Early Growth of Some Deciduous Tree Species on Abandoned Agricultural Lands in Estonia

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The present paper is based on 14 demonstration areas of deciduous plantations on abandoned agricultural land, located in different parts of Estonia. For the establishing of the plantations, various deciduous tree species (*Betula pendula* Roth., *Quercus robur* L., *Fraxinus excelsior* L., *Betula pendula* var. *Carelica* (Mercklin) Hämet-Ahti, *Populus x wettsteinii* Hämet-Ahti) were used as planting material. The monitoring system for plantations was developed and field measurements were carried out in 2000. Silver birch proved to be the most suitable species in afforestation of abandoned agricultural lands in Estonia. Oak and ash are sensitive to frost and show very moderate mean annual height-growth on agricultural lands. Establishing a plantation on agricultural land, it is important to analyse the nitrogen and phosphorus content in the soil, as these are the elements having the greatest effect on annual height-growth of silver birch. When planting silver birch, mulch polyethylene has to be considered as the most effective cover material.

Key words: *Betula pendula, Quercus robur, Fraxinus excelsior, Betula pendula var. carelica, Populus* x *wettsteinii,* abandoned agricultural land, plantation, height-growth, weed control, Estonia

Introduction

Due to socio-economic reasons the intensity of agricultural land-use in Estonia has dropped drastically during the last decade. In comparison to the previous decades, the need for agricultural production for the domestic market is much lower than the production rate. Therefore, the share of arable land has strongly decreased and fallow land has increased. A slight increase has been also noted in areas of semi-natural grasslands, wetlands and forest. Besides the natural forest regeneration in arable land the afforestation is needed to produce productive forest. However, it should be remembered that about 50 % of Estonia is already covered by forest community. Due to ongoing land reform and land restitution in Estonia continuously increasing interest in afforestation of abandoned low value/low productive agricultural land is foreseen. Know-how is needed both for state-owned and private land property to select previously agricultural land which can both benefit from afforestation and not conflict with nature conservation and objectives to sustain natural diversity.

The aims and strategies for afforestation of abandoned agricultural land are stated in the Forestry Development Plan. Part of the land is under natural regeneration but it is reasonable to afforest other parts as an alternative way of land utilization. Tree species that grow in these areas are usually alder, willow, birch and aspen, in sandy soils also pine. The need to study this issue has arisen from the fact that valuable deciduous and coniferous trees, especially birch, need to attain a target diameter for them to be of use. Both consumption and quality requirements of timber have rapidly increased.

On the other hand, the methods of artificial regeneration are highly variable and depend on certain objectives. The species composition and structure of the stands can be determined by the regeneration patterns. Forest planting enables us to increase economic and ecological value of stands if the proper methods are selected. It is important to choose the right species composition considering the management goals and ecological suitability.

Very little is known about afforestation of abandoned agricultural land with deciduous tree species

in Estonian conditions. Thus in 1999 an Estonian-Swedish co-operation project was started and 14 experimental plantations of deciduous trees were established. The aims of the study were (i) to introduce a one-year step monitoring system developed for plantations, (ii) to compare the growth of various deciduous tree species on abandoned agricultural lands after the second growing season, (iii) to describe the influence of the soil nutrient status and cover materials (paper, polyethylene, sawdust) on silver birch annual height-growth, and (iv) to give recommendations for practical applications.

Material and methods

The present paper is based on 14 demonstration areas of deciduous plantations on private agricultural land which are located in different parts of Estonia. One plantation is located in each county (excluding Jõgeva county) (Figure 1).

