Extended abstract 139

LONG-TERM EFFECT OF ASH FERTILISATON AND WEED CONTROL IN AFFORESTATION OF ORGANIC AGRICULTURAL SOIL

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SUMMARY

Tree seedlings compete with weeds for light, water and nutrients on former agricultural land, and on organic soils, nutritional imbalance can endanger stand development. We studied the effects of wood ash fertilisation and chemical weed control on the growth and nutritional status of Scots pine (*Pinus sylvestris* L.) seedlings planted in an organic agricultural field in Northern Finland. Ash application increased the seedlings' growth, while weed control also reduced mortality, and there were no interactions between these treatments. In 21 years, ash fertilisation increased stand volume by 35 m^3 ha^{-1} and weed control by 21 m^3 ha^{-1}, and the combined effect of the treatments was 56 m^3 ha^{-1}.

KEYWORDS: wood ash, afforestation, peat soil, vegetation control, herbicide, Scots pine

INTRODUCTION

Since the end of 1960s, more than 260 000 ha of agricultural land has been afforested in Finland, and a considerable share of that comprises organic soils. Diversity and competitiveness of weeds increases with soil fertility, and competition is a great challenge, especially on former agricultural land. The development of ground vegetation on afforested fields is usually fast and vigorous, which retards stand development, increases seedling mortality, and causes damage to them. Agricultural practices have been found to increase peat ash concentration, pH, and phosphorus and calcium concentrations in the former tilling layer (Hytönen and Wall 1997). Since peat in agricultural fields is well humified, it contains a lot of nitrogen available to the vegetation. However, deficiencies of potassium and boron, indicated by foliar analyses, are typical of trees growing on afforested agricultural peat soils (Hytönen & Ekola 1993). Nutritional disturbances can weaken and damage the seedlings to such an extent that afforestation fails. Therefore, improvement of the nutritional status is required for successful afforestation of some peat-based sites.

The use of wood fuels is increasing rapidly in Finland, and consequently, the production of ash is increasing as well. Ash has been used as a fertiliser for a long time, and composition of wood ash has proved to be favourable, especially for adjusting the nutritional status of peatland forests. Wood ash is rich in phosphorus and potassium, which are the most important nutrients for limiting growth on peat soils rich in nitrogen. Numerous fertilisation experiments with wood ash have shown that it can produce long-term effects on tree nutrient status and stand growth (Silfverbeg 1996, Moilanen et al. 2005).

Short-term studies covering the early post-planting years show the importance of weed control. The effect of weed control diminishes over time as seedlings grow and become more competitive. However, the permeancy of the gains in growth and yield by vegetation management is not well known. This is especially the case on peatland, where nutritional problems can result in failure in afforestation. Therefore, long-term (> 10 years) follow-up of the development of both target species and competing vegetation is required. In the present study we investigated the effects wood ash fertilisation and chemical weed control on the development and nutrient status of Scots pine (*Pinus sylvestris* L.) based on a 21-year field experiment established on former agricultural organic soil.

MATERIAL AND METHODS

A factorial ash fertilisation and weed control experiment was established on a former peat-based organic soil field located in Vuolijoki, Northern Ostrobothnia (64°05'N, 25°58'E). The mean depth of the organic layer was 70 cm. During the agricultural use of the land, mineral soil had been added on top of the peat layer in order to increase soil fertility and to improve trafficability. In 1990, the field was mounded, and three-year-old 15 cm tall bare-rooted Scots pine seedlings (2800 per ha) were planted in spring 1991.

The treatments in the experiment were a) control (untreated), b) wood ash application (5 t ha^{-1} dry weight), c) chemical weed control, and d) the combination of wood ash application and chemical weed control. Randomised block design with four replicates on plots sized 450 m^2 was applied. Herbicides, glyphosate (Roundup, application rate 7 l ha^{-1}) and terbuthylazine (Gardoprim, application rate 3 l ha^{-1}) was sprayed over the entire plots in July 1991, and the treatment was repeated the following year. The wood ash applied on the experimental plots in spring 1992 contained 48 kg ha^{-1} of P, 124 kg ha^{-1} K, 1010 kg ha^{-1} Ca, and 75 kg ha^{-1} Mg (Hytönen 1993). Foliar samples were taken after the 21st growing season for analysing the nutritional status of the trees. Seedlings were measured on the plots after 9, 16 and 21 growing seasons from planting. Analysis of variance was used to test the effects of treatments on the examined variables.

