ARTICLES

Wood Density and Growth Rate of European and Hybrid Aspen in Southern Finland

HENRIK HERÄJÄRVI, REIJO JUNKKONEN
Finnish Forest Research Institute, Joensuu Unit, P.O. Box 68, FIN-80101 Joensuu, Finland
+358 10 211 3037; henrik.herajarvi@metla.fi

Heräjärvi, H., Junkkonen, R. 2006. Wood Density and Growth Rate of European and Hybrid Aspen in Southern Finland. *Baltic Forestry*, 12 (1): 2–8.

Abstract

Aspen species are mainly used for paper production in Finland. In order to increase the cutting potential, hybrid aspen has lately been planted in southern Finland. In this study we compared the rotation-time-long growth rate and within-stem density distribution of mature European and hybrid aspen. The material consisted of 30 naturally born European aspen trees and 45 planted hybrid aspen trees from southern Finland. From those trees, altogether 225 discs were measured for the ring-width data and 5109 specimens for the basic density data. The results showed that after an initiation phase of 5–10 years, European aspen grows relatively steadily ca. 5–8 mm/a in diameter, until the tree age exceeds ca. 50 years. Thereafter the diameter growth decreases. Hybrid aspen attains the average diameter growth of 10–14 mm/a, at the age of 10–20 years. At the age of 25, the diameter growth has already decreased down to the level of 5–6 mm/a. The within-stem density distribution was more uniform in hybrid aspen. The average basic densities of European and hybrid aspen wood material were 376 and 363 kg/m^3, respectively.

Key words: basic density, European aspen, growth rate, hybrid aspen, *Populus tremula*, *Populus tremula x tremuloides*

Introduction

European aspen (*Populus tremula* L.) is the fifth common tree species in Finland after Scot pine (*Pinus sylvestris* L.), Norway spruce (*Picea abies* Karst.), European white birch (*Betula pubescens* Ehrh.) and silver birch (*Betula pendula* Roth.). In the entire country, aspen species are dominant on an area representing 0.3% of the total forest area, whereas in southern Finland the respective proportion is 0.5%. Aspen species make up ca. 1.5% (30 Mill. m^3) of the total volume of Finland's growing stock of 2000 Mill. m^3 (Peltola 2004). There are ca. 54,000 hectares of aspen-dominated forests in southern Finland. Volumetrically, however, most of the aspen grows in stands dominated by conifers or birch. Lots of aspen grows also in fragmented small stands along the agricultural lands and roads, for instance. Therefore, harvesting is difficult and expensive compared to harvesting stands with a larger uniform area.

Tree breeding trials of European aspen and North American aspen (*P. tremuloides* Michx.) during the 1950's led up to finding an exceptionally fast growing tree for boreal conditions, *i.e.*, hybrid aspen (*P. tremula x tremuloides*). It can yield as much as 20 m^3/ha/a in southern-Finnish fertile soils. In former agricultural lands in southern Sweden, even 30 m^3/ha/a average yields have been recorded (Karacic *et al*. 2003). It is basically the only species that can be grown in a manner of agroforestry in boreal conditions.

The faster growth of *P. tremula x tremuloides* in comparison to *P. tremula* is at least partially due to the differences in their phenology. *P. tremula x tremuloides* grows its leaves earlier in spring, and continues its growth later in autumn (Yu *et al*. 2001). On the other hand, this makes it more susceptible to frost damages. Also two peaks of fast growth have been noticed during one growing season for hybrid aspen: one in the middle of July and another in the middle of August. *P. tremula* grows most rapidly in the middle of June (Yu *et al*. 2001). Still, no studies have been made to compare the *Populus* species life-long growth rhythms.

