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COST-EFFICIENT ENERGY BIOMASS PRODUCTION ON CUT-AWAY PEATLANDS: TWO-YEAR RESULTS

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SUMMARY

Biomass production with various energy crops could be an interesting alternative for land use of cut-away peatlands. We compared in a 19 ha experiment biomass production and production costs of reed canary grass, short-rotation willows, and several indigenous tree species. The tree plantations were established by seeding and by natural regeneration using ash fertilization and various soil preparation methods. The most successful establishment method for downy birch was broadcast seeding on ash-fertilized peat (75 000 seedlings ha^{-1} in two years). Correspondingly natural regeneration of ash fertilized peat resulted in 5500 birch seedlings ha^{-1}. Also sowing of aspen on ash-fertilized peat was promising (50 000 seedlings ha^{-1} in two years). Wood energy production on cutaway peatlands could offset soil CO_2 emissions due to an increase in sequestration of atmospheric CO_2-C into the growing biomass.

KEYWORDS: cut-away peatland, bioenergy, downy birch, short-rotation

INTRODUCTION

Forest chip consumption in Finland is to be increased from current 6.9 million m^3 (2010) up to 13.5 million m^3 by 2020. This implies a high utilization degree of the harvestable forest chip potential (16 million m^{3}a^{-1}) and increase in production costs. Since the energy wood potential of existing forest is already utilised to a high degree studies on the possibilities of producing bioenergy as the main product in dense dedicated plantations is gaining interest. Especially cut-away peatlands show potential for increasing the production of energy biomass.

At present, peat is harvested on an area of roughly 60,000 hectares. Annually approximately 2500 ha are released from peat production. Peat cut-away areas differ considerably from forested peatland sites in regard to their soil properties and hydrology. These sites are characterized by variation in peat thickness, low pH levels, high nitrogen concentration, and low - phosphorus and potassium concentrations (Hytönen & Kaunisto 1999, Aro et al. 1997). The large nitrogen stores in the remaining peat layer are an advantage by reducing the need for fertilization. CHP plant ash containing phosphorus, potassium and micronutrients could be ideal fertilizer for cut-away peatlands.

Biomass production for fuel with various energy crops could be one of the many alternatives (Selin 1999) for further land use of cut-away peat areas. Reed canary grass has been studied intensively (Reinikainen et al. 2008) and in 2007 it was produced on approximately 6,000 ha of cut-away peatlands. However, recently the cultivation area of reed canary grass has started to decline. Besides short-rotation willows other potential biomass energy crop options (e.g. native deciduous trees, downy birch, alders, aspen and native willows) are poorly known. However, there are indications that growing dense stands of native tree species could also yield considerable amounts of biomass (e.g. Hytönen & Saarsalmi 2009), and e.g. in Finland and Ireland dense downy birch thickets have been established by natural regeneration on cut-away peatlands (Hytönen & Kaunisto 1999; Renou-Wilson et al. 2010; Huotari 2011). Carbon sequestration by woody energy crops makes afforestation of former peat production areas an interesting restoration option. The aim of this study was to compare alternatives for bioenergy production on cut-away peatlands and especially their cost-effective establishment methods.

MATERIALS AND METHODS

We established a 19 ha preliminary experiment in spring 2010 on a cut-away peatland located in northern Ostrobothnia, Finland (Piipsanneva, 64^{o}06’N 25^{o}36E). In the experiment we compared the biomass production and production costs of different bioenergy production chains. Reed canary grass (*Phalaris arundinacae*) (3.1 ha) was sown and short-rotation willows (*Salix viminalis*, clones Klara and Karin) (4.0 ha) established with cuttings (8300 cuttings ha^{-1}) on limed and fertilized peat (Fig. 1). Natural regeneration of downy birch (*Betula pubesces*) (7 ha) was studied on wood ash (6 t ha^{-1}) fertilized peat, ditch mounded peat, ploughed peat and intact cut-away peat (control). Broadcast sowing of downy birch and aspen (*Populus tremula),* grey alder (*Alnus incana),* Scots pine (*Pinus sylvestris)* and Norway spruce (*Picea abies*) was studied on ash fertilized peat.

Fig. 1. Reed canary grass after second growing season (A) and one-year old willow sprouts (*S. viminalis,* clone ´Klara´) (B) in autumn 2011.

We measured the number of seedlings in all treatments after the first and second growing season using circular sub-sample plots. The biomass of willows was calculated with dry-mass equations based on sample sprouts taken from the willow stands. The biomass of reed canary grass will be measured in spring 2012.

