From Forest Nursery Notes, Summer 2013

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Forestry An International Journal of Forest Research

Institute of Chartered Foresters

Forestry 2013; **86**, 91–98, doi:10.1093/forestry/cps062
Advance Access publication 10 September 2012

A comparison of long-term effects of scarification methods on the establishment of Norway spruce

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Received 30 January 2012

Scarification is the most common measure to improve the planting environment in Sweden. However, different scarification methods give varying results. During the early 1990s, a nation-wide experiment with 10 field installations was established in order to test the effect of several scarification methods, including two intensities of soil inversion and mounding, on growth of planted Norway spruce seedlings and in comparison with no scarification (i.e. control). Eighteen growing seasons after planting, a higher seedling survival was found following soil inversion (77 per cent for normal and 76 per cent for intensive) compared with mounding (67 per cent) and control (57 per cent). The mean height of the planted trees across all sites 18 years after planting was 413 and 430 cm following normal and intensive soil inversion, respectively, 424 cm after mounding and 346 cm in the control. The difference in height between the scarification treatments and the control corresponded to a time gain of ∼4 years of growth after 18 years. However, the length of the leading shoot was not affected by scarification after 14–18 years, indicating that scarification did not affect growth beyond the establishment phase. Scarification reduced variation in height of the planted trees. On scarified plots, the number of naturally regenerated trees increased with more than 100 per cent to reach a mean value of 2300 stems per hectare.

Introduction

Seedling establishment on a reforestation site is restricted by a number of factors. The access to water and nutrients is often limited, and this is partly caused by competition from surrounding vegetation, but also due to climatic factors, seedling characteristics and soil properties.[1] In Sweden, scarification is the most common silvicultural practice to alter the planting environment and to increase the success of seedling establishment, irrespective of species. Today, 92 per cent of the planted area in Sweden is scarified mechanically.[2] The two dominant methods are disc trenching and mounding. Disc trenching can be applied on most sites, even on stony soils, while mounding is more common on mesic to moist sites with moderate stoniness. However, the quality of the planting spots varies between these two methods depending on the specific site and its limiting factors.[3] After disc trenching, planting is often made in the trench where the humus is removed, which can result in a poor nutrient supply and a surplus of water. Mounding, on the other hand, where seedlings are planted on elevated spots, can increase the risk of drought stress in the newly planted seedlings,[4] especially if the buried humus layer becomes too thick and therefore acts as a barrier for the capillary water to reach the seedling root system. Also, the degree of soil disturbance for the two methods is rather high, and there have been concerns regarding possible negative effects on both the short-term- and the long-term productivity after scarification due to increased levels of nutrient losses.[5] Another negative aspect is from a recreational and environmental point of view, where scarification can be a disadvantage if damages are caused to cultural and natural values.

Soil inversion can reduce some of these issues by creating a planting spot at the same level as the surrounding ground.[6] The planting spot consists of an inverted humus layer covered by loosened mineral soil, which is returned to the original hole. Soil inversion was introduced as a scarification method in the early 1990s, and for a long time it has been recognized as a treatment that improves early establishment of planted seedlings in Sweden.[6–8] Another important aspect affected by scarification treatments is damage caused by pine weevil (*Hylobius abietis*). If the seedlings are surrounded by pure mineral soil, the damages related to pine weevils will decrease substantially.[9] In comparison with other scarification methods, planting spots created by soil inversion have shown to have a higher content of pure mineral soil.[10] Despite this fact, soil inversion has not been used operationally due to the lack of technical equipment. Recently, new technical improvements have made it possible and again raised the interest for the method.[11]

The current knowledge about the effects of different scarification methods on tree growth beyond the establishment phase is