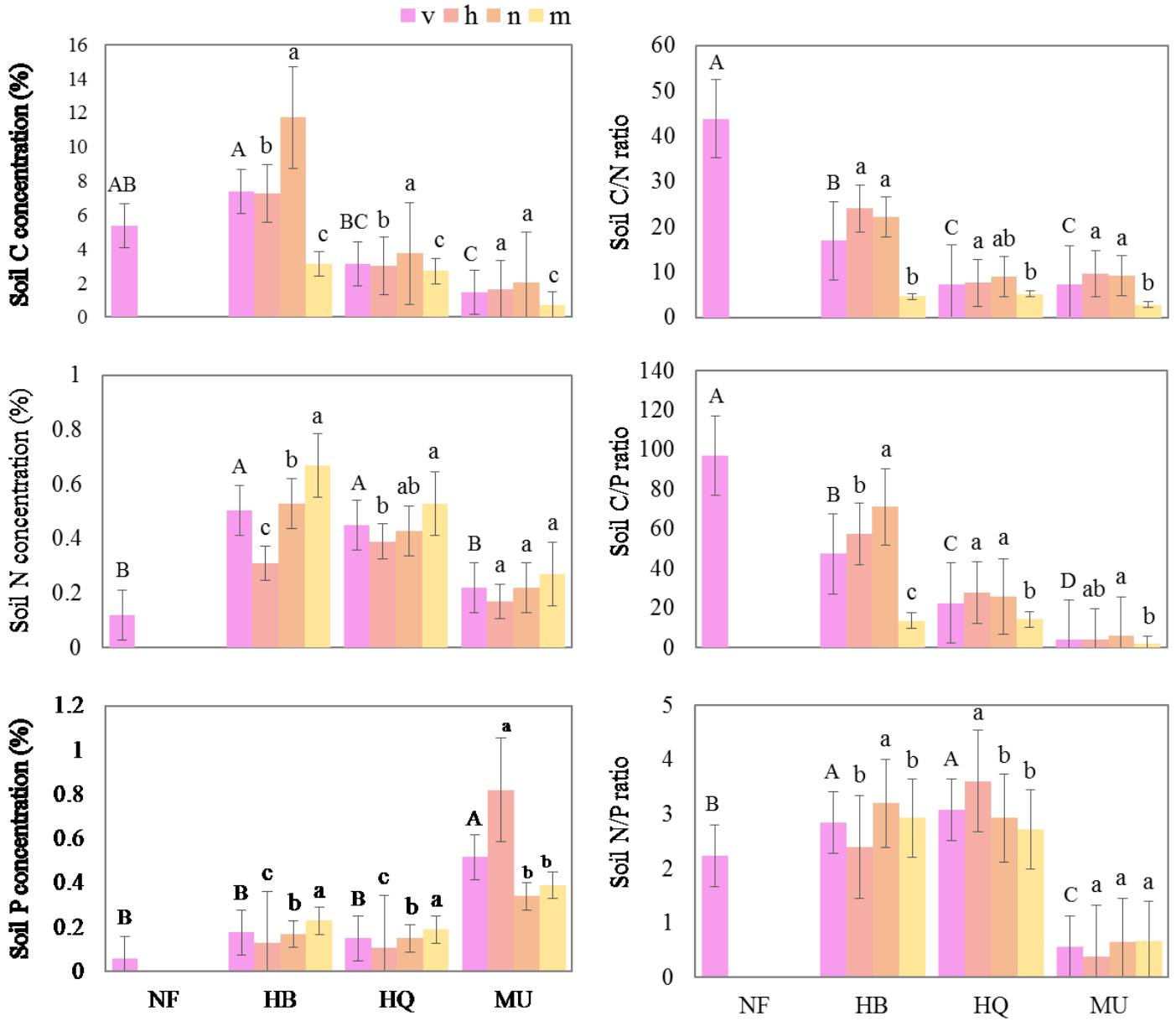

FIGURE 4 Differences in soil C, N and P stoichiometric characteristics across the growth stage between natural forest and plantations. Error bars are the standard error (n=3). "h" for the half-mature forest, "n" for the near-mature forest, "m" for the mature forest, "v" for the mean value of h, n, and m. Different capital letters indicate significant differences in mean values among study areas, different litter letters indicate significant differences among stand ages.