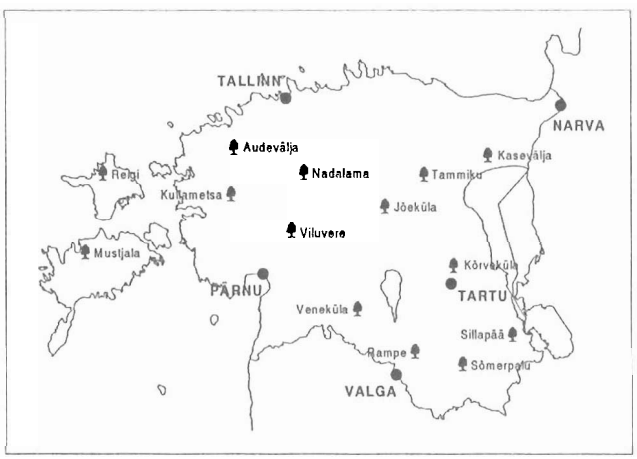


Figure 1. Demonstration areas of deciduous plantations in Estonia.

The plantations were established in the early spring of 1999. The size of each demonstration area is one hectare. All the plantations were surrounded by wire fencing to prevent possible damage by big game. Different methods were used in soil preparation, planting and later treatment. The sample plots are placed in demonstration area in a way which enables us to collect representative material concerning the influence of various treatment of planting and weed control: planting space covered by polyethylene, paper, sawdust or natural condition. Fixed spacing was used for tree species in each plantation (Table 1). During the first growing season some necessary treatment work in the plantations such as weeding, soil loosening, mowing and removal of natural regeneration was carried out by the private owners.

Table 1. Soil preparation methods, planted tree species, survival of the plants in the autumn of 1999, initial height of planting material (H), spacing and used cover materials in the investigated plantations.

Plantation	Planted species	Survival (%)	H (cm)	Spacing (m x m)	Preparation (% of area)	Cover material
Tartu (Kõrveküla)	Silver birch Oak	60 75	25 15	2.0 x 2.0 2.0 x 2.0	ploughing 25 without preparation 75	paper, polyethylene
Põlva (Sillapää)	Silver birch Oak	50 90	30 15	2.0 x 2.0 2.0 x 2.0	ploughing 100	paper, polyethylene
Võru (Sõmerpalu)	Silver birch Oak	40 98	30 15	2.0 x 2.0 2.0 x 2.0	ploughing 100	paper, polyethylene
Ida-Viru (Kasevälja)	Silver birch Oak	75 87	25 125	2.0 x 2.0 2.0 x 0.8	ploughing 100	paper, polyethylene
Järva (Jõeküla)	Silver birch Oak	97 73	30 120	2.0 x 2.0 2.5 x 2.5	ploughing 100	paper, polyethylene
Viljandi (Veneküla)	Silver birch	93	12	2.0 x 2.0	ploughing 100	paper, polyethylene
Valga (Rampe)	Silver birch Oak Ash Hybrid aspen	98 98 98 98	25 130 10 60	2.0 x 2.0 2.0 x 2.0 2.0 x 2.0 2.0 x 2.0	ploughing 25 without preparation 75	paper, polyethylene, sawdust
Rapla (Nadalama)	Silver birch	92	25	2.0 x 2.0	ploughing 100	paper, polyethylene
Pärnu (Viluvere)	Silver birch Ash	95 97	20 15	2.0 x 2.0 2.0 x 2.0	ploughing 100	paper, polyethylene
Lääne (Kullametsa)	Silver birch Oak	90 88	45 20	1.6 x 1.2 3.0 x 2.0	ploughing 50 without preparation 50	paper
Hiiu (Reigi)	Silver birch Curly birch Oak	85 73 95	45 45 25	2.0 x 2.0 2.0 x 2.0 2.0 x 2.0	ploughing 100	paper, polyethylene
Saare (Mustjala)	Silver birch Curly birch Black alder	32 50 50	25 15 25	2.0 x 2.0 2.0 x 2.0 2.0 x 2.0	ploughing 100	paper, polyethylene
Lääne-Viru (Tammiku)	Oak	60	120	1.2 x 3.0	ploughing 100	without cover
Harju (Audevälja)	Silver birch Oak	87 87 84	20 100	2.0 x 2.0 1.0 x 8.0	furrows 50 preparation with ground miller 50	paper, polyethylene

