Effects of *Abietinella abietina* extracts on the germination and seedling emergence of *Picea crassifolia*: results of greenhouse experiments

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**ABSTRACT**

Moss cushion plays an important role in recruitment of vascular plants. In this study, we examined the effects of water soluble extracts (WSE) of *Abietinella abietina* on germination of Qinghai spruce (*Picea crassifolia*) and the effects of moss substrates (*A. abietina*) on seedling emergence of *P. crassifolia* in two greenhouse experiments. We found that the WSE of moss affected germination of *P. crassifolia* in two ways: (1) the WSE reducing the risk of fungal infection to the seeds, improve the germination rate; and (2) the WSE affects germination by its concentration, that is, low concentrations of WSE (i.e., 0.5 mg ml⁻¹ and 5 mg ml⁻¹) stimulate, while high concentrations (i.e., 50 mg ml⁻¹) inhibit it. In seedling emergence experiments, we detected that the moss substrates (both thick and thin mosses) facilitate the emergence of *P. crassifolia* in dry and intermediate moisture conditions, but inhibit it in moist conditions. In bare soil, the *P. crassifolia* emergence was also controlled by moisture conditions; the highest (60%) and the lowest (35%) emergence occurred in the moist conditions and dry conditions, respectively. We also found that *P. crassifolia* seedlings were thinner and taller, but their number higher in moss cushion than in bare soil. Thus we conclude that there is nurse effect of *A. abietina* cushion on recruitment of *P. crassifolia* in both dry and intermediate moisture conditions.

**KEY WORDS**
facilitation, inhibition, extracts, *Picea crassifolia*, *Abietinella abietina*, germination, seedling emergence

**INTRODUCTION**

Mosses are essential members of various plant communities and play important roles in recruitment of vascular plants (Zamfir 2000, Ingerpuu et al. 2005, Jeschke and Kiehl 2008, Soudzilovskaia 2010, Meiners 2014), especially in sub-arctic and alpine environments (Brooker et al. 2008). Mosses influence the recruitment of plants positively mostly by modifying microenvironment conditions (Sohlberg and Bliss 1987, Düring and Torne 1990, Donath and Eckstein 2010, Spasojevic et al. 2014). For example, seedling emergence of white spruce (*Picea glauca* (Moench) Voss) was significantly improved in hair-cap mosses (*Polytrichum* spp.) as compared with the burned littler seedbeds (Parker et al. 1997). However, Steijlen (1995) suggested that the moisture and barriers of nutrient availability of *Pleurozium schreberi* (Brd.) appeared to inhibit early pine establishment or alter the morphological features of seedlings comparing with the bare soil. Likewise, allelochemicals were also an important effect of mosses on the regeneration of vascular plants (Keizer et al. 1985, Sohlberg and Bliss 1987, Tadesse et al. 2004, Michel et al. 2011). Huneck and Meinunger (1990) found that the allelopathic effect of moss can facilitate the seed germination rate of vascular plants due to