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RESULTS OF REHABILITATION OF CUT-OVER PEATLANDS FIVE YEARS AFTER APPLICATION OF FERTILIZERS

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SUMMARY

The aim was to determine the potential of natural sowing and planting of trees in conjunction with fertilizers containing P and K as afforestation method in peatlands. The area was fertilized with wastewater sludge, mineral fertilizers and liming material and trees planted. The amount of natural seedlings exceeded the number of living planted trees and natural ground vegetation cower was formed at all trials except control plots. Variations in amount and height of seedlings, vegetation cover and number of species correlated linearly with applied fertilizer. Natural sowing in combination with fertilization can be recommended in afforestation of cut-over peatlands.

KEYWORDS: cut-over peatland, afforestation, fertilization, wastewater sludge

INTRODUCTION

Rehabilitation of cut-over peatland may involve planting trees in certain areas to serve as windbreaks, to improve site aesthetics, or to reproduce the wooded margins and isolated stands of trees that occur in natural bog landscapes. Characteristics of cut-over peatlands do not favor the early growth of trees. These include low nutrient concentrations, usually high and widely fluctuating water table. On the other hand, peat extraction removes competing weeds and possibly also pathogenic microbes (Croft at al., 2001; Bussières et al., 2008). Afforestation is the main way of rehabilitation also in Finland. In Sweden the large scale experiments of afforestation of cut-over peatlands were made in 1983. Besides afforestation, growing of short-rotation trees for biomass has been of interest. Trials with different willow species have been made in Lithuania and Finland (Pikka, 2005).

For a long time drainage was regarded as the necessary measure for good tree growth on peatlands, including open bogs (Odins et al., 1960; Zalitis, 2006; Sundström and Hånell, 1999). The first large-scale drainage in Latvia was started in 1851 and these activities ceased approximately in 1990. Initially, the drainage systems comprised comparatively sparse ditch network, which gradually became denser with practical experience gained and the research results put into practice. The forest stand grows the best close to the ditch, and presently the distance between ditches explains the variations in stand productivity within the limits of one site index class (Zālītis et al., 2010). Since the importance of mineral nutrients for tree growth on poor peat soils was discovered, fertilization has become a commonly accepted afforestation measure, in addition to drainage (Sundström, 1998; Sundström and Hånell, 1999). Research results show that the necessity of fertilization of mire forests depends greatly on forest type and content of nutrients in the substrate. Cut-over peatlands are very acidic and deficient in plant nutrients, that is why fertilization is believed to be necessary for tree growth, if a substantial peat layer remains (Bussières et al., 2008). Fertilization with P and K improved the performance of Scot pine substantially, but only in central and southern Sweden.(Sundström, 1998), drainage and fertilization also improve growth of Scots pine and Norway spruce in Latvia on peat soils (Odins et al., 1960; Zalitis, 2006). However, sufficient soil aeration is a necessary precondition for the growth of highly productive forest stands on peat soils, but amount and composition of nutrients are second limiting factors for natural regeneration of the cut-over peatlands.

Success of natural sowing on cut-over peatlands in conjunction with drainage, fertilization and cultivation are the reasons to believe that natural seeding cans supplement or even replace artificial stand establishment (Sundström and Hånell, 1999).
The aim of the study was to determine the potential of natural seeding and planting of trees as the afforestation method. The stand structure and ground vegetation were evaluated after addition of different fertilizers and planting of trees. Effect of wastewater sludge on growth of trees and development of ground vegetation was compared with effect of mineral fertilizers and liming material.

