Growth and Stem Quality of Mature Birches in a Combined Species and Progeny Trial

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The growth and stem quality of silver birch (*Betula pendula*), downy birch (*B. pubescens*) and paper birch (*B. papyrifera*) were compared in a 32-year-old field trial in southern Finland. The material consisted of different unselected stand origins and progenies of phenotypically selected plus trees of silver and downy birch from southern Finland and differing stand origins of paper birch from the North-West Territories, Canada. Growth, yield and a number of stem quality traits, including taper, sweep, stem defects, heights of different crown limits and length of the veneer timber part of the stem were measured or observed. The native Finnish silver and downy birches were superior to paper birch in terms of both yield and stem quality, silver birch being the best. Progenies of silver birch plus trees were better than the stand origin, indicating that the former are able to reach high quality veneer log size in a shorter time than unselected material. The cultivation of paper birch can not be considered viable in Finland.

Keywords *Betula pendula* Roth, *Betula pubescens* Ehrh., *Betula papyrifera* Marsh., progeny, growth, stem quality, timber production
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1 Introduction

Silver birch (*Betula pendula* Roth) and downy birch (*B. pubescens* Ehrh.) are important raw materials in the mechanical and chemical forest industry of Finland. Until the 1960's, the natural birch forests were sufficent to meet the need of the industry, but then a shortage of raw material threatened the veneer industry and planting of birch started. In order to improve the genetic quality of the material used in cultivation, an intensive breeding programme, including plus tree selection and progeny testing, was initiated. Planting of birch increased significantly in the late 1980's, reaching its peak in the beginning of the 1990's. In 1997 nurseries were producing 19.3 million birch seedlings, which was about 13 % of the total seedling production in Finland (Sevola 1998).

On suitable sites, i.e. fertile mineral soils, silver birch has a higher growth potential than downy birch (Raulo 1977). The stem quality of silver birch is also usually better than that of downy birch (Heiskanen 1957, Verkasalo 1997). However, these two native birch species have not been compared with regard to the selection of breeding material.

The natural range of paper birch (*B. papyrifera* Marsh.) is in North America, where it is mainly used in the pulp industry and to some extent also in the saw mill industry (Brisbin and Sonderman 1973, Verkasalo 1990). In Finland, it has only been grown for research purposes (Hämet-Ahti and Alanko 1987). Paper birch is known to have a fast growth when juvenile (Johnsson 1949, 1967, Brisbin and Sonderman 1973). However, little is known about its growth and stem quality in Finland, particularly when maturing. Paper birch can be hybridized with both silver and downy birch, producing hybrids with fast growth (Johnsson 1945, 1949).

The aim of this study was to compare the growth and stem quality of stand origins and plus tree progenies of the native Finnish silver and downy birches and paper birch in a mature field trial in southern Finland.

2 Material and Methods

2.1 Field Trial

The material in our study comes from a small combined species and progeny trial (no 542/8 in the forest genetic register of the Forest Research Institute) at the Rautalahti Birch Experimental Farm south of the city of Jyväskylä (62°08'N, 25°43'E, 85 m a.s.l.). The trial includes open pollinated progenies of silver birch and downy birch plus trees from southern Finland, stand seed of silver birch and downy birch from southern Finland and paper birch from three stands in northwestern Canada (Table 1).

The site had formerly been farmed and is located on a gentle north facing slope. The soil is fine textured and developed on sorted glacial-fluvial deposits. The experiment has a randomized block design with four blocks and was established in spring 1965 with two-year-old seedlings. Plot size was 10 × 10 m with 25 plants per plot at 2 × 2 m spacing. The total area of the experiment was 0.5 ha. The experiment was planned and established as a part of a large breeding and research programme on silver birch (Raulo and Koski 1977, Raulo 1984).

The trial has been selectively thinned from below four times (in 1973, 1978, 1985 and 1991), the intention being to leave the same number of trees in each plot after thinning. After the last thinning, in 1994, when the measurements for this study were made, the number of trees on the plots averaged 455 per hectare.

2.2 Observations and Measurements

The trial was measured in September 1994 at the age of 32 years. The trial included altogether 12 lots and nine of them were measured for this study (Table 1). Three of the five silver birch plus tree progenies of Keuruu origin in the original trial were excluded on a random basis from the study. Various traits describing the size, form and technical quality of the stems were either measured or observed. The measurements were made according to procedures described by Niemistö et al. (1997), and made from all trees (9–20 per lot).

