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From Forest Nursery Notes, Winter 2012

205. © Pine weevil damage to Norway spruce seedlings: effects of nutrient-loading, soil inversion and physical protection during seedling establishment. Wallertz, K. and Petersson, M. Agricultural and Forest Entomology 13:413-421. 2011.

Pine weevil damage to Norway spruce seedlings: effects of nutrient-loading, soil inversion and physical protection during seedling establishment

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- Abstract**
- 1 The pine weevil *Hylobius abietis* (L.) feeds on the bark of young conifer seedlings and is one of the most economically important forest pests in Europe.
 - 2 In a field experiment, we examined the combined effects of the treatments: nutrient-loading of seedlings, planting in scarified plots and protection of seedlings against pine weevil damage for either half a season or a full season.
 - 3 Nutrient loading had no significant effect on the amount of pine weevil feeding.
 - 4 Seedling mortality was significantly reduced when seedlings were protected from pine weevil feeding during establishment. This occurred even though the debarked area of protected seedlings 5 weeks after the shields had been removed was similar to that of the unprotected seedlings. This indicates that initial protection rendered the seedlings more tolerant to later wounding by pine weevil.
 - 5 Planting in soil inversion significantly reduced feeding compared with planting in humus.
 - 6 We conclude that nutrient-loading of seedlings in the autumn before planting would not increase pine weevil feeding after planting. Mortality could be reduced by treatments that postpone the start of pine weevil feeding on seedlings. Such treatments, combined with planting in soil inversion, would result in increased seedling growth, vitality and tolerance to pine weevil attack.

Keywords Establishment, fertilization, *Hylobius abietis*, Norway spruce seedlings, pine weevil, reforestation, soil inversion.

Introduction

Reforestation after clear-felling is common practice over large areas of Europe, including Sweden, where the main pest of newly-planted conifer seedlings on reforested sites is the pine weevil *Hylobius abietis* (L.). Adult weevils feed on bark on the main stem of seedlings, which leads to decreased growth and increased seedling mortality (Leather *et al.*, 1994; Örlander & Nilsson, 1999; Långström & Day, 2004; Day *et al.*, 2004). The risk of damage to newly-planted seedlings is highest during the first 3 years after clear-felling but decreases during the fourth and fifth years (Örlander & Nilsson, 1999; Nordlander *et al.*, 2009). A common method used to reduce pine weevil damage is to treat the seedlings with insecticides (Leather *et al.*, 1999; Långström & Day, 2004; Viiri *et al.*, 2007), although a number of nonchemical control strategies may also be employed.

Alternative silvicultural methods that may be used to reduce damage include soil scarification, planting under shelter trees or protecting the seedlings with physical barriers (von Sydow & Örlander, 1997; Örlander & Nilsson, 1999; Petersson & Örlander, 2003; Nordlander *et al.*, 2009). In southern Sweden, where there is a very high risk of damage on new clear-cuts, a combination of at least two measures is recommended to decrease seedling mortality (Petersson & Örlander, 2003).

Feeding by pine weevil is influenced by several factors, with one of the most important being the environment surrounding the seedling (Björklund *et al.*, 2003; Petersson *et al.*, 2005, 2006). Planting seedlings in scarified soil reduces pine weevil damage to seedlings and the reduction is most evident in the first year after planting (Örlander & Nordlander, 2003). Soil scarification not only reduces pine weevil damage, but also benefits root growth by increasing soil water availability, reducing soil density and increasing soil temperature (Nordborg & Nilsson, 2003; Örlander *et al.*, 1990). Rapid early root

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