Most of the annual aspen wood consumption, *i.e.*, ca. 1.2 Mill. m^3, goes for production of high-quality papers in Finland. In fact, the domestic cuttings do not nearly fulfil the industries needs; the majority of aspen pulpwood must, thus, be imported. Finnish wood product industries use some 3000–5000 m^3 of aspen logs annually. The statistics are not exact since most of the sawing and veneering is done according to customer orders, and therefore the annual variations are extensive.

In timber purchase, the most severe problem has been that the aspen supply is so fragmented and the harvesting removals per hectare are, subsequently, small. Only seldom pure aspen stands are harvested, mostly timber is obtained in small amounts as a secondary assortment of harvesting spruce or birch dominated stands (see: Heräjärvi and Junkkonen 2004). There is a countrywide buyer for aspen pulpwood, but only adventitious buyers for aspen logs. Thus, the small amounts of sawable or veneerable logs often end up to the paper mills.

Due to a company-driven campaign started at the end of the 1990's, ca. 1000 hectares of *P. tremula x tremuloides* has been planted in Finland (Holm 2004). Their principal aim is to fulfil the needs of paper industries, but it can be supposed that after two decades also some timber will be available for the wood product industries.

The wood technological properties of *Populus* species have been studied in some Finnish (*e.g.*, Jalava 1945, Tikka 1955, Kärkkäinen and Salmi 1978, Kärki 2001, Pérez 2002) and North American (*e.g.,* Yanchuk *et al.* 1983, Beaudoin *et al.* 1992, Matyas and Peszlen 1997, DeBell *et al.* 1998, Herni̧ndez *et al.* 1998, Koubaa *et al.* 1998, Semen *et al.* 2001, DeBell *et al.* 2002, Peters *et al.* 2002) studies. In addition to the external quality factors, such as size, stem form and branchiness, wood density can be considered as the most important single property describing the usefulness of timber. According to Kärkkäinen and Salmi (1978), the basic density (dry mass per green volume) of *P. tremula* wood material in saw logs varies from 390 kg/m^3 (upper logs) to 410 kg/m^3 (butt logs). Yanchuk *et al.* (1983) found that in Canadian *P. tremuloides* wood density decreases from the pith towards the surface until the borderline of heartwood and sapwood, and then increases again towards the surface of the stem. The wood density of *P. tremula* and *P. tremula x tremuloides* hasn't been studied using comparable Finnish materials.

The objective of this study was to determine the differences between the rotation-time-long growth rhythms of *P. tremula* and *P. tremula x tremuloides* grown in southern Finland (ca. 61–63º N.L.) by the annual ring width analysis. In addition, the basic density of wood material was compared between the species and within individual stems in order to facilitate end use oriented planning of industrial woodworking processes for aspen logs.

Materials and Methods

The material comprised of 12 stands located in southern and central Finland. Criteria were set for the area and soil fertility of the stand, as well as for the size and quality of the trees. Five of the stands were *P. tremula* stands; two of them mixed stands of aspen and conifers. One of the *P. tremula* stands was planted and four of them were of natural origin. The rest of the stands, 7 of them, were cultivated single-species *P. tremula x tremuloides* stands. One of those represented "second generation", *i.e.*, it was regenerated by root suckers. All the stands were located on medium-fertile to fertile mineral soils, either on forestland or on former agricultural land. The average age of the *P. tremula* stands was 44 years and that of *P. tremula x tremuloides* stands was 32 years.

Altogether 6 to 7 circular sample plots with an area of one hundred square metres were measured from each stand to determine the average growing conditions and tree characteristics (Table 1). The tree in the centre of each sample plot was selected as a sample tree. After measuring certain characteristics of that stem and drawing a line showing towards north on the stem, the stem was felled, and cut into two-metre-long logs until the diameter of ca. 5 cm. A sample disc of ca. 5 cm was sawn from cutting heights of 0, 2, 4, 8, 12, 16 and 24 metres for the annual ring width and wood density analyses. A sign positioning

Table 1. Basal areas and technical properties characterising the dominant aspen trees in the sample stands. Standard deviations of the Dbh range from 13 to 52 mm