RESULTS

Height and diameter of trees

Wood ash had a significant effect on height and breast height diameter of the trees during the entire follow-up period of 21 years, while the effect of the weed control was not seen after the 16th growing season (Fig 1). The treatments did not have significant interaction. By the end of the 21st growing season, ash fertilisation had increased the seedlings' mean height and diameter by 1.6 m and 2.5 cm, respectively.

Mortality and volume

Weed control reduced mortality by 35 and 27 percentage points after 16th and 21st growing seasons, respectively, while ash did not affect mortality (Fig. 2). After 21 growing seasons, 65% of seedlings on the plots lacking weed control had died. A high increase in mortality on weed control plots (no ash) from the 16th (6%) to the 21st (49%) growing season could be due to nutritional imbalances.

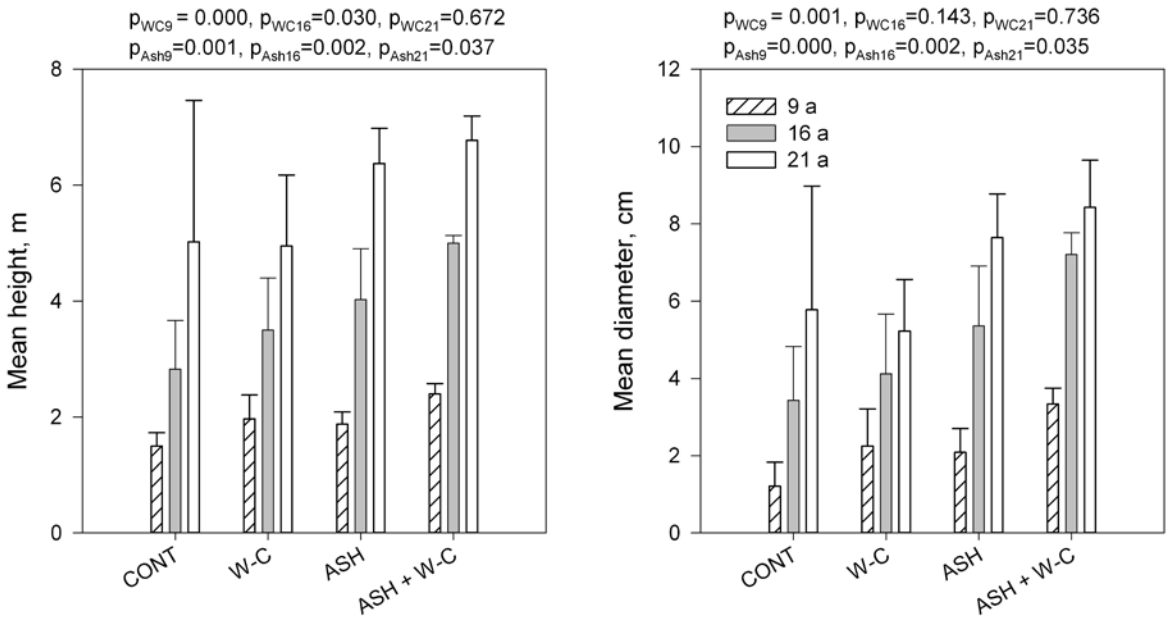

Fig. 1. Mean breast height diameter and mean height of trees 9, 16 and 21 years from planting. Statistical significance (p-values) of weed control (WC) and ash fertilisation (Ash) treatments.

Both weed control and ash fertilisation had significantly increased stem volume (Fig. 2). The main factorial effect of weed control on stem volume after 21 years was 21m^3ha^{-1} and that of ash fertilisation was 35 m^3 ha^{-1}, while their combined effect was 56 m^3ha^{-1}.

