# Changes in the Growth of Silver Birch (*Betula pendula* Roth) and Black Alder (*Alnus glutinosa* (L.) Gaertn.) Seedlings on Peat Soils Fertilised with Wood and Peat Ashes

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*Abstract*

The short-term influence of different biofuel ashes on the growth of silver birch (*Betula pendula* Roth) and black alder (*Alnus glutinosa* (L.) Gaertn.) seedlings and suitable wood, peat and mixed ash doses for regulating biomass production on peat soil were studied. The experiments were conducted with 1-year-old seedlings planted in vegetation pots. The growth of seedlings for different ash treatments was analysed using the variations in the absolute values of mean annual increments of the height and diameter at the root collar of seedlings, by the final heights and diameters at the end of the experiment, by the increase in height and diameters compared to corresponding initial parameters in the year of the application of ashes and finally the growth of fertilised seedlings was compared with the growth of unfertilised seedlings. In the first growing season, the growth of silver birch seedlings of all treatments exceeded that of the control seedlings. In the second growing season, the height increments of treatments with higher doses of peat and mixed ash were considerably larger than those for control seedlings. Only the application of the larger doses of peat ash increased significantly the height and radial growth over a 2-year period as a whole compared to the control. Wood ash, particularly the smaller amounts used in experiments, favoured the growth of the black alder seedlings. Along with wood ash peat ash is a promising tool in the afforestation of cut-away peatlands.

**Key words**: biofuel ashes, cut-away peatlands, fertilisation, silver birch, black alder

## Introduction

Negative environmental impacts of fossil fuel combustion have increased the use of biomass for energy production. In 1990, over 200 million m$^3$ wood equivalent, or 46% of the annual fellings of stemwood was used for energy in the 15 countries of the European Union (Hakkila and Parikka 2002). The Biomass Action Plan of the Commission of the European Communities (Commission… 2005) aims at raising the production of bioenergy from biomass and waste from 67 Mtoe in 2003 to 143 Mtoe by 2010. One third of this increase could be covered by forest biomass. In Estonia, the consumption of firewood for energy production increased from 2.748 million solid cubic metres (scm) to 3.710 million scm (including wood chips and waste) in 1995–2004 (Statistical… 2005). As a consequence of the increased use of biofuels, the production of ashes will increase greatly in the near future. For example, in Sweden approximately 200 000 tonnes (Eriksson et al. 1998) and in Finland 100 000 tonnes (Vesterinen 2003) of wood ash is produced annually. Most of the ash is still dumped in landfills, which is connected with economic problems and risks for the environment among which pollution of soils with heavy metals occurring in ash is the most serious one (Bramryd and Fransman 1995).

Effective and balanced biogeochemical cycling of nutrients is a fundamental mechanism that sustains forest site productivity. The importance of mineral nutrition in regulating the productivity of forest stands is widely recognised (Waring and Schlesinger 1985, McMurtrie 1991, Cropper and Gholz 1994, Ozolinčius et al. 2007). Because of relatively high contents of plant nutrients, biofuel ashes can be recycled as mineral fertilisers to preserve the vitality and productivity of soils (Olsson et al. 1996, Sander 1997). Although wood ash does not contain N, the increase in the soil pH leads to higher bacterial growth and activities and thus accelerates the decomposition processes followed by increased organic N mineralisation and N availability (Weber et al. 1985, Bååth and Arnebrant 1994, Fritze et al. 1994, Haimi et al. 2000, Saarsalmi et al. 2004). The fact that Ca, K and B contents of plants increase noticeably with the application of wood ash is generally known (Ohno and Erich 1990, Demeyer et al. 2001, Saarsalmi et al. 2005). However, application of wood ash with high concentrations of heavy metals increases the risk for heavy metal accumulation in the soil (Bramryd and Fransman, 1995, Nieminen et al. 2005, Ozolinčius and Varnagirytė 2005, Ozolinčius et al. 2006, Pitman 2006).