Tree height (dm) and diameters (mm) over bark at stump, 1.3, 2.0, 4.0 and 6.0 m height were measured. Diameters were measured perpendicularly from two sides of the stem and the mean value used. Heights (dm) from the ground to the lower limit of the continuous living crown, to the lowest living branch and to the lowest dead branch more than 5 mm thick were also measured. A single living branch was ignored when it was at a distance of more than 1.5 m from the continuous crown. Corresponding relative heights were calculated as percentages of tree height. Individual stem volumes were calculated using tree height and the five diameters and the regression models for birch developed by

Table 1. Material included in the study.

Lot no.	Species	Material type	Origin
1	*B. pendula*	open pollination of a plus tree	Finland, Keuruu, plus tree E 1599 62°07'N, 24°43'E, 110 m asl
2	*B. pendula*	open pollination of a plus tree	Finland, Keuruu, plus tree E 1600 62°07'N, 24°43'E, 110 m asl
3	*B. pendula*	open pollination of a plus tree	Finland, Kangasala, plus tree E 1971 * 61°26'N, 24°08'E, 120 m asl
4	*B. pendula*	stand seed	Finland, Padasjoki ** 61°21'N, 25°17'E
5	*B. pubescens*	open pollination of a plus tree	Finland, Kangasala, plus tree E 1973 * 61°26'N, 24°08'E, 120 m asl
6	*B. pubescens*	stand seed	Finland, Padasjoki ** 61°21'N, 25°17'E
7	*B. papyrifera*	stand seed	Canada, North-West Territories Fort Resolution 61°11'N, 113°40'W
8	*B. papyrifera*	stand seed	Canada, North-West Territories Fort Smith, west bank of Slave River 60°01'N, 111°40'W, 213 m asl
9	*B. papyrifera*	stand seed	Canada, North-West Territories Fort Smith, west bank of Slave River 60°01'N, 111°40'W, 213 m asl

* Plus trees E 1971 and E 1973 were selected in a plantation at Kangasala, southern Finland, but the origin of the stand is probably central Finland.
** Seeds were collected in the same stand at Padasjoki, and the seedlings of silver and pubescent birch were separated later.

Laasasenaho (1982). The current standing volume per hectare and total stem wood production were subsequently calculated.

Stem taper was calculated as the difference between $d_{1.3}$ and $d_{6.0}$ and the relative taper calculated as a percent of the $d_{1.3}$ value. Sweep (cm) of the stem was measured as the maximum perpendicular deviation (>2 cm) from a straight 4-m long pole placed next to the stem with the lower end of the pole at stump height.

Stem defects, which decrease the size or quality of the veneer timber part of the stems, were observed. The defects recorded were basal curve, middle curve, vertical branch, fork, crookedness, sweep, thick branch ($\varnothing > 6$ cm) and group of thick branches. The lengths of the stem defects, or the estimated length effected by the defect, were measured in the vertical direction. If there were several defects, only the nature of the most severe was recorded, but the length of the whole defected part was measured. Decay or signs of decay that could be seen on the surface of the stem were also noted.

The length of the jump butt (dm) and total length of jump cuts (dm) that would be rejected for veneer timber were also measured, as well as the reason (healthy branch, dead branch, big knot bump, vertical branch, group of branches, sweep, crookedness, decay, scar, surface crack) noted.

Height (dm) from the ground to the highest limit of the veneer log part of the stem was defined according to quality. Above this height no veneer log will be obtained that would fullfill the minimum quality requirements for veneer logs. The length of the veneer timber part obtained from each stem was calculated by subtracting the total length of rejected jump butt and jump cuts from the highest limit of the veneer log part. This was calculated for both veneer log stems and all stems.

2.3 Statistical Analysis

Differences among the lot means were tested by using a two-way analysis of variance (general linear model) and multiple comparisons (Student-Newman-Keuls test) used to identify which means were significantly different. The SAS/STAT™ statistical package was used (SAS/STAT user's guide 1989). A mixed model was applied using lot as a fixed effect and block as a random effect and type III estimable functions. Before the analysis of variance, percentage values were *arcsin* transformed. The analysis of variance was performed on the plot means. Differences among lots in the length of stem and surface defects were tested by using the non-parametric Friedman's analysis of variance according to Kouki et al. (1990).