In Estonia, the average temperatures range from +20.9°C in July to –5.8°C in February. Maximum temperature can rise to +32.0°C in summer and fall to –25.0°C in winter. The mean annual precipitation varies from 500 mm on the coast to almost 700 mm in the uplands. Precipitation is highest at the end of summer, and lowest in spring (by Estonian Meteorological and Hydrological Institute). The average annual temperatures in 1999 and 2000 were +3.1°C and +2.8°C, respectively. In May 1999, after establishment of the plantations the weather was extraordinarily cold. During the first decade of May the temperature fell to –11.0 °C at some nights. Moreover, the summer of 1999 was unusually hot (the average temperature in July was +22.4 °C) and droughty in Estonian climatic conditions. The weather in the winter and spring of 1999/2000 was normal for Estonia, the summer of 2000 was more rainy than usually. A certain number of tree-plants died because of the cold spring and droughty summer of 1999. As occasion required, most of the plantations were replenished with new tree-plants in the autumn of 1999. These plants were tagged, to prevent their

possible occurrence among the model trees in the next year.

For the establishing of the plantations, mainly silver birch (*Betula pendula* Roth.) and oak (*Quercus robur* L.) were used as planting material. Only a small number of ash (*Fraxinus excelsior* L.), curly birch (*Betula pendula* var. *Carelica* (Mercklin) Hämet-Ahti) and hybrid aspen (*Populus x wettsteinii* Hämet-Ahti) were planted. On the demonstration area of Saare, also very few black alders (*Alnus glutinosa* (L.) Gaertn.) were planted. Unfortunately, the occurrence of black alder in the plantation was not frequent enough to draw any profound conclusions. It is thought that black alder may prove to be a promising tree species in afforestation of abandoned agricultural land in Estonia (Vares, 2000), but the subject requires further investigation.

During the first growing season (1999), no research work in plantations was carried out. In the first year the growth of tree-plants and general situation of the plantations was observed by the owners of the plantations and by forestry advisers of the counties. An equable monitoring system and methods for investigation of the plantations were developed in the spring of 2000. Field work in the plantations started immediately after the development of the methods and carried out at two stages: soil samples were collected in June and measuring of trees was carried out in August. On the principle of contingency, 3-m-wide sample belts crossing with plant rows were established in each demonstration area. The location of sample belts in the plantation was marked, to facilitate finding and re-measuring of model trees during the following years. On each sample strip, the height of 100 tree-plants, the height of the beginning of living crown, the annual height-growth and diameter from the root-collar were measured. The proportion of measured tree-plants of different species was determined by total proportion of species in plantation. While observing plantations the method of single-tree was used, in the course of which all the measured trees were marked with numbered metal labels for further long-time observation. In each plantation 30 soil samples were diagonally taken from 3 upper soil layers (0-10; 10-20; 20-30 cm). Of 30 samples from each soil layer one summarized sample was selected and prepared for further laboratory analysis. Soil samples were analysed for organic matter content, pHKCl, total Kjeldahl nitrogen (Tecator ASN 3313), and available (ammonium lactate extractable) phosphorus (Tecator ASTN 9/84) and potassium (Flame Photometric method) at the laboratory of the Estonian Agricultural University. According to the statistical analysis (one-way analysis of variance; $p < 0.05$), no significant differences in nutritional status between the soil layers were found. The soil types, humidity conditions and the mean soil characteristics (upper 30 cm layer) of the plantations are given in Table 2. Multifactor analysis of variance was used to test the statistical significance ($p < 0.05$) of the soil nutrient status and weed control treatment on silver birch annual height-growth. Throughout the study, means are presented together with standard error (± SE).