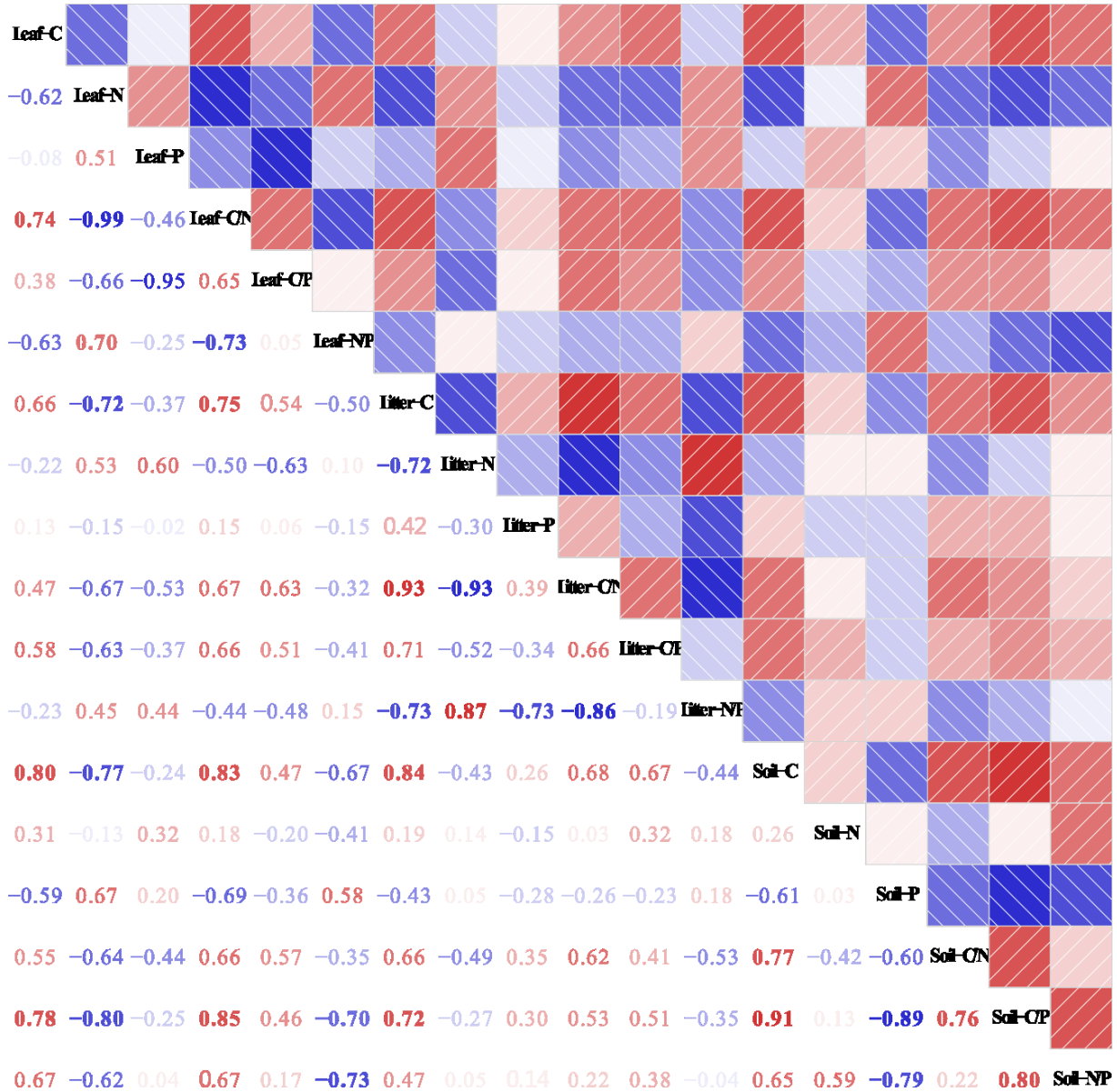

FIGURE 5 Relationship between C-N-P stoichiometric characteristics among leaf-litter-soil system. Red indicates positive correlations, blue indicates negative correlations. The numbers in the graph are correlation coefficients.

