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ORIGINAL PAPER

Odors of Norway spruce (*Picea abies* L.) seedlings: differences due to age and chemotype

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Abstract Small conifer seedlings (mini-seedlings) are less damaged by the large pine weevil *Hylobius abietis* (L.) (Coleoptera: Curculionidae) compared to conventional seedlings. Chemical difference between the seedling types is one possible explanation for this phenomenon. In the present paper, the emissions of volatile organic compounds (VOC) of 7- to 43-week-old Norway spruce [*Picea abies* (L.) Karst.] seedlings were analyzed. Collection and identification of the volatiles was made by solid phase micro-extraction and gas chromatography mass spectrometry (SPME–GC–MS). The enantiomers of α-pinene and limonene were separated in a two-dimensional GC (2D-GC). Most of the seedlings represented either a limonene- or a bornyl acetate-chemotype. Only minor changes in the volatile composition of the two types of seedlings were found during the first year. Age-related changes, however, were found in the volatiles released by wounded phloem where green leaf volatiles (GLVs) and borneol were the dominated VOC for young seedling. The attractive compound for the pine weevil, α-pinene, was first detected in the phloem emissions of 18- to 22-week-old seedlings. Different storage conditions of the seedlings during the winter/early spring-phase influenced the volatile composition in the phloem. High amount of GLVs was characteristic for the 43-week-old seedlings stored in naturally changing outdoor temperature, but not present in the seedlings winter-stored at a constant temperature of −4 °C. The possible role of these observed differences in odor emissions between seedlings of different age and physiological status for the feeding preferences of the large pine weevil is discussed.

Keywords *Picea abies* (L.) Karst. · Mini-seedling · Volatile emission · Chemotype · Age · Green leaf volatiles · Estragol

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Introduction

The large pine weevil, *Hylobius abietis* (Coleoptera: Curculionidae), often feeds on the bark of young conifer seedlings. Due to this feeding behavior it has become a serious forest pest in areas, where the forestry is based on clear cutting and subsequent replanting (Långström and Day 2004). Hitherto, chemical seedling protection using insecticides has been the main method to control seedling damage (Långström and Day 2004, and references therein), but during the last decades several other methods have been tested for keeping the attack of pine weevils on young