Results and discussion

Of the investigated 14 plantations 1100 model tree-plants in 11 plantations were numbered and selected for further monitoring (in Tartu, Põlva, Võru, Viljandi, Valga, Ida-Viru, Järva, Rapla, Pärnu, Lääne and Hiiu Counties). While selecting the plantations, the number of living tree-plants during the field works was the main criterion. In addition, the general situation and territorial location of plantations was also considered. Growth conditions (climate, soil etc.) all over Estonia, represented in the form of selected demonstration areas had to be as different as possible.

By the end of the second growing season the tallest silver birches occurred in the plantation of Lääne (101.9 ± 3.9 cm) and the shortest ones in the plantation of Harju (54.7±2.1 cm). The mean annual height-growth in the year 2000 was greatest in the plantation of Ida-Viru (62.2 ± 2.4 cm) and least in the plantation of Saare (13.2 ± 1.2 cm) (Figure 2A). The greatest mean d^2h of silver birches occurred in the demonstration area of Lääne, while the difference of that variable, considering the plantations, was remarkably greater, compared with their height (Figure 2B). The results of our study have indicated that silver birch exhibits very rapid growth on abandoned agricultural lands in Estonia. Despite different soil conditions (Table 2), the growth of silver birches in the observed plantations was quite good. After Evans (1984), in the first years after planting silver birch shows rapid growth under different growing conditions. Based on the data by Niklus and Rosenvald (1999) the silver birches planted on abandoned agricultural land may show very good mean survival (96.2 %) under Estonian conditions and their height-growth may extend up to 23,8 ± 1,0 cm during the first growing season. Similarly, silver birch has appeared to be a very rapidly-growing tree-species on agricultural land in Finland (Hynönen and Saksa, 1997; Hynönen, 2000) where by 1994 that species had been planted on an area of 100 000 ha (Ferm et al., 1994).

In Estonia, oak grows in the northern border of its distribution area (Kasesalu, 2001) and, therefore, is quite fastidious about the conditions of habitat, as compared to silver birch. While investigating these plantations, rather many oaks showed damage from

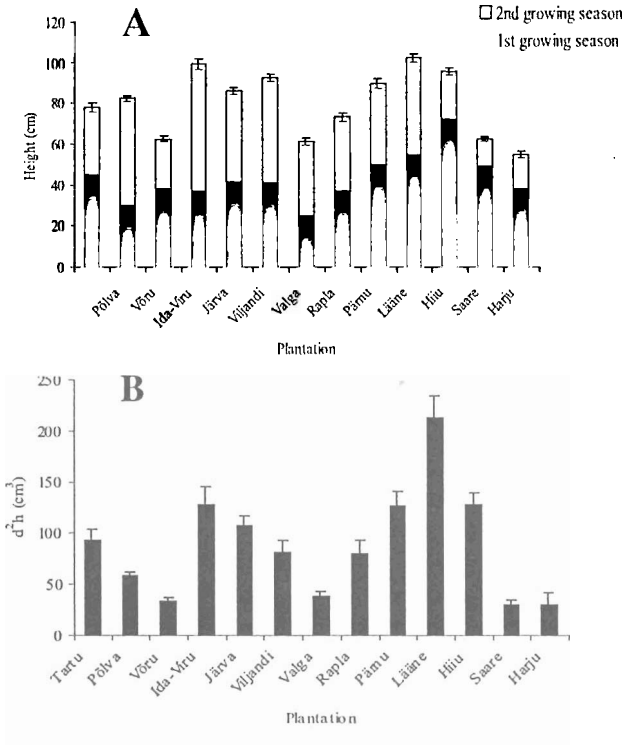


Figure 2. Mean height of silver birches at the end of the first and second growing seasons (A) and d²h at the end of the second growing season (± SE) (B).