The fertilisation of forest soils with ashes is a topic of scientific research and an increasingly used forest management practice, especially in Scandinavian countries. According to experiments, no clear stem growth response to ash application on mineral soils has been reported. The trees often show no growth response at all, or only a slight decrease or increase in growth is observed depending much on the N availability in soils (Moilanen and Issakainen 2000, Jacobson 2001, Saarsalmi et al. 2004, Pärn 2005). On nitrogen-rich drained peatlands in Finland considerable increases in the growth of Scots pine were achieved (Lukkala 1951). Later studies (Silfverberg and Huikari 1985, Silfverberg and Hotanen 1989, Silfverberg and Issakainen 1996, Moilanen et al. 2002) confirmed a long-lasting (30–50 years) effect of wood ash fertilisation. According to Jacobson (2003), the main purpose of adding wood ash on mineral soils is to counteract long-term nutrient depletion rather than to obtain a short-term increase in forest growth.

Numerous ash fertilisation experiments are carried out with the aim to study the effect of wood ash on coniferous trees, mainly on Scots pine and Norway spruce. Research results on the effects of wood and other biofuel (peat, bark) ashes on deciduous trees are scarce. Along Scots pine only some birch-dominated plots were established in peatland experiments in Finland (Silfverberg and Huikari 1985).

In Estonia, nearly 15,000 ha of harvested peatlands (Paal et al. 1999) needs recultivation to reduce the discharge of carbon dioxide due to the decomposition of peat, to promote its uptake by re-establishing vegetation and to produce new biomass for bioenergy production. Because the natural development of the vegetation on the abandoned peatlands is a long-lasting process the afforestation of cut-away peatland with fast-growing deciduous trees is considered as the most effective (Saarmets 1999). The deficiency of mineral nutrients in peat soils is commonly the principal factor limiting the growth of trees. An increase in biomass production of several deciduous trees after fertilisation on cut-away peatland areas was shown in Finland (Hytönen et al. 1995).

The aim of this study was to understand the short-term response of silver birch and black alder seedlings to addition of different biofuel ashes as fertiliser and to suggest suitable wood and peat ash doses for short-term regulation of biomass production of seedlings on peat soil without causing any unacceptable short-term effects on soil and plants.

## Material and methods

### *Experiment design*

The experiments were conducted with the 1-year-old seedlings of silver birch and black alder planted in vegetation pots (10 l). Seedlings with similar height and habits were selected for the experiment.

Birch seedlings were planted in peat soil in May 2007. After planting different doses of wood and peat ash and their mixture (75% peat ash + 25% wood ash) were added to the soil. The amounts of ashes per pot were calculated considering the surface area of substrate in pots and corresponding treatment doses. Experiments were carried out in 10 treatments and in 3 replications:

1. Control, without treatment (C)

Treatment with wood ash (WA)

2. WA 0.25 kg $m^{-2}$ (WA 0.25)
3. WA 0.5 kg $m^{-2}$ (WA 0.5)
4. WA 1.0 kg $m^{-2}$ (WA 1.0)

Treatment with peat ash (PA)

5. PA 0.25 kg $m^{-2}$ (PA 0.25)
6. PA 0.5 kg $m^{-2}$ (PA 0.5)
7. PA 1.0 kg $m^{-2}$ (PA 1.0)

Treatment with a mixture of peat ash and wood ash (MA)

8. MA 0.25 kg $m^{-2}$ (MA 0.25)
9. MA 0.5 kg $m^{-2}$ (MA 0.5)
10. MA 1.0 kg $m^{-2}$ (MA 1.0)

Black alder seedlings were planted in peat soil in April 2008. After planting different doses of wood ash were added to the soil. Experiments were carried out in 4 treatments and in 3 replications:

1. Control, without treatments (C)

Treatment with wood ash (WA)

2. WA 0.25 kg $m^{-2}$ (WA 0.25)
3. WA 0.5 kg $m^{-2}$ (WA 0.5)
4. WA 1.0 kg $m^{-2}$ (WA 1.0)

After planting, the pots were placed outdoors on ground covered with plastic film to eliminate the impact of the underlying soil surface. During the arid periods the seedlings were watered.