Stand (basal area, m^2/ha)	Age year	Dbh mm	Lengt m	Lowest dead branch, m	Lowest living branch, m
P. tremula					
1$^{1)}$ (32)	52	325	24.2	4.4	9.3
2 (28)	38	279	23.7	3.7	11.2
3 (23)	34	244	19.0	3.9	7.0
4$^{1)}$ (25)	57	326	24.8	3.8	10.0
5$^{2)}$ (31)	42	267	29.2	1.4	16.5
P. tremula x tremuloides					
6 (30)	29	263	26.6	1.1	10.4
7 (32)	42	296	29.6	3.3	14.8
8$^{3)}$ (27)	33	241	22.8	3.8	9.9
9$^{4)}$ (20)	23	248	24.4	2.9	9.8
10 (28)	34	312	25.8	1.6	13.3
11 (29)	33	290	26.0	2.8	11.6
12 (16)	32	238	23.5	0.7	10.5
	Mean values				
P. tremula	44	288	24.2	3.4	10.8
P. tremula x tremuloides	32	270	25.5	2.1$^{5)}$	11.5
Naturally-born stands	41	284	23.2	3.7	9.5
Cultivated stands	35	272	26.2	1.8$^{5)}$	12.4
Entire material	***37***	***277***	***25.0***	***2.7***	***11.2***

1) Mixed stand of conifers, birch and aspen.
2) Cultivated *P. tremula* stands.
3) Pruned up to a height of 4 metres in 1986.
4) 2nd generation stand, regenerated by the root suckers.
5) Calculated without the pruned stand nr. 8.

north was drawn in every disc. The discs were delivered to freezer within 24 hours after felling the tree.

Discs were further processed in laboratory conditions. A 5-cm-wide diagonal was sawn from every disc in south-north direction. For the heights 0 m, 2 m, as well as the uppermost disc in each tree, the diagonals were further split into two pieces, one intended to density measurements and the other intended to annual ring measurements (Fig. 1). The annual ring widths were measured separately for south and north sides of the diagonals, using a microscope. The basic density specimens were manufactured by splitting the diagonals from the pith towards the surface for ca. 20-mm-wide samples so that the innermost sample included the pith (Fig. 1). The densities in single annual rings were, thus, not measured. The specimens from the north and south side of the diagonal were numbered increasingly from zero upwards towards the cambium. Then, the ca. 20 x 20 x 30 mm specimens were sunk into water for at least two days, after which their moisture content was supposed to be above the fibre saturation point, *i.e.*, they were fully swollen.

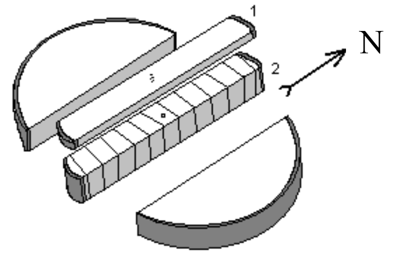

Figure 1. Manufacturing principle for specimens for annual ring width measurements (1) and basic density measurements (2). N shows to the north

The intention was to study the basic density variations from the point of view of woodworking processes. Therefore, the density specimens were measured and analysed as a function of location parameters only, no attention was paid on the growth rate or the ring number in this analysis. The results show how the wood density changes from the butt to the top of the tree and from the pith to the surface of the tree. This information can be utilised, for instance, in planning the sawing patterns for aspen logs.

Volume of each specimen was measured using the hydrostatic method (*e.g.*, Kärkkäinen 2003), after which they were dried at 103º C as long as their mass did not change anymore. Then the specimens were weighed, and basic density was calculated on the basis of dry mass and green volume. Altogether 5097 basic density specimens were measured. The statistical differences in wood densities between the two aspen species were analysed using Mann-Whitney U-test.