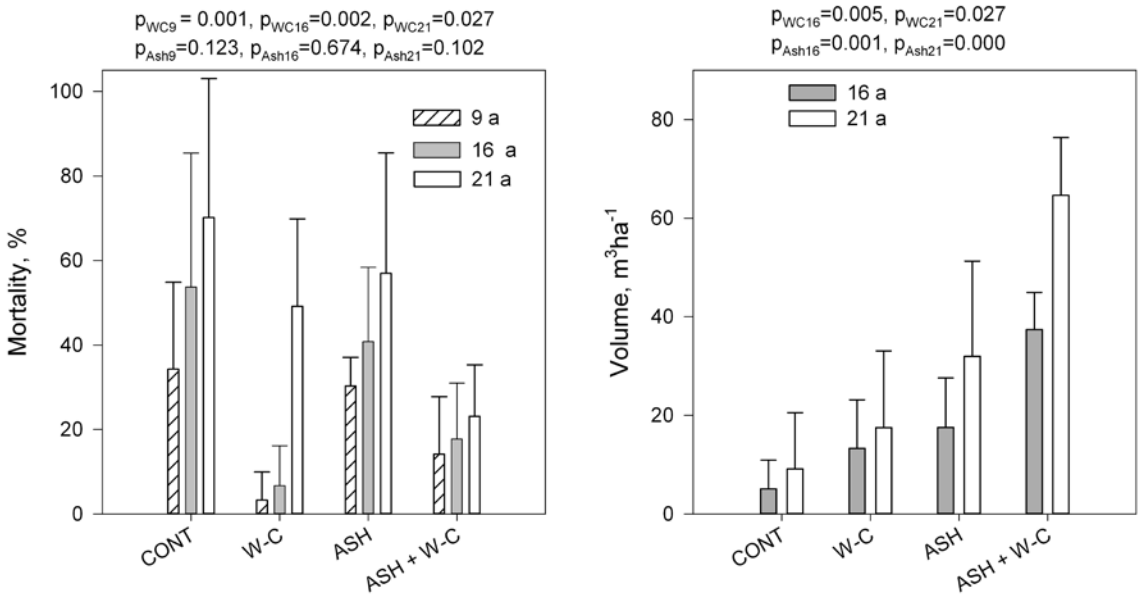

Fig. 2. Effect of weed control and fertilisation on seedling mortality and stand volume. Statistical significance (p-values) of weed control (WC) and ash fertilisation (Ash) treatments are shown above the graphs.

Nutrition

The treatments did not significantly affect foliar N, P, K or B concentrations. However, a non-significant increment of 0.3 g kg^{-1} in foliar K was measured on the plots with ash applications. The mean K concentration in all treatments was very low, 2.6 g kg^{-1}, indicating severe K deficiency. On the other hand, the concentrations of P (1.6 g kg^{-1}) and N (16 g kg^{-1}) were very high, resulting in greater nutritional imbalance.

DISCUSSION

Severe competition from light, water and nutrients caused by the weed species is among the major problems associated with the field afforestation of former agricultural fields. The present study indicated that weed control and ash fertilisation affect stand volume in diverging ways. Weed control was crucial for stand establishment. It reduced competition from vegetation, which was seen mostly in the decrease in mortality. On the plots lacking weed control, 65% of the seedlings had died by the end of the follow-up period of 21 years. Ash fertilisation did not affect mortality, but it increased seedling growth significantly. Chemical weed control also increased seedling growth, but its effect decreased with the increase in stand age. The decreasing effect of weed control on height and diameter is likely due to the increased mortality of smaller trees and the consequent increase of mean height on the control plots rather than decrease or even impermanency of the effect of vegetation control.

The annual stand volume increment caused by weed control was 1.0 m^3ha^{-1} in 21 years. This is in line with earlier studies on Scots pine planted on agricultural mineral soils (Hytönen & Jylhä 2006, Jylhä & Hytönen 2010). At the stand age of nine growing seasons, the factorial main effects of weed control and ash fertilisation on the seedlings' height and diameter were equal, but thereafter, ash had greater impact. Within 21 growing seasons, ash increased annual volumetric growth by 1.6 m^3ha^{-1}. The factorial main effect of the combination of ash fertilisation and weed control was 2.6 $m^3ha^{-1}a^{-1}$.

Potassium deficiencies are typical of afforested peat soils (Hytönen & Ekola 1993). Even though mineral soil had been used for amelioration, there were visible symptoms of potassium deficiency, in particular on control plots and the plots with herbicide treatment. These symptoms were interlinked to low foliar potassium concentration. However, the effect of ash fertilisation was not seen in the foliar potassium concentration, which may result from the dilution effect.

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