***Origin and composition of ashes***

Loose wood and peat ash with the pH 12.4–12.6 from Türi heating plant (58º48'22'' N, 25º25'17'' E, Central Estonia) was used. Dry ash was collected from different places of ash storage and mixed carefully to get homogeneous material for application. For chemical analyses 10 subsamples were collected from each ash type and then pooled together to produce one combined sample. Chemical composition of ashes was analysed in the Estonian Environmental Research Centre Ltd., which is competent according to EVS-EN ISO/IEC 17025:2000 to conduct environmental chemical analyses.

The major components of both wood and peat ashes were Ca, K, Fe, Mg and P (Table 1), but otherwise considerable differences were found between the mineral composition of WA, PA and MA.

**Table 1.** Concentrations of chemical elements (mg $kg^{-1}$) in ashes and in growth substrate at the beginning of the experiment

| Element | WA | MA | PA | Substrate |
|---|---|---|---|---|
| Cd | 11.7 | 3.75 | 3.43 | <1 |
| K | 29700 | 19500 | 5200 | 112 |
| Ca | 155000 | 180000 | 238000 | 23400 |
| Cr | 67.7 | 24.7 | 15.2 | 1 |
| Mg | 15600 | 17100 | 18000 | 315 |
| Mn | 2722 | 2747 | 3073 | 32.6 |
| Pb | 157 | 120.3 | 73.4 | <2 |
| Fe | 19100 | 31600 | 44900 | 5800 |
| Zn | 3031 | 419 | 94.4 | 5.6 |
| Cu | 69.4 | 42.5 | 31.1 | 9.5 |
| N | 230 | 440 | 1390 | 24700 |
| P | 6140 | 2790 | 2010 | 455 |
| pH | 12.7 | 12.5 | 12.4 | 4.74 |

Although N is an important element in biomass, its concentration in ashes was relatively low because it had vaporised during combustion. Still, PA contained relatively large amounts of N, while in WA its concentration was quite low. High concentrations of N in PA suggest that the fuel peat was not well burned in furnaces of the heating plant. PA contained 1.5 times more Ca and 6 times more N than WA, but WA contained 5.7 times more K and 3 times more P than PA. The concentrations of K, Ca, Pb and N in MA were somewhat different depending on their concentrations in WA and PA.

As all biomass fuel contains heavy metals, part of them remains in ash. This is one of the contamination risks in recycling biofuel ashes since heavy metals could be absorbed by plants or leached into groundwater. The concentration of heavy metals was somewhat greater in WA compared to PA: WA contained Zn 32, Cd 3.4, Cu 2 and Pb 2 times more. At the same time PA contained about 2.3 times more Fe.

***Origin and composition of substrate***

The peat used for the growth substrate originated from Lavassaare sphagnum peat bog in West Estonia. Before the application of ashes the pH and concentrations of various elements in the growth substrate were determined. Two samples for chemical analyses were collected, each from ten places of the peat supplied for the planting before filling the pots. Soil analyses were repeated at the end of the first vegetation period. Analyses were carried out in the Estonian Environmental Research Centre by the ICP, using ISO 11885 (1999) methods. Soil pH was determined potentiometrically from KCl solution (ISO 10390, 1994).

The composition of the substrate before the application of ashes is presented in Table 1. The growth substrate used in the experiment was poor in nutrients in comparison with the added ashes, except N, whose concentration was higher in the peat. Generally the N content in Estonian bog soils is rather low (<1%) but it may vary depending on the type of bog (Valk 1988). Although the substrate came from a peat bog, its N concentration was more characteristic of soils of fens or transition bogs, however. The peat also contained rather large amounts of Ca, which is common for the fens. The concentrations of heavy metals were rather low except for Fe.

***Statistical analyses***

The heights and diameters (measured at the root collar) of all the seedlings were measured at the beginning of the experiment in May 2007 and at the end of each vegetation period, in September 2007 and 2008, when the yearly growth had stopped. The mean annual heights and diameters and their mean increments, as well as percentage of the control (=100%) were calculated for each treatment.