3 Results

3.1 Growth and Yield

The average tree size of the birch lots varied considerably (Table 2), and statistically significant differences among the lots were found for *height*, *diameter* and *mean stem volume* (Table 3). The silver birches were the biggest and paper birches the smallest. As regards height, the lots of different birch species differed significantly (SNK test $p < 0.05$), and the northernmost paper birch lot was significantly shorter than the two other paper birch lots (Table 2). As regards diameter and mean stem volume, the paper birches differed significantly from silver and downy birches, whereas there was no significant difference between the plus tree progenies and stand origins of the native species.

The *total yield* of the birch lots varied between 34 and 293 m^3/ha and the *present growing stock* between 20 and 172 m^3/ha (Table 2), and significant differences among the lots were indicated (Table 3). The silver birches had the highest and paper birches the lowest total yield and present

Table 2. Lot means (and *standard deviations*) of growth and yield characteristics. Means followed by a different letter are significantly different by the SNK test ($p < 0.05$). B. pen = *Betula pendula*, B. pub = *B. pubescens*, B. pap = *Betula papyrifera*, E1599 op = progeny from open pollination of plus tree E 1599.

Lot	Number of trees measured	Height, m	$d_{1.3}$, cm	Mean stem, dm^3	Present growing stock, m^3/ha	Total yield, m^3/ha	Number of trees/ha
B. pen, FIN, Keuruu E1599 op.	15	20.6 *(1.0)* a	21.0 *(1.6)* a	340 *(62)* a	170 *(13)* a	282 *(25)* a	500
B. pen, FIN, Keuruu E1600 op.	20	21.6 *(0.8)* a	20.5 *(2.5)* a	344 *(85)* a	172 *(27)* a	293 *(41)* a	500
B. pen, FIN, Kangasala E1971 op.	19	21.9 *(1.0)* a	21.1 *(1.8)* a	354 *(64)* a	168 *(30)* a	290 *(42)* a	475
B. pen, FIN, Padasjoki, stand	14	21.1 *(1.1)* a	21.1 *(2.9)* a	343 *(113)* a	160 *(27)* a	252 *(49)* ab	467
B. pub, FIN, Kangasala E1973 op.	20	19.2 *(1.1)* b	20.2 *(2.2)* a	280 *(62)* ab	140 *(15)* a	243 *(15)* ab	500
B. pub, FIN, Padasjoki, stand	15	19.1 *(1.3)* b	19.4 *(2.4)* a	260 *(67)* b	130 *(12)* a	221 *(23)* b	500
B. pap, CA, Fort Resolution, stand	9	13.5 *(2.8)* d	12.4 *(3.7)* b	88 *(72)* c	20 *(9)* c	34 *(11)* d	225
B. pap, CA, Fort Smith, stand	19	17.5 *(0.7)* c	14.6 *(2.1)* b	133 *(34)* c	63 *(10)* b	110 *(17)* c	475
B. pap, CA, Fort Smith, stand	19	16.6 *(1.3)* c	13.9 *(2.4)* b	116 *(42)* c	55 *(16)* b	95 *(19)* c	475
Mean		19.3 *(2.6)*	18.4 *(3.9)*	257 *(120)*	117 *(59)*	198 *(99)*	455

Table 3. Analysis of variance of growth and yield characteristics.

Trait	Lot	Block	Error
Height	F = 48.94 DF = 8 p < 0.0001	F = 1.26 DF = 3 p < 0.3152	MS = 0.59 DF = 21
$d_{1.3}$	F = 19.98 DF = 8 p < 0.0001	F = 0.48 DF = 3 p < 0.6965	MS = 2.28 DF = 21
Mean stem	F = 33.95 DF = 8 p < 0.0001	F = 0.61 DF = 3 p < 0.6135	MS = 1295.55 DF = 21
Present growing stock	F = 32.62 DF = 8 p < 0.0001	F = 0.57 DF = 3 p < 0.5047	MS = 396.45 DF = 21
Total yield	F = 41.92 DF = 8 p < 0.0001	F = 0.81 DF = 3 p < 0.5047	MS = 867.66 DF = 21

growing stock. The paper birch lots differed significantly from the native birch species lots, and the northernmost paper birch origin had significantly lower total production and present growing stock than the two other paper birch lots.

3.2 Crown Limits

The average height to the *lowest dead branch* among lots varied from 2.6 to 5 m, corresponding to 17–28 % relative height of the tree. The average height to the *lowest living branch* among lots varied from 4.8 to 8.7 m, corresponding to 25–50 % of the tree height. The average relative height to the lowest living branch of the paper birch lots (41–50 %) was somewhat higher than those of the native birches. However, statistically significant differences in the height to the lowest living and dead branches among the lots were not found.