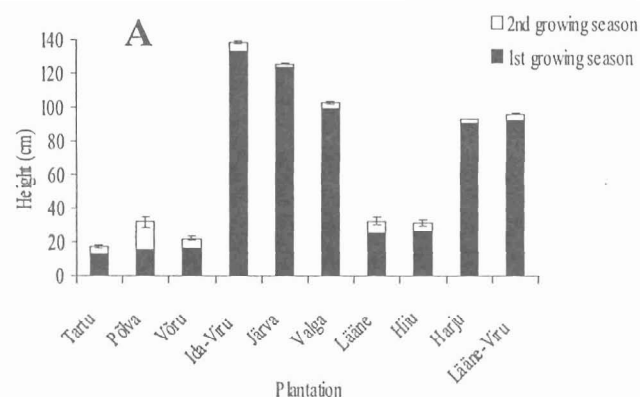
spring frost as a result of which the smaller plants were mostly bush-like. Therefore, in Estonia it would be more beneficial to plant oak on the smaller plains that could offer some side-shadow, unlike large-scaled wide-open fields. When planting an oak it would be also preferable to weed only in the neighbourhood of trees, and to desist from over-ground hay-mowing as weeds may offer some side-shadow to small saplings. The death of oaks of great extension (with the height of more than 50 cm) appeared to be quite great in several demonstration areas that may be caused by droughty summer and late-spring frost, in some extent also by wrong planting technology. Mean height-growth of oaks in 2000 was very moderate, being smallest in the demonstration area of Järva (2.3 ± 0.3 cm) and greatest in the plantation of Ida-Viru (16.3 ± 3.2 cm) (Figure 3A). After the second growing season, the greatest mean d²h of oaks was calculated for the plantation of Põlva (Figure 3B). It should be noted that the calculated mean height of oaks and birches after the first growing season appeared to be lower in some of the plantations or it was almost at the same level, when compared with the initial height of planting material. It may be due to the fact that the top of some saplings withered in consequence of cold and droughty weather and wrong planting process. After withering of top sprouts the new sprouts sprang up, thus giving the impression that

Table 2. Soil type (FAO/ISRIC), humidity conditions and the mean (± SE) soil characteristics (upper 30 cm layer): pHKCL, nitrogen (N), phosphorus (P), potassium (K) and organic matter content (O).

Plantation	Soil type	Humidity conditions	pH KCl	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	O (%)
Tartu	Cambisol	temporary hydromorphic	6.52 ±0.06	0.126 ±0.010	22.35 ±1.73	177.05 ±33.04	2.84 ±0.17
Põlva	Podzol	automorphic	6.51 ±0.03	0.081 ±0.002	53.55 ±6.44	93.89 ±3.53	1.97 ±0.07
Võru	Podzol	automorphic	7.01 ±0.07	0.094 ±0.002	79.18 ±19.40	191.49 ±32.13	1.86 ±0.04
Viljandi	Podzol	automorphic	5.65 ±0.06	0.162 ±0.010	18.70 ±3.23	126.65 ±27.57	3.80 ±0.22
Valga	Podzol	automorphic	4.96 ±0.01	0.123 ±0.012	15.15 ±2.40	59.36 ±14.03	2.70 ±0.26
Pärnu	Podzol	automorphic	6.77 ±0.02	0.271 ±0.008	387.85 ±29.54	201.79 ±12.88	4.72 ±0.03
Rapla	Cambisol	automorphic	6.17 ±0.04	0.146 ±0.014	56.00 ±3.55	213.79 ±38.13	2.87 ±0.27
Järva	Podzol	automorphic	5.87 ±0.07	0.182 ±0.006	22.24 ±1.56	168.67 ±24.74	3.87 ±0.16
Ida-Viru	Carbi-Gleyic Podzol	hydromorphic	4.33 ±0.05	0.107 ±0.015	4.37 ±1.04	41.82 ±18.36	2.60 ±0.31
Lääne-Viru	Cambisol	automorphic	6.06 ±0.65	0.146 ±0.033	22.74 ±7.97	73.64 ±33.49	3.26 ±0.68
Lääne	Podzol	temporary hydromorphic	4.05 ±0.05	0.137 ±0.015	14.65 ±1.04	13.92 ±18.36	3.37 ±0.31
Harju	Rendzic Leptosol	temporary hydromorphic	7.20 ±0.09	0.231 ±0.031	20.14 ±10.17	67.04 ±22.15	4.62 ±0.55
Saare	Podzol	automorphic	7.24 ±0.03	0.122 ±0.008	40.11 ±4.07	20.76 ±3.44	2.47 ±0.24
Hiiu	Rendzic Leptosol	automorphic	7.22 ±0.05	0.197 ±0.018	31.37 ±3.92	168.62 ±14.28	3.31 ±0.31