The statistical significance of differences in the diameter and height increments between the control and ash-treated experimental plots and of differences between treatments was tested by two-tail Student's test. The *t*-tests were considered significant at $p<0.05$.

## Results

***Chemical changes in the soil***

After the first growing season the largest changes occurred in the concentration of K, in which 1.1–7.3-fold increases were observed compared to the control and the initial state. The WA treated soil showed the greatest rise, while the soil treated with K-poor PA hardly showed any difference from the control. Changes in the Ca concentrations were modest, being statistically insignificant. The concentration of Mg increased for the highest dose of all three types of ashes, with the largest increases occurring for WA and MA, respectively 1.8–2.6 and 1.4–2.7 times. The concentration of N in the substrate decreased compared to its initial relatively high status. The decrease was 40–60% both in the control and in the treated substrate. Compared with the control, the substrates treated with relatively N-rich PA showed a higher level of N at the end of the first growing season than the soils treated with WA and MA did. The concentration of P in the substrate changed only a little, the change being somewhat greater for the largest WA dose (1.4 times).

The concentration of heavy metals in the substrate showed a significant increase for Zn, Fe, Cr, Cu and Pb, especially in the substrate treated with WA. Although the ashes contained considerable amounts of Cd, its concentration in the substrate was below detection limit in the control as well as in all treatments (<1 mg $kg^{-1}$ by the end of the first growing season). The concentration of Cr increased 1.3–3 times in the substrate treated with Cr-rich WA. For PA treated substrate the Cr concentration was only slightly over detection limit. Among heavy metals, the concentration increase was greatest for Zn in WA treated substrates. It was 4–16 times higher at the end of the vegetation period compared to the substrate before treatments. In PA and MA treatments the increase was negligible.

### *The height growth of silver birch*

In the first growing season (2007), the seedlings planted in the substrate fertilised with PA showed the highest (45.1 cm) mean annual increment (Figure 1) followed by the WA fertilised seedlings (43.5 cm). The annual height increments of ash fertilised seedlings exceeded that of the control seedlings significantly except for MA 0.25 and MA 0.5 treatments (Figure 2). In the PA and MA treatments the height growth increased when higher doses of ashes were used. For the WA treatments the annual height growth of seedlings decreased almost inversely proportionally to ash doses ($r$ = –0.95; $p$<0.05). During the second growing season the PA treatments showed again the best mean annual increment (44.4 cm) followed in this growing season by the MA treatments (40.3 cm). The control seedlings exhibited good annual increment, which was significantly exceeded only by the growth of the seedlings fertilised with higher doses of PA. Relatively higher annual height increments in the second growing season were achieved when higher doses of ashes were used for fertilisation.