The lot average of the height to the *lower limit of the continuous living crown* ranged between 5.4 and 10.1 m, corresponding to 28–58 % of tree height. A significant difference among the lots as regards the relative height to the lower limit of the living crown was found ($p < 0.0038$). For the paper birch lots, the average relative height to the lower limit of the living crown was 48–58 %, whereas for the native species it was 28–35 %.

3.3 Stem Taper

Average *stem taper* among the lots varied between 28 and 38 mm and *relative taper* between 13 and 33 % (Table 4). In the latter, a statistically significant difference among lots was found (Table 5). The paper birch lots had the highest and the silver birch lots had the lowest relative taper values. The northernmost paper birch origin differed significantly ($p < 0.05$) from all other lots, and all paper birch lots from the silver birch plus tree progenies.

3.4 Stem Defects

Decay was observed on the surface of the stem in 5 % of all trees. The silver birch lots showed no decay and in the two downy birch lots, the proportion of trees showing decay averaged 5 and 7 %. The proportion of trees showing decay in the paper birch lots averaged between 0 and 38 %, and was the highest for trees of the northernmost lot.

Nearly all (96 %) the trees showed at least a slight stem *sweep* (deviation from straight > 2 cm). The average sweep measured on four meters basal part of the stem among the lots ranged from 4.3 to 9.7 cm (Table 4) and a significant difference among lots was found (Table 5). The paper birch lots and silver birch stand lot had the

Table 4. Lot means (and *standard deviations*) of stem taper, relative stem taper, sweep and length of stem defects (excluding sweep). Means followed by a different letter are significantly different by the SNK test (p < 0.05). Abbreviations: see Table 2.

Lot	Taper, mm	Taper, %	Sweep, cm	Length of stem defect, dm
B. pen, FIN, Keuruu E1599 op.	31 *(8)* a	15 *(4)* a	5.5 *(2.3)* a	16 *(13)* ab
B. pen, FIN, Keuruu E1600 op.	28 *(9)* a	13 *(3)* a	5.3 *(1.7)* a	7 *(5)* c
B. pen, FIN, Kangasala E1971 op.	32 *(6)* a	15 *(2)* a	4.3 *(1.5)* a	5 *(3)* c
B. pen, FIN, Padasjoki, stand	35 *(10)* a	17 *(4)* ab	6.9 *(4.5)* ab	22 *(23)* abc
B. pub, FIN, Kangasala E1973 op.	38 *(8)* a	19 *(3)* abc	5.0 *(1.6)* a	12 *(15)* bc
B. pub, FIN, Padasjoki, stand	37 *(9)* a	19 *(4)* abc	4.5 *(1.6)* a	12 *(15)* bc
B. pap, CA, Fort Resolution, stand	38 *(8)* a	33 *(11)* d	9.7 *(4.7)* b	46 *(28)* abc
B. pap, CA, Fort Smith, stand	32 *(11)* a	21 *(5)* bc	7.8 *(4.5)* ab	63 *(29)* a
B. pap, CA, Fort Smith, stand	34 *(11)* a	24 *(5)* c	6.6 *(2.9)* ab	55 *(16)* ab
Mean	33 *(9)*	19 *(7)*	6.1 *(3.2)*	26 *(28)*

Table 5. Analysis of variance of stem taper, relative stem taper, sweep and length of stem defects.

Trait	Lot	Block	Error
Taper	F = 2.32 DF = 8 p < 0.054	F = 0.23 DF = 3 p < 0.8731	MS = 20.09 DF = 21
Relative taper	F = 14.24 DF = 8 p < 0.0001	F = 0.58 DF = 3 p < 0.6366	MS = 0.00 DF = 21
Sweep	F = 4.83 DF = 8 p < 0.0018	F = 0.48 DF = 3 p < 0.6998	MS = 2.67 DF = 21
Length of stem defect *	F = 4.97 DF = 8 p < 0.001		MS = 3.27 DF = 24

* Non-parametric Friedman's analysis of variance was used.

highest average sweep values. The northernmost paper birch lot differed significantly from downy birches and silver birch plus tree progenies (Table 4).

A *stem defect* of some degree was observed in nearly all (98 %) the trees. The length of the stem defects (excluding sweep) varied between 5 and 63 dm among the different lots (Table 4). Paper birches had the longest stem defects. The results of the ANOVA indicate a significant difference among the lots (Table 5).