MATERIAL AND METHODS

The experiments were conducted on a cut-over peatland (56º50'41.75"N 24º06'23.42"E; 9 m under sea level) with thick residual peat layer. The area was divided by contour ditches into rectangles. Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), black alder (*Alnus glutinosa*), Aspen (*Populus tremula*) and Silver birch (*Betula pendula*), were planted 10 m from the ditches in a 2 x 2 m distance. Willows (*Salix spp.*) (varieties Tora and Torhild) were planted in the two row scheme. Both varieties did not survive, even after replanting with longer cuttings and natural sowing take place in their plots. At the East and South the plot bordered with forest wall, at the west – with sparse woody vegetation. The thickness of the peat layer was 1.5-2 m. Two types of fertilizers were applied – wastewater sludge (WWS) 10 tDM ha^{-1} and 3.5 t ha^{-1} mineral fertilizer NPK (10-0-20); liming was done in 2006 (10 t ha^{-1} dolomite). The content of nutrients in peat were low with exception of N; soil was acidic. Content of N before fertilization was 247.2 ± 3.8; P 0.60 ± 0.1; K 45.05 ±6.9 mg kg^{-1}. Average pH of topsoil was 4.2 (Lazdiņš, 2006). WWS for experiments were taken from SIA "Rīgas Ūdens" wastewater treatment plant. The concentration of heavy metals in WWS was significantly below the permissible limits set by the regulation No. 362 of the Cabinet of Minister (MK noteikumi Nr. 362). The more common concentration of nutrients in the sludge in Riga city is 51 g kg^{-1} of $N_{tot.}$, 17 g $kg^{-1 \, of}$ $P_{tot.}$, and 65% of organic matter (Kāposts et al., 2002; Gemste and Vucāns, 2007).

RESULTS AND DISCUSSION

Growth results during the first season are described at previous publications of authors (Lazdina, 2006; Lazdiņš, 2007). After fertilization seeds of trees and grass from surrounding stands came and started to germinate, so the fertilizer not only promoted the growth of planted trees, but also the natural regeneration of different tree species. All fertilized blocks were invaded by competing vegetation, and tending was done to reduce their impact. No such invasion occurred in the absence of fertilization, where trees also failed to grow. The number of natural seedlings in case of different fertilization variants is given in Table 1. Combination of mineral fertilizers with liming material and WWS caused more intense natural revegetation.

Table 1. Number of germinated seedlings of trees per ha

Fertilizer/ seedlings of trees	Aspen 2006	Aspen 2007	Birch 2006	Birch 2007	Salix sp. 2006	Pine 2006	Pine 2007	Total 2006.	Total 2007
WWS	17143	12400	47143	46800	-	1429	1200	65715	60400
WWs +liming	36667	8000	31667	63600	3333		1200	71667	72800
Minerals	-	400	30000	9200		1667	19200	31667	28800
Minerals +liming	136000	114400	14000	38000	42000	2000	9200	194000	161600

Results of studies in Sweden after 22 years since establishment and fertilization showed that the most common (81%) of the naturally established species was downy birch. It was present at 88% of all strips and reached a mean height of 2.2 m (9500 trees ha^{-1}). Scots pine was found on almost 50% of the strips 1-5.6 m height, and made on average 685 trees ha^{-1}. Norway spruce was present in all areas but in smaller numbers, on average less than 100 trees ha^{-1}.The mean height of the spruce was just under1.5 m. Silver birch was found only in small numbers in four of the five areas and only on 11% of all strips. *Salix spp.* were the most common of other deciduous species, especially in the Northern most area (Sundström and Hånell, 1999). In our experiment Salix did not survive and some of them naturally occurred only four years later. Three years after application of WWS and mineral fertilizers a sufficient quantity of natural seedlings grew in all fertilized plots. During fourth year mortality of trees planted on control plots reached 98 %. All willow cuttings sprouted, but after one year 97 % of them die and these plots were occupied by natural seedlings. Fours years after establishment of the plantation tending was done leaving naturally ingrown birch trees in former willow plots. In the fifth year after establishment it was complicated to recognize planted and natural seedlings.

The most intensive growth of trees was observed in plots fertilized with mineral fertilizers in 2005 and additionally treated with lime in 2006. While in the control areas natural afforestation and ground vegetation did not develop even after spreading of liming material. Three years after planting there were no significant difference in height between planted of pine and natural seedlings of pine. In case of birch naturally ingrown trees were considerably smaller during the first three years. But after five growing seasons planted and naturally sowed birches had same height (Fig.1).