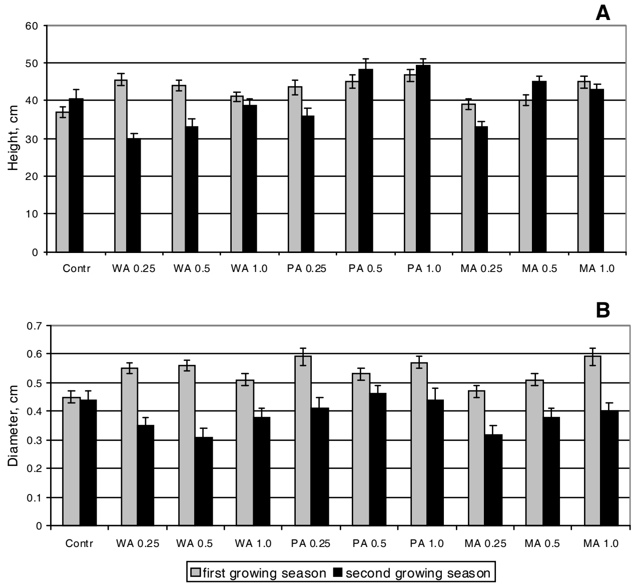
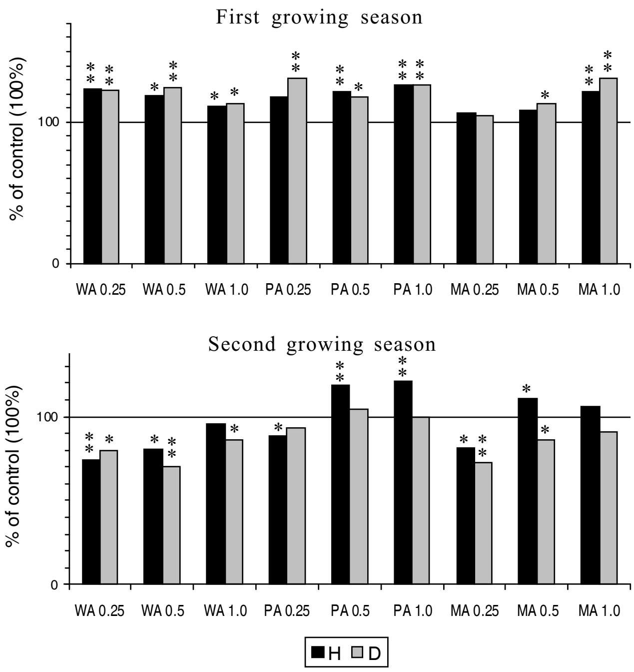



**Figure 1.** Mean annual increment of height (A) and diameter (B) of silver birch seedlings in the first and second growing season. The error bars show standard error

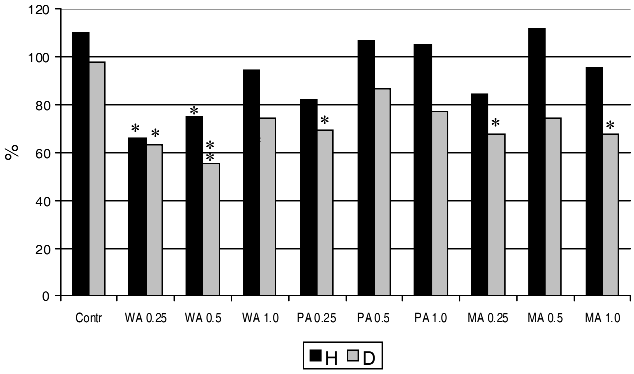



* – difference from control significant at $p$<0.05

** – difference from control significant at $p$<0.005

**Figure 2.** Annual increment of height (H) and diameter (D) of silver birch seedlings as percentage of the control (=100%) in the first and second growing season

In the second growing season, the height increments of the control, the PA 0.5 and 1.0 and the MA 0.5 treatments exceeded those of the previous growing season although the differences were not significant (Figure 3). Significant decreases were observed in the annual height increment for the WA 0.25 and WA 0.5 treatments in the second vegetation period compared to the previous growing season.




* – difference significant at $p$<0.05

** – difference significant at $p$<0.005

**Figure 3.** The increase in the mean annual increment of height (H) and diameter (D) of silver birch seedlings in the second growing season compared to the increments in the first growing season

By the end of the second growing season the PA treated seedlings had the largest mean height followed by the MA treated seedlings (115.5 cm and 106.0 cm, respectively) (Figure 4). The mean height of the seedlings increased compared to the mean height in the year of ash application on average 4.4 and 4.1 times, respectively. The largest mean height was shown by the seedlings fertilised with 1.0 kg $m^{-2}$ of PA. No effect of the WA application amounts on the mean height of seedlings was detected at the end of the experiment. In the case of the PA and MA application, the larger doses of the ashes had a greater effect.