The most common types of stem defects observed were: crookedness (31 % of the trees), sweep (25 %), basal curve (21 %), and vertical branch (13 %). Of the paper birch lots, a remarkably high proportion of the trees (56–89 %) had a crooked stem. In silver and downy birch the most common stem defects were basal curve and sweep. In addition, a high proportion of downy birch trees (27 and 30 %) had vertical branches.

3.5 Yield of Veneer Timber

Proportion of veneer log trees varied from 0 to 100 % among lots (Table 6). Silver birch lots

Table 6. Proportion of veneer log trees, highest limit of veneer log part, length of veneer timber part of veneer log trees and length of veneer timber part of all trees (and *standard deviations*). Means followed by a different letter are significantly different by the SNK test (p < 0.05). Abbreviations: see Table 2.

Lot	Proportion of veneer log trees, %	Highest limit of veneer log part, dm	Length of veneer timber part/veneer log tree, dm	Length of veneer timber part/tree, dm
B. pen, FIN, Keuruu E1599 op.	93	71 *(14)*	61 *(14)* ab	57 *(21)* ab
B. pen, FIN, Keuruu E1600 op.	95	75 *(15)*	69 *(16)* a	65 *(22)* ab
B. pen, FIN, Kangasala E1971 op.	100	81 *(16)*	76 *(18)* a	76 *(18)* a
B. pen, FIN, Padasjoki, stand	86	64 *(8)*	57 *(12)* ab	48 *(23)* b
B. pub, FIN, Kangasala E1973 op.	80	61 *(10)*	55 *(11)* ab	44 *(30)* b
B. pub, FIN, Padasjoki, stand	73	63 *(15)*	60 *(15)* ab	44 *(25)* b
B. pap, CA, Fort Resolution, stand	0	- -	- -	0 *(0)* c
B. pap, CA, Fort Smith, stand	32	50 *(12)*	45 *(8)* b	14 *(22)* c
B. pap, CA, Fort Smith, stand	21	51 *(15)*	42 *(7)* b	9 *(18)* c
Mean	64	65 *(16)*	58 *(17)*	40 *(32)*

Table 7. Analysis of variance of veneer timber characteristics.

Trait	Lot	Block	Error
Highest limit of veneer log part	F = 4.47 DF = 7 p < 0.0063	F = 0.13 DF = 3 p < 0.9381	MS = 98.56 DF = 16
Veneer timber part/ veneer log trees	F = 5.23 DF = 7 p < 0.003	F = 0.10 DF = 3 p < 0.9595	MS = 91.63 DF = 16
Veneer timber part/ all trees	F = 18.14 DF = 8 p < 0.0001	F = 1.10 DF = 3 p < 0.372	MS = 153.43 DF = 21

had the highest proportion of veneer log trees (86–100 %) and paper birch lots the lowest (0–32 %). The highest limit of veneer log part of the stem among lots varied between 50 to 81 dm. It was the highest in the silver birch lots and the lowest in the paper birch lots, and a significant difference among lots was shown (Table 7).

The average length of jump butts rejected from veneer logs varied between 1.1 and 8.3 dm among lots, and the length of jump cuts between 0.5 and 2.9 dm. The most important cause of jump butts was crookedness (89 %). The most common reasons for jump cuts were: vertical branch (58 %), crookedness (19 %), and healthy branch (14 %).

When the total length of jump butts and jump cuts was subtracted from the highest limit of veneer log part, an estimation of the length of the veneer timber part per tree was obtained. It was calculated separately for veneer log trees and for all trees. The average veneer timber part of veneer log trees varied between 42 and 76 dm among lots (Table 6), and a significant difference was shown (Table 7). Paper birch lots had the lowest values.

The lot average of veneer timber part per stem for all trees varied between 0 and 76 dm (Table 6), and a significant difference among lots was shown (Table 7). Silver birch lots had the longest veneer timber part per stem (48–76 dm) and paper birch lots the shortest (0–14 dm). Paper birches differed significantly from the native birches as regards the length of the veneer timber part. In addition, the best silver birch plus tree progeny was significantly better than the silver birch stand origin and both downy birch lots.

4 Discussion

Although based on rather limited material, one field trial with small plot size, our results strengthen earlier reports on the better growth and stem quality of silver birch compared to downy birch. Raulo (1977) showed that the stem volume of dominant trees of silver birch was two times that of downy birch in 30-year-old cultivated birch stands on fresh mineral soils. In this study, the difference was smaller. The average stem volume of the silver birch stand origin was 32 % higher than that of the downy birch stand origin. The difference in the total yield between the two species was less, 14 % when stand lots were compared. Statistically, the difference in total yield was significant only between the selected plus tree material of silver birch and the stand origin of downy birch (Table 2).