Results

The average height growth of *P. tremula* trees was ca. 0.7 metres per year, whereas that of *P. tremula x tremuloides* trees was ca. 1.0 metres per year for the first twenty years. Calculated for the entire life span, the annual height growth of *P. tremula x tremuloides* was 0.81 m/a and that of *P. tremula* was 0.56 m/a. Height growth was especially fast for the “second generation” *P. tremula x tremuloides* trees, ca. 1.5 metres per year. It appears, thus, that the root suckers can utilise effectively the existing root system. *P. tremula* trees grown in mixed stands of aspen and conifers represented the slowest height growth.

The growth rhythms of the aspen species differed distinctively from each other. *P. tremula* appears to grow rather steadily, 2–4 mm per year until mature phase at the age of 55 to 60 years. *P. tremula x tremuloides*, on the other hand, grows more rapidly for a period of ca. 15 years, after which its growth decreases considerably (Fig. 2). The diameter growth of *P. tremula x tremuloides* was, at its highest, two times faster than that of *P. tremula*.

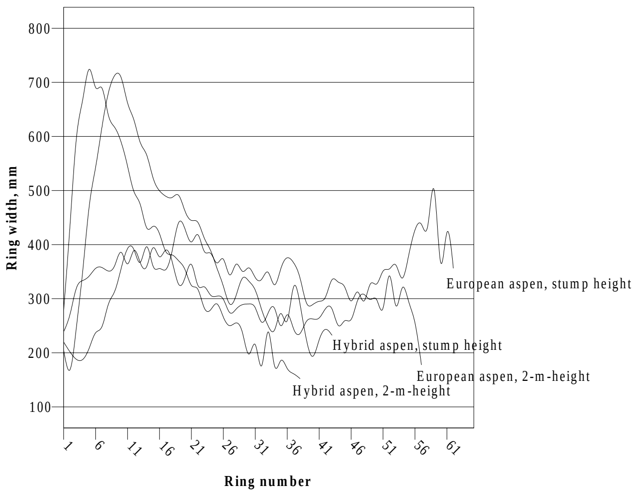

Figure 2. Annual ring widths of trees at the stump and 2-metre-heigths

The average basic density of *P. tremula* wood was 376 kg/m^3, and that of *P. tremula x tremuloides* wood was 362 kg/m^3. According to the Mann-Whitney U-test, the difference was significant ($p < 0.001$). Thus, the average basic density of *P. tremula x tremuloides* wood was ca. 15 kg/m^3 lower than that of *P. tremula* wood. Densities measured from the south and north sides of the stems did not differ significantly (Mann-Whitney U-test: $p = 0.480$). Furthermore, densities of slightly discoloured and defect free wood on average differed only 1.6%. According to the Mann-Whitney U-test, the difference was still significant ($p < 0.001$).

Wood material of *P. tremula x tremuloides* was more homogeneous than that of *P. tremula* (Fig. 3). This was mainly due to the considerable longitudinal variation in the density of *P. tremula* wood. However, also the radial variation of wood density was slightly smaller in *P. tremula x tremuloides* (Fig. 4). Irrespective of the aspen species or the within-stem vertical location of the specimen, the lowest densities were observed at the distance of ca. 20–60 mm from the pith. In the pith-including specimens, the average wood density was clearly higher. Furthermore, both species had the lowest average density at the height of 2–8 metres from the stump. More than 400 kg/m^3 basic densities were observed at the stump height near the cambium, and near the pith in the top parts of the stem. In radial direction, basic density varied mostly at the heights of 2–4 metres, ca. 60 and 40 kg/m^3 from the pith to the cambium for *P. tremula* and *P. tremula x tremuloides* wood, respectively. Fig. 5 shows the behaviour of the basic density as a function of vertical location at three different distances from the pith. It appears that the butt log up to 4–6 metres that is usually considered the most valuable part of the tree, actually contains the lightest and, thus, weakest wood material in aspen stems.