RESULTS

Broadcast seeding of all of studied tree species - except alder - on ash fertilized cut-away peat was successful (Fig. 2). The number of seedlings of all tree species in the first autumn exceeded 20 000 ha^{-1}. Their number decreased in 2011 but remained still quite high. There were also lot of naturally established seedlings, mainly downy birches on the plots. The seedlings on plots seeded with downy birch include also naturally regenerated seedlings since it was not possible to separate seeded and natural downy birches. The most successful establishment method was on ash-fertilized peat broadcast seeding of downy birch followed by aspen, resulting in 75 000 and 50 000 seedlings ha^{-1} after second growing season, respectively. Probably due to frost heaving observed in spring 2011 most alder seedlings died. The dominant height of birches exceeded 50 cm after two growing season and those of aspen 40 cm (Fig 2).

Natural regeneration of downy birch resulted in considerably smaller number of seedlings than broadcast seeding. The best treatment was ash fertilization. Ash-fertilized areas left for natural regeneration had after second growing season 5500 birch and 3300 aspen seedling ha^{-1} (Fig 3). The number of seedlings was low on untreated control area (Fig. 3) and on ploughed and mounded areas. On ploughed and mounded areas birch seeds were probably buried in the soil. Their number increased during the second growing season but remained much lower than on ash-fertilized peat.

Establishment of reed canary grass and short-rotation willows was successful. Willows were cut back after first growing season. The leafless above-ground biomass of the one-year old shoots in autumn 2011 was 1.4 t ha^{-1} (´Klara´) and 0.7 t ha^{-1} (´Karin´). The biomass of reed canary grass will be measured in spring 2012.

The costs of the studied establishment methods differed considerably from each other. The most extensive methods (control excluded) were cheapest (natural regeneration of birch on mounded or ash-fertilized peat surface). Broadcast seeding on ash fertilized peat surface was more expensive. The most intensive methods, reed canary grass and willow (Fig 1) cultivation had highest establishment cost.

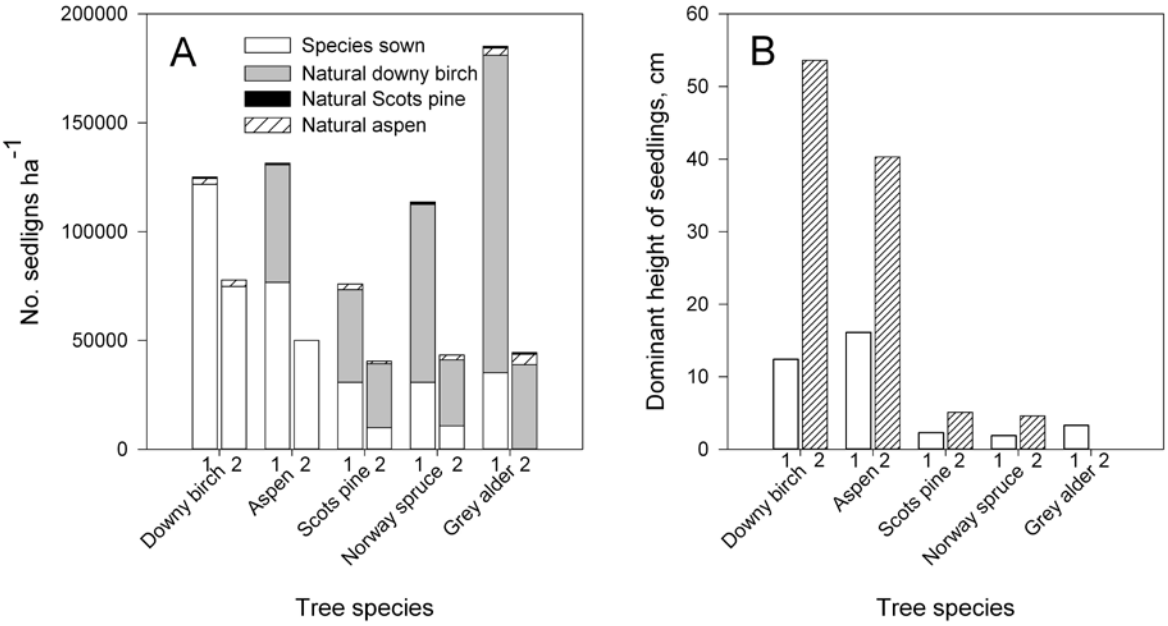

Fig. 2. The number of seedlings (A) and their height (B) following broadcast seeding of different species. Two year results (1,2). Number of naturally regenerated downy birch, Scots pine and aspen seedlings is also shown.