In earlier studies downy birch has been shown to be worse than silver birch as regards stem quality (Heiskanen 1957), but the growing demand for raw material has increased the use of downy birch in the veneer industry (Verkasalo 1988, 1997). When natural stands of same age were compared by Verkasalo (1997), downy birch was shown to be worse than silver birch as regards veneer timber production, especially in terms of stem size, proportion of veneer log part and stem form of the butt log. However, the difference between the two species was smaller when downy birch stands growing on peatland were excluded (Verkasalo 1997). According to our results, the proportion of veneer log trees, the highest limit of veneer log part of the stem, and the length of the veneer timber part of veneer log trees defined according to quality were somewhat lower in downy birch than in silver birch, although not significantly. When the length of the veneer log part was calculated as an average of all trees, the difference between the species was bigger (Table 6). But even then, the downy birch trees differed significantly only from the best progeny of silver birch. When both the average stem size and the length of the veneer log part are considered, the difference in veneer timber production, however, is clearly in favour of silver birch.

Except for the trees belonging to one of the silver birch progenies, all the silver and downy birch trees exhibited some type of stem defect. In this study the proportion of trees with defects was high; much higher than that reported by Niemistö et al. (1997). This difference may be explained, at least partly, by the subjective nature of identifying defects and differences among observers. Among the native species, the most common types of defect were sweep and basal curve. The high number of sweep trees may be related to the fertile and fine-grained soil at Rautalahti, factors which have been shown to affect sweep (Niemistö et al. 1997).

The growth and stem quality of the paper birch lots in this study were clearly inferior to those of the native Finnish birch species. Paper birch that has been cultivated in Finland has been short-stemmed, crooked and branchy (Heikinheimo 1956, Hämet-Ahti and Alanko 1987). Although the juvenile growth of paper birch has been shown to be clearly faster than that of silver and downy birch in trials carried out in southern Sweden, the growth of paper birch at a later age slowed and was overtaken by that of silver and downy birch (Johnsson 1967). The difference in comparison to the silver birch was especially clear. Thick branches and bad stem form were also typical of the paper birch trees in Johnsson's study. In Austria, cultivations of paper birch have grown well (Günzl 1989). Johnsson (1945) hybridized paper birch with silver and downy birch and showed that in the beginning, the hybrids grew faster than the parental species (Johnsson 1949), but later their growth retarded (Johnsson 1967). Although the geographical coverage of the paper birch material used in the study was limited, we conclude that the cultivation of paper birch would not be a viable alternative to native species in Finland.

There is evidently large variation in the growth of paper birch among different geographical origins. The natural distribution of paper birch is very wide (Brisbin and Sonderman 1973, Little 1979), and it is not surprising that the paper birch complex (*B. papyrifera* Marsh.) contains a lot of genetic variation. Several varieties, subspecies and even species have been described (Brayshaw 1976, Scoggan 1978, Little 1979). The ploidy levels have been shown to vary from tetraploidy (2n = 56) to hexaploidy (2n = 84) (Woodworth 1931, Brittain and Grant 1965, 1966, 1967, 1968a, 1968b). There were marked differences in the growth and stem quality even among the three paper birch stand origins included in our study. Two of the seedlots were collected from two closely situated stands, may be even the same stand (Fort Smith). The origin of the third paper birch lot was somewhat further north (Fort Resolution), and was sent to Finland as *B. neoalaskana*. It is probably a representative of Alaskan white birch, *B. papyrifera* var. *neoalaskana* (Sarg.) Raup., a variety of paper birch which has also been called *B. neoalaskana* Sarg. and *B. alaskana* Sarg. (Brayshaw 1976, Little 1979). This may explain why the growth and quality traits of this particular lot were so different from the two others. Experiments carried out by Heikinheimo (1956) also included *B. papyrifera* var. *neoalaskana* from Cooking Lake, Alberta, and its growth was also found to differ considerably from that of the main species of paper birch.

There are few comparisons of unselected stand seed and selected material from mature field trials of birch in Finland. This is because the progeny trials established in the 1960's were done so without proper comparison lots (Raulo and Koski 1977, Raulo 1979). The Rautalahti trial 542/8 is an exception, but unfortunately there are only a few seed lots. However, the silver birch progenies from open pollination of selected plus trees had 12–16 % higher total production than the stand origin (Table 2). Although not statistically significant, this difference refers to the genetic gain obtained from phenotypical plus tree selection.

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