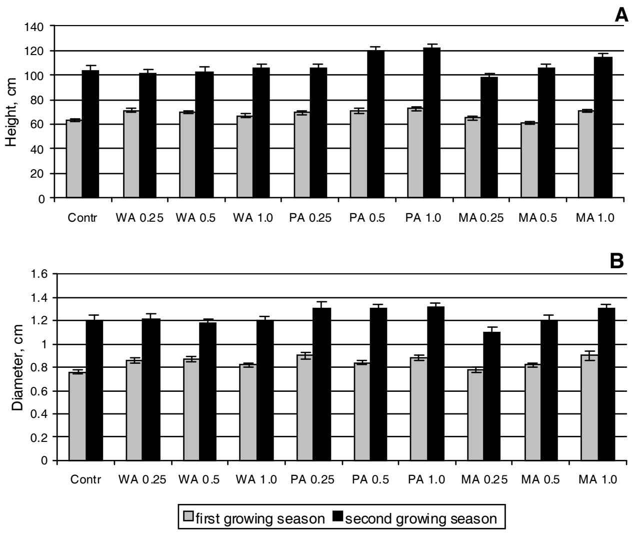



**Figure 4.** The mean height (A) and diameter (B) of silver birch seedlings at the end of growing seasons. The error bars show standard error

***The radial growth of silver birch***

Like the height growth during the first growing season, the seedlings growing on the substrate fertilised with PA showed the highest (0.56 cm) mean annual radial increment followed seedlings fertilised with the highest dose of MA fertilised seedlings (0.54 cm) (Figure 1). The annual radial increments of ash fertilised seedlings exceeded that of the control seedlings significantly except for MA 0.25 treatment (Figure 2). The relationships between the radial growth of seedlings and ash doses showed no regular pattern. In the WA and PA treatments all doses had a strong effect on the radial growth of seedlings, which was somewhat less in the WA 1.0 and PA 1.0 treatments, however. The effect of MA was most pronounced when the higher ash doses were used. During the second growing season the PA treatments showed again the best mean annual radial increment (0.44 cm) followed in this growing season almost equally by the WA and the MA treatments (0.35 cm and 0.37 cm, respectively). The mean annual radial increment of the control seedlings was exceeded only by the PA 0.5 treatment but not significantly. As a rule, the higher ash doses favoured the radial growth of trees in this growing season.

In the second growing season, the radial increments did not reach the increment values obtained in the previous year for any treatment (Figure 3). Compared to the increment in the first growing season, the seedlings of the PA 0.5 treatment showed the best and the seedlings of the WA 0.5 treatment the worst growth (86.8% and 55.4% of the increment of the first year, respectively). The radial increments for the WA 0.25, WA 0.5, PA 0.25, MA 0.25 and MA 1.0 treatments differed significantly in the two successive growing seasons.

By the end of the second growing season all PA treatments and the MA 1.0 treatment showed the largest and almost equal (1.3 cm on an average) mean diameter at the root collar. The mean diameters of the control seedlings, of all WA treatments and of the MA 0.5 treatment were by 0.1 cm smaller although these differences were not statistically significant. Compared to the mean initial diameter in the year of the application of ashes the diameters of the seedlings fertilised with PA increased over the 2-year period as a whole more (by 4.2 times) than those of the seedlings of the WA and MA treatments (3.9 times in both case).

***The height and radial growth of black alder***

The mean annual height increment of seedlings was largest for the WA 0.5 treatment. Compared to the increments of seedlings of the other treatments the differences were not significant. The increment of all ash treated seedlings exceeded that of the control seedlings but not significantly (Figure 5). The seedlings treated with WA 0.5 showed the largest (87.0 cm) and the control seedlings the smallest (80.2 cm) mean height at the end of the growing season. By the end of the growing season the mean height of the seedlings of the PA 0.5 treatment had increased on average 3.6 times compared to the mean diameter in spring followed by the seedlings of the PA 1.0 treatment (3.4 times).