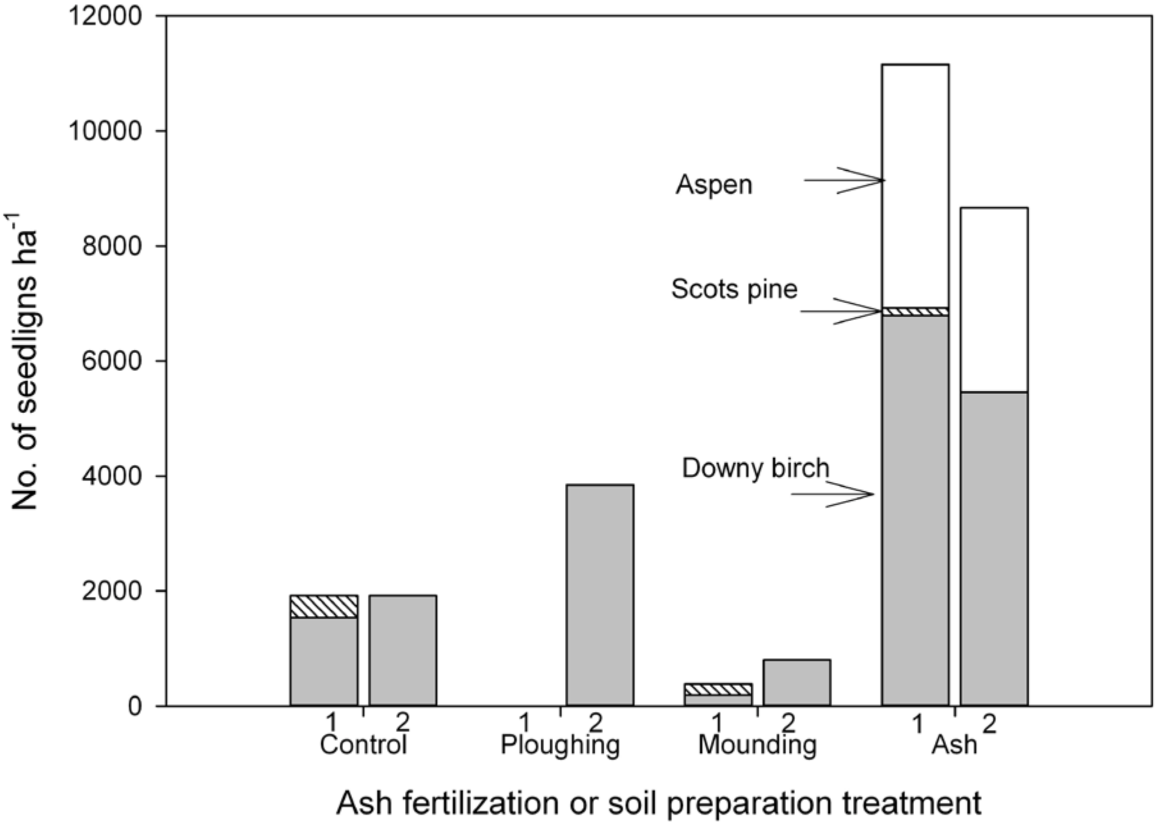

Figure 3. The effect of soil preparation treatments and ash fertilization on the number of naturally regenerated seedlings.

DISCUSSION

According to these preliminary results dense plantations of various tree species can be established on cut-away peatlands. Several establishment methods varying in intensity and costs can result in acceptable biomass plantations. According to this study dense plantations of downy birch can be successfully established on ash-fertilized areas both by broadcast seeding and by natural regeneration. In this study broadcast seeding however, resulted in much more denser plantation after two growing seasons. Low number of seedlings in control area emphasised the importance of ash fertilization or soil preparation in the establishment phase. However, high mortality of alder seedlings, probably due to frost heaving, showed that experiments have to be followed longer. Our results are in accordance with earlier studies showing the effect of ash fertilization in the establishment of downy birch by broadcast seeding or by natural regeneration (Huotari 2011). The poor first year results of mounding and plowing was most probably due to the soil disturbance and subsequently burial of the birch seeds. During the second year number of seedlings rose especially in ploughed area and the number of seedlings will probably increase also in the mounded area in the following years. The number of seedlings in the untreated control area was low and they grew mostly close to ditches.

Wood energy production could have potential as an alternative to reed canary grass cultivation. Willows produce biomass in short-rotations but compared with willows and reed canary grass, the rotation of birch, alder and aspen has to be many times longer but the advantages include much lower establishment costs, smaller soil amelioration and fertilization requirements and less harvest repetitions.

Recycling of ash could promote sustainable forestry on cut-away peatlands and significantly reduce the waste problem caused by ash. Nutrition of birch can be secured by using ash, and intensive mineral fertilization is not needed.
Wood energy production on cut-away peatlands could be seen as a possible means of offsetting soil CO_2 emissions due to an increase in sequestration of atmospheric CO_2-C into the growing biomass. This can considerably decrease carbon loss (Mäkiranta et al. 2007) from peat. More experimentation is needed to confirm the establishment methods and biomass yields that could be achieved in different peat cutaway areas, and the dependence of the yield on peat quality, nutrition and peat thickness.

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