there was not any height-growth during the year after planting.

Ash also seems to be sensitive to late-spring frost and also becomes bush-like. The mean annual height-growth of ashes was 1.9 ± 0.4 cm in the plantation of Pärnu and 5.1 ± 1.3 cm in the plantation of Valga. Hybrid aspen proved to be a tree-species of very rapid growth in Valga (mean annual height-growth 62.3 ± 9.7 cm), exceeding all the other species in its mean annual height-growth. After Reisner (2001) the maximum annual height-growth of hybrid aspen planted on the agricultural land may extend even up to 84 cm after the first growing season in Estonia. Hybrid aspen has been planted also in Finland (Hynönen and Hytönen, 1997) and Sweden (Jonsson, 1967; Eriksson, 1984; Christersson, 1996) where it has proved to be a very rapidly growing species. After Luht (1993) the growth of hybrid aspen in Estonia is comparable with its



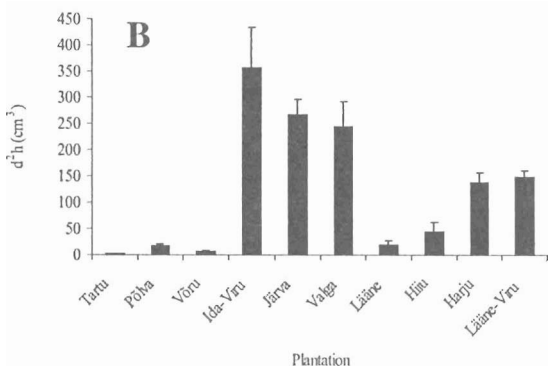


Figure 3. Mean height of oaks at the end of the first and second growing seasons (A) and d^2h at the end of the second growing season (± SE) (B).

growth in South-Finland as well as in South-Sweden and Middle-Sweden; the planting of hybrid aspen in Estonia may thus be expedient.

Curly birch was cultivated in the plantations of Saare and Hiiu. Curly birches showed the best mean annual height-growth in the plantation of Saare (21. 6 ± 2.1 cm), while in Hiiumaa the height-growth was only 9.5 ± 1.1 cm. As curly birch was cultivated only in small numbers and only in 2 plantations, it would not be correct to draw more far-reaching conclusions on the basis of that selection. There are, however, agricultural lands in Estonia that could be appropriate for the planting of curly birch (Sibul, 2000).

Multifactor analysis of variance (Table 3) showed that nitrogen and phosphorus had the greatest effect on the annual height-growth of silver birch in the top layer of soil (up to a depth of 30 cm); potassium had a more moderate effect on the height-growth of birches. A paper by Helliwell and Harrison (1979) also revealed a strong correlation between the soil indices and growth of trees after planting. Nevertheless, one should not draw any final conclusions about the correlations with soil indices and growth of tree-plants, as most likely it is just the competition with weeds that determines growth of saplings during the first years after planting.

Table 3. Multifactor analysis of variance for silver birch annual height-growth.