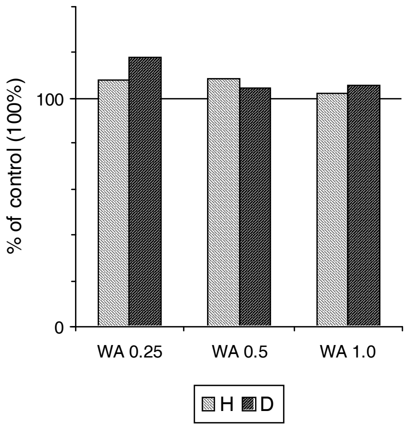



**Figure 5.** Annual increment of height (H) and diameter (D) of black alder seedlings as percentage of the control (=100%)

The mean annual increment of the root collar diameter exceeded that of the control seedlings for all treatments, but significantly only for the WA 0.25 treatment. The seedlings of this treatment showed also the largest diameter (1.86 cm) and mean annual diameter increment (1.29 cm), followed by other WA treatments. In the WA 0.25 and WA 0.5 treatments, the mean diameter at the root collar of the seedlings increased compared to that in spring on average 3.2 times. For the control and the WA 1.0 treatment this increase was about 2.9 times.

## Discussion

The characteristics and chemical composition of ashes may be different depending on the fuel incineration technique, additives and storage conditions. In our experiments the major components found in ashes were Ca, K, Fe, Mg and P. High concentrations of these elements were found in peat and wood ashes used for similar experiments (Hytönen 2003, Mandre et al. 2006) although the proportions differed somewhat.

The favourable impact of wood ash on the growth and distribution of birch on some N-rich bog soils in Finland was reported by Silfverberg and Huikari (1985) and Hytönen and Kaunisto (1999). The peat ash application increased the biomass production of Scots pine and willows on peat soils especially when higher amounts were applied (Hytönen 1998, Hytönen 2003).

The results for the individual treatments in our experiment showed that the addition of ashes had a favourable effect on the stem growth of seedlings in the first growing season. The mean annual increments of height and root collar diameter of all ash treatments exceeded these indicators of the control seedlings significantly. In the second growing season, only seedlings fertilised with higher doses of PA and MA showed significantly better height growth compared to the control. The diameter growth of all ash treatments remained significantly less than that of the control. Earlier higher percentage of increase in the mean diameter and height than that of the control in the first year and a decrease in growth in the second year after the treatment with WA was detected in the experiment conducted in a young *Calluna*-site type Scots pine stand on poor mineral soil in Northern Estonia (Pärn 2005).

The utilisation of N contained in the peat substrate in the physiological processes of trees to such an extent that its small amounts in ashes could not compensate for the supply of this element in the growth substrate is obviously one of the reasons of the decreased growth of nutrient-demanding birch in the second vegetation period. On the other hand, the deficit of the available N may be caused by increased N immobilisation due to increased microbial activity and biomass after ash application (Bramryd and Fransman 1995, Jacobson 2003). The high utilisation rate of N by birch seedlings was expressed by the significant decrease in the N concentrations in the growth substrates at the end of the first growing season. Due to the higher N concentration in PA and thus also in MA the growth of young birch seedlings was most promoted when the substrate was treated with higher doses of PA and MA.

An increase in temperature sums was reported to have a positive effect on the growth in ash fertilisation experiments (Silfverberg and Huikari 1985). The mean temperature during the first growing season was considerably higher than that in the second growing season (14.5ºC and 13.4ºC, respectively). Therefore, the decrease in the radial and height growth of birches in the second growing season may be partially influenced by the climate factor, which was not fully considered in the analysis.

Most studies on the fertilisation and afforestation of cut-away peatlands address the use of Scots pines, birches and willows (Silfverberg and Huikari 1985, Silfverberg and Hotanen 1989, Hytönen et al. 1995, Hytönen 1998, Hytönen and Kaunisto 1999). Although black alder shows vigorous growth on well-decomposed humus soils, good results were obtained in afforestation experiments of closed oil shale opencasts with this species (Kaar 2002, Lõhmus et al. 2006, 2007). Black alder has several advantages over other species, which makes it a promising species for the afforestation of cut-away peatlands. It has rapid growth in young age, symbiotic N-fixing root nodules and its fast-decomposing nutrient-rich litter of leaves ameliorates the soil. However, results from fertilisation experiments with black alder on peatlands are lacking and comparisons cannot be provided.