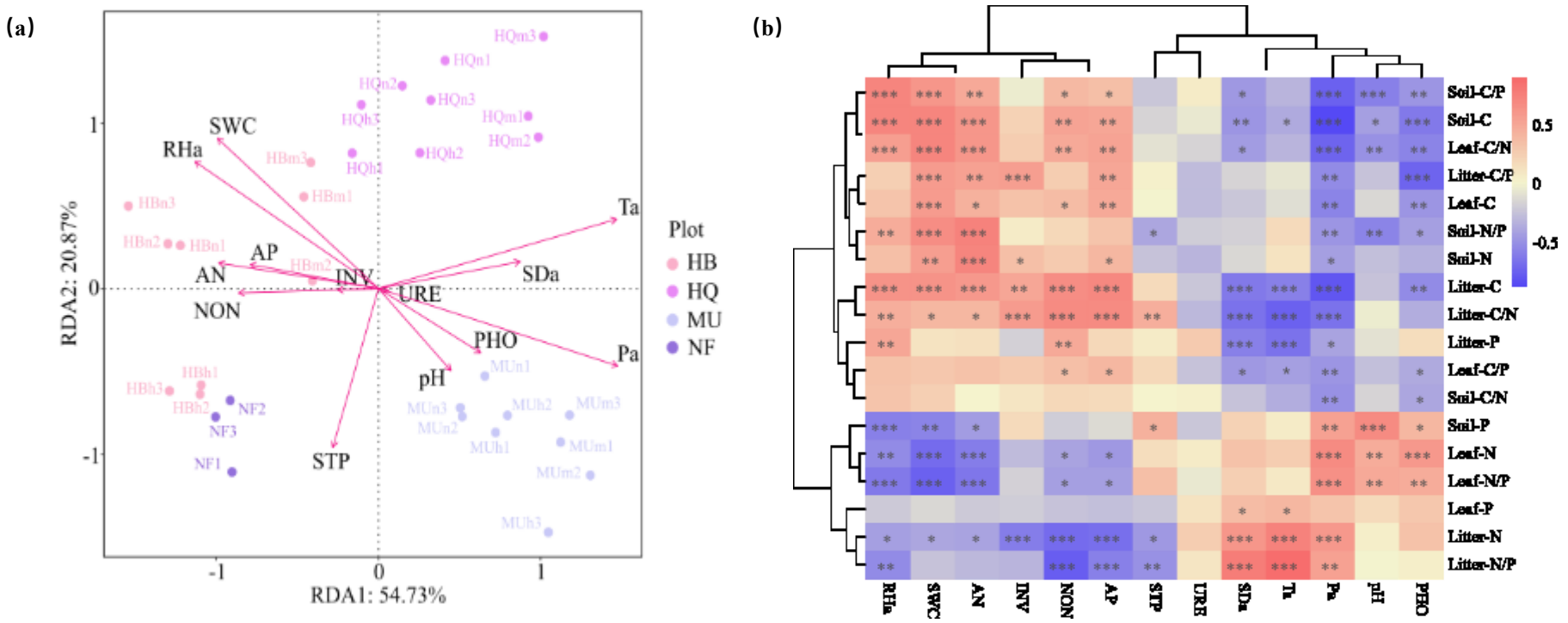

FIGURE 6 Relationship between C-N-P stoichiometric characteristics and environmental factors, including RDA analysis (a) and correlation analysis (b). The arrow direction and length indicate correlation to C-N-P stoichiometry and effect size of the variables, and asterisks and double asterisks indicate $P < 0.05$ and $P < 0.01$, respectively.