Source of variation	Sum of squares	d.f.	Mean square	F-ratio	p-value
n	31231.0	2	15660.5	47.9	<0,0001
			7110.7	21.8	<0,0001
Cover material	61717.7	2	20572.6	62.9	<0,0001
Error	302878.5	927			
Total	429720.5	936			

After establishment of plantations on abandoned agricultural land the growth of tree-plants depends very greatly on the competition with weeds. This competition may be lessened by the owner of the plantation, using various treatment methods. Competition between weeds and planted trees involves root-competition and competition for light. The character and extent of competition are determined by a certain habitat (regime of nutrient and moisture of the soil, various species of weeds) and the species of the planted tree. It is clear that silver birch, characterized by rapid growth and remarkable resistance to climate conditions, rises more rapidly out of surrounding weeds around than oak or ash. Mostly, the competition between planted trees and weeds happens to be combined and it is very difficult to say if the growth of trees is more influenced by competition for light, water or nutrients. According to the literature (Davies, 1985), during the first years after planting, the growth of trees is more influenced by competition for water and nutrients and it appears to be particularly strong on dry soils.

Preparation of the soil before the establishment of a plantation may diminish covering by weeds and improve the regime of water, air and nutrients. On most of the plantations, over-ground ploughing had been made or plough furrows and milling had been used (Harju, Lääne-Viru). In some of the areas (Tartu, Valga, Lääne), soil was partly prepared, but partly it was left unprepared. According to the results, it is possible to say that ploughing has greater influence on growth of tree-plants in areas where weed growth is more intense, but the influence is of relatively short duration. Already during the first growing season there is a need to loosen the soil and diminish competition by weeds. Likewise preparation of the soil is more significant, as it improves the regime of soil water, air and nutrients. Positive effect of milling and plough furrows on growth of tree-plants was not noted, but the subject requires further investigation.

Concerning an alternative to traditional treatment methods, it is possible to prevent the growth of weeds

in abandoned agricultural land using various cover materials (Davies, 1985; Ferm et al., 1994). Mostly, mulch paper and polyethylene were used as cover materials on the plantations, also sawdust in Valga. The effect of these cover materials on the annual height-growth of silver birches was studied. Statistical analysis (Table 3) showed that cover materials had significant effect on the annual height- growth of silver birches. Moreover, polyethylene was the most effective cover material, because the birches grown on polyethylene had the greatest mean annual height-growth after the second growing season (Figure 4).

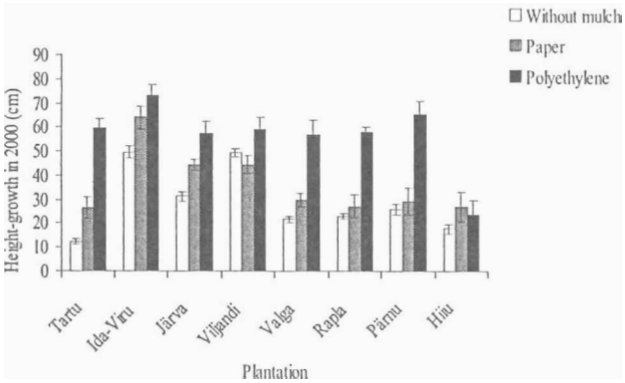


Figure 4. The effect of cover materials on the mean annual height-growth (± SE) of silver birch.

The demonstration area of Hiiu, where the effect of polyethylene was moderate, represented an exception. The favourable effect on the growth of silver birches depends, above all, on better moisture conditions in soil covered with polyethylene. An experiment made by Davies (1985) in Great Britain gave the same results. Apparently, polyethylene has a significant role in competition with herbacious plants (both in root-competition and in competition for light), but it depends on the area of the ground covered with polyethylene. The role of polyethylene, which absorbs warmth and intensifies soil processes, is also quite important. Polyethylene is favourable to the activity of voles, thus having a negative effect on the growth of birches. Plants crown on the polyethylene were more damaged by voles. Similarly to the results of research conducted in Finland (Ferm et al., 1994), the soil under the cover was very advantageous to voles, offering them a place where to hide and build a nest.