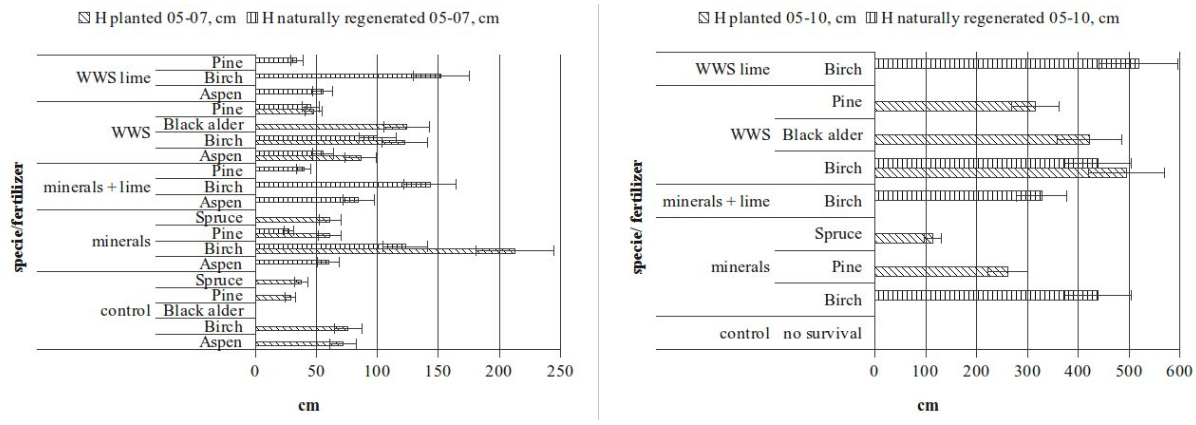

Fig.1. Height of planted and naturally regenerated trees 3 and 6 years after planting.

Liming with dolomite contributed naturally regenerated trees growing at plots fertilized with the sewage sludge and minerals.

Cover of the natural vegetation was measured at the end of 2011. Eleven species of trees and scrubs from 0.5 to 7 m in height, 37 species of coalescent plants and scrubs under 0.5 m and 12 species of mosses and lichens were found in fertilized plots. Denser and higher vegetation were found under pine and black alder fertilized with WWS (Fig. 2).

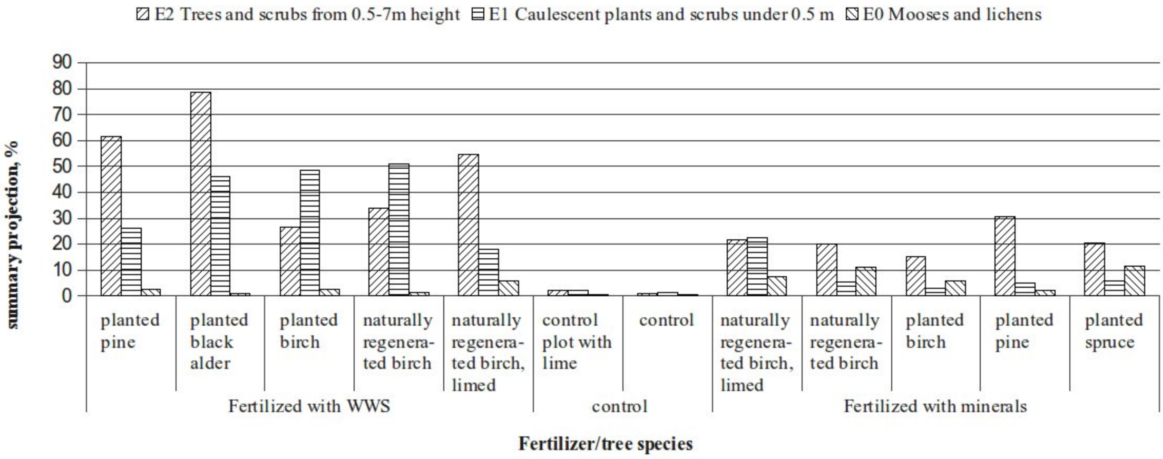

Fig.2. Vegetation cover % of experimental trial plots at 2011 (six years after fertilization).

It is necessary to fertilize young trees planted on cut-over peatlands. The effect of fertilizer indicates that development of vegetation in the study area was hampered by lack of phosphorus, potassium and other elements in soil. Effect of fertilization could differ between regions and depending from initial status of nutrients in soil.

CONCLUSIONS

1. WWS in long term is good substitution of mineral fertilizers to compensate nutrients in cut-over peatlands. WWS significantly improve natural regeneration and yield of trees on cut-over peat lands planted with birch, black alder and pine.
2. This study indicated that natural afforestation favored by fertilization is a realistic alternative for rehabilitation of the abandoned cut-over peatland securing at the same time high level of biodiversity.
3. There is a lack of knowledge on how the number and growth of natural seedlings correlate with climate conditions, site quality, drainage intensity, fertilizer amendments and distance to nearest seed source.

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