In our black alder experiments, only wood ash was used for fertilisation. The growth data obtained for one growing season indicate that the mean annual height and root collar diameter increment exceeded those of the control seedlings for all treatments but not significantly. Better growth was shown by the seedlings fertilised with low and medium application rates. Obviously the increased pH values of the substrate caused by higher WA application amounts decreased the mobility and availability to plants of some important nutrients such as N and Mn.

## Conclusions

The short-term influence of different biofuel ashes on the growth of silver birch and black alder and suitable wood, peat and mixed ash doses for regulating biomass production on peat substrate were studied. The growth of seedlings for different ash treatments was analysed using the variations in the absolute values of the mean annual increments of the height and diameter at the root collar of seedlings, the final heights and diameters at the end of the experiment, the increase in height and diameters compared to corresponding initial parameters in the year of the application of ashes and finally the growth of fertilised seedlings was compared with the growth of unfertilised seedlings.

The results have shown that the effect of peat ash as a fertiliser for silver birch on peat soils is comparable with that of wood ash. In both growing seasons, the seedlings treated with higher application amounts (0.5 kg $m^{-2}$ and 1.0 kg $m^{-2}$) of peat and mixed ashes had a larger increase in the growth rate compared to control and wood ash treatments. By the end of the two-year experiment the mean height of the seedlings treated with peat ash and mixed ash increased compared to the mean height in the year of ash application on average 4.4 and 4.1 times, accordingly. The diameters of the seedlings fertilised with PA increased over the same period by 4.2 times exceeding that of wood an mixed ash treatments. Wood ash, particularly its smaller amounts used in the experiments, favoured the growth of the black alder seedlings.

Although experiments were short-term, the obtained results showed that fertilisation with wood and peat ash is a promising tool in the afforestation of cut-away peatlands with silver birch and black alder. The amount of peat ash produced in combustion is small in Estonia compared to the amount of wood ash, but the use of peat ash mixed with wood ash is recommended for ash recycling. A set of long-term experiments on exhausted peat quarries under variable environmental conditions would be needed to explore the more general long-term effects of biofuel ash on recultivation of cut-over peatlands.

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# ИЗМЕНЕНИЯ В РОСТЕ БЕРЕЗЫ БОРОДАВЧАТОЙ (*BETULA PENDULA* ROTH) И ОЛЬХИ ЧЕРНОЙ (*ALNUS GLUTINOSA* (L.) GAERTN.) НА ТОРФЯНЫХ ПОЧВАХ ВСЛЕДСТВИЕ УДОБРЕНИЯ ЗОЛАМИ ОТ БИОТОПЛИВА

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*Резюме*

Воздействия различных доз золы от биотоплива, используемого как удобрение, на рост однолетних саженцев березы бородавчатой и ольхи черной на торфяных почвах в течении двух лет было исследовано. Были определены годичные приросты по высоте и по диаметру и обшие приросты в течении всего периода эксперимента. Были проанализированы различия по росту саженцев между удобренными вариантами и контролем. В эксперименте были применены древесная зола, торфяная зола и их смесь. Использовались дозы 0 кг/м$^2$ (контроль), 0,25 кг/м$^2$, 0,5 кг/м$^2$ и 1,0 кг/м$^2$. Было установлено, что торфяная зола имеет определенное преимущество перед древесной золой как удобрение для деревьев на исчерпанных торфяных карьерах. В течении двух вегетатационных периодов саженцы березы, удобренные более высокими дозами торфяной и смешанной зол, показали лучший рост, чем саженцы, растущие на контрольном участке и саженцы, удобренные древесной золой. Древесная зола, особенно использованная в минимальных дозах, имела благоприятное влияние на рост саженцев ольхи черной. Хотя эксперимент был кратковременным, полученные результаты показали, что древесная зола и ее смесь с торфяной золой, могут быть успешно реутилизированы как удобрения на бедных питательными веществами торфяных почвах.

**Ключевые слова**: золы от биотоплива, торфяная почва, удобрение, береза бородавчатая, ольха черная