The effect of paper on the growth of silver birches was reserved in most of the plantations. Sawdust had a positive effect on the birches in winter, as it prevented the freezing of the soil and roots. As for paper, the plantation of Lääne can be characterized as an exception, because silver birches grown on paper were significantly higher than birches grown on uncovered ground. In some demonstration areas it could be noted that paper fell to pieces because of wind and rain already during the first growing season. Weeding the plants by hand or over-ground hay-mowing were remarkably less effective methods than polyethylene. Presumably, weeding may improve light-conditions for a tree but does not preclude root-competition (Richardson, 1953; Atkinson, 1990).

Conclusions

An equable monitoring system for further investigation of demonstration areas was developed in 2000. Of 14 established plantations 11 plantations were selected to observe the growth of model trees and factors influencing them.

• Silver birch proved to be the most suitable species in afforestation of abandoned agricultural lands in Estonia. Rapid growth of silver birch in the first years and less requirements for habitat conditions are its advantages, when compared with oak. Oak and ash are sensitive to frost and show very moderate annual height-growth on agricultural lands. As to the rapid growth of silver birch, only hybrid aspen can compete with birch.

• When planting silver birch, mulch polyethylene has to be considered the most effective cover material. In most of the plantations silver birches grown on polyethylene had greater mean annual height-growth. For the establishing of a plantation on abandoned agricultural land, it is also essential to analyse the nitrogen and phosphorus content in the soil, as these are the elements having the greatest effect on the annual height-growth of silver birch.

• Direct preparation of the soil before establishing a plantation has a positive effect on the growth of tree-plants, but it is an effect of short duration. When using no cover materials weeding the neighbourhood of tree-plants or over-ground hay-mowing is necessary already in the first year after planting. The effect of soil preparation is more noticeable in areas with more intense weed growth.

• In Estonia, it would be more beneficial to plant oak on the smaller plains that could offer some side-shadow, unlike large-scaled wide-open agricultural fields. When planting an oak it would be also be preferable to weed only in the neighbourhood of tree-plants, and to desist from over-ground hay-mowing as weeds may offer some side-shadow to tree-plants.

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НАСАЖДЕНИЕ НЕКОТОРЫХ ВИДОВ ЛИСТВЕННЫХ ДЕРЕВЬЕВ НА БЫВШИХ ПАХОТНЫХ ЗЕМЛЯХ ЭСТОНИИ

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Резюме

Настоящая статья основывается на данных 14 видов культур лиственных деревьев (*Betula pendula* Roth., *Quercus robur* L., *Fraxinus excelsior* L., *Betula pendula var. carelica* (Mercklin) Hдmet-Ahti, *Populus ` wettsteinii* Hдmet-Ahti), ?осаженных в различных областях Эстонии. При насаждении в качестве посадочного материала использовались различные виды лиственных деревьев. В 2000 году была выработана и реализована система наблюдения, которая применялась для изучения культур произрастающих на пахотных землях. Плакучая береза (*Betula pendula* Roth.) оказалась наиболее подходящим для насаждения на бывших пахотных землях, черешчатый дуб (*Quercus robur* L.) и обыкновенный ясень (*Fraxinus excelsior* L.) – морозонеустойчивыми и поэтому не пригодными для посадки на бывших пахотных землях. При насаждении культур на бывших пахотных землях необходимо учитывать содержание азота и фосфора в почве, так как именно эти элементы более всего влияют на рост деревьев. При культивизации плакучей березы самым эффективным защитным материалом оказалась полиэтиленовая пленка.

Ключевые слова: *Betula pendula, Quercus robur, Fraxinus excelsior, Betula pendula var. carelica, Populus × wettsteini,* бывшая пахотная земля, культура, прирост высоты, борьба с сорняками, Эстония.