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Research article

Seasonal changes in soil acidity and related properties in ginseng artificial bed soils under a plastic shade

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ABSTRACT

Background: In Changbai Mountains, *Panax ginseng* (ginseng) was cultivated in a mixture of the humus and albic horizons of albic luvisol in a raised garden with plastic shade. This study aimed to evaluate the impact of ginseng planting on soil characteristics.
Methods: The mixed-bed soils were seasonally collected at intervals of 0–5 cm, 5–10 cm, and 10–15 cm for different-aged ginsengs. Soil physico-chemical characteristics were studied using general methods. Aluminum was extracted from the soil solids with NH_4Cl (exchangeable Al) and Na-pyrophosphate (organic Al) and was measured with an atomic absorption spectrophotometer.
Results: A remarkable decrease in the pH, concentrations of exchangeable calcium, NH_4^+, total organic carbon (TOC), and organic Al, as well as a pronounced increase in the bulk density were observed in the different-aged ginseng soils from one spring to the next. The decrease in pH in the ginseng soils was positively correlated with the NH_4^+ ($r = 0.463$, $p < 0.01$), exchangeable calcium ($r = 0.325$, $p < 0.01$) and TOC ($r = 0.292$, $p < 0.05$) concentrations. The NO_3^- showed remarkable surface accumulation (0–5 cm) in the summer and even more in the autumn but declined considerably the next spring. The exchangeable Al fluctuated from 0.10 mg g^{-1} to 0.50 mg g^{-1} for dry soils, which was positively correlated with the NO_3^- ($r = 0.401$, $p < 0.01$) and negatively correlated with the TOC ($r = -0.329$, $p < 0.05$). The Al saturation varied from 10% to 41% and was higher in the summer and autumn, especially in the 0–5 cm and 5–10 cm layers.
Conclusion: Taken together, our study revealed a seasonal shift in soil characteristics in ginseng beds with plastic shade.

1. Introduction

Panax ginseng Meyer (ginseng, Araliaceae) is a perennial herb cultivated for its highly valued root. Ginseng prefers a cool and temperate climate and is widely planted in the mountainous region of Northeast China. Its cultivation is difficult because of its long cultivation period and its demand for deep shade and nutrient-rich, slightly acidic, deep, and well-drained soils. Replantation in old fields usually fails, and it takes up to 30 yrs for previously cultivated fields to recover. The following factors may contribute to the problem: deteriorated soil conditions [1–5]; plant diseases (soil sickness) [6]; and autotoxicity [7]. This study primarily focuses on soil conditions.

The Changbai Mountains are famous for ginseng production, with their fertile soils with good water permeability and aeration. People have collected wild ginseng here for 17 centuries and have been planting ginseng by simulating natural conditions since the Yuan dynasty. Today, the ginseng supply relies mainly on intensive field cultivation under artificial-shade structures. Floating plastic mulch is positioned above the ginseng bed, except during the winter, to create shade, enhance photoselectivity, and defend against strong rain. The semi-protective cultivation mode has the potential to affect the bed soil conditions.

Albic luvisol is one of the main soil types used for ginseng cultivation in the Changbai Mountains, which is derived from loess and characterized by high clay and organic-matter content. After

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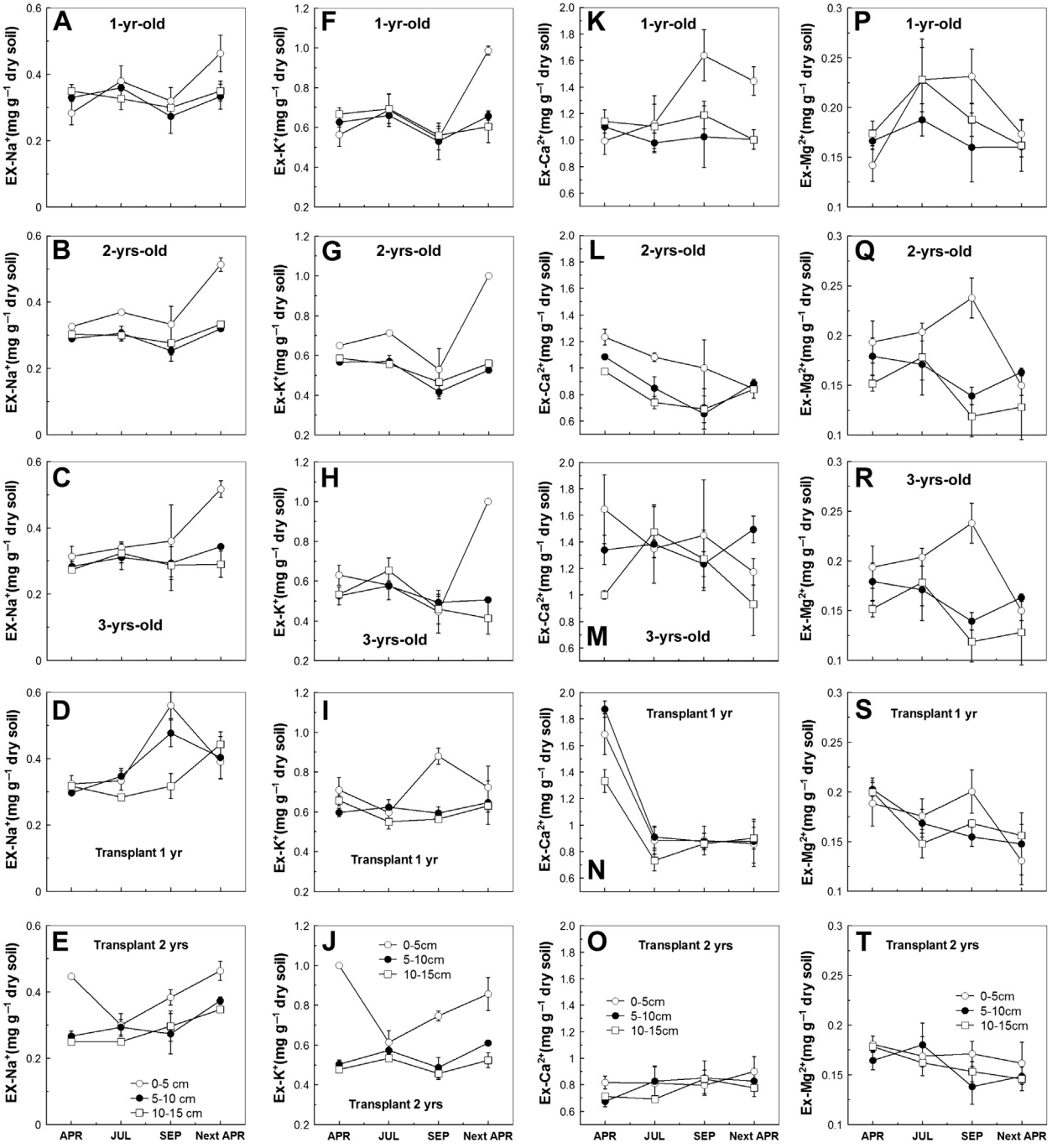

Fig. 1. The seasonal variation of major cations in different aged ginseng bed soils. Soil were collected from beds with different-aged ginseng at depths of 0–5 cm (upper roots), 5–10 cm (root zone), and 10–15 cm (down root) in April (spring), July (summer), September (autumn), and the next April (the next spring). The exchangeable Na^+ (A, B, C, D, and E), exchangeable K^+ (F, G, H, I, and J), exchangeable Ca^{2+} (K, L, M, N, and O) and exchangeable Mg^{2+} (P, Q, R, S, and T) were measured. Data are means ± standard deviation ($n = 3$).

the land was cleared, a binary mixture of the humus and albic horizons (generally 1:1) was created in an elevated bed [8]. Ginseng bed soils from albic luvisols have been shown in our research, as well as others', to be acidic [4,9]. Soil pH has a large influence on ginseng growth and development. Producing American ginseng (*Panax quinquefolius* L) at a pH of 5.5 doubled its yield when compared with a pH of 4.4 [10]. A low pH, low calcium (Ca), and high exchangeable aluminum (Al) reportedly led to the development of red skin and rusty roots in ginseng [11]. Impacts related to soil acidity, such as Al toxicity, might contribute to ginseng replant disease in albic ginseng garden soils. Systematic and comprehensive investigation is necessary to understand the development of acidity and related characteristics in ginseng planting soils. In this study, the soil conditions were investigated seasonally at a ginseng farm located in the Changbai Mountains in Northeast China.

2. Materials and methods

2.1. Description of sites and mode of ginseng cultivation

The study was carried out in a field (41°32′N, 128°09′E) on the first ginseng farm in Malugou County, Jilin province, China. It is located on the lava plateau of the Changbai Mountains. Different-aged ginseng seedlings are grown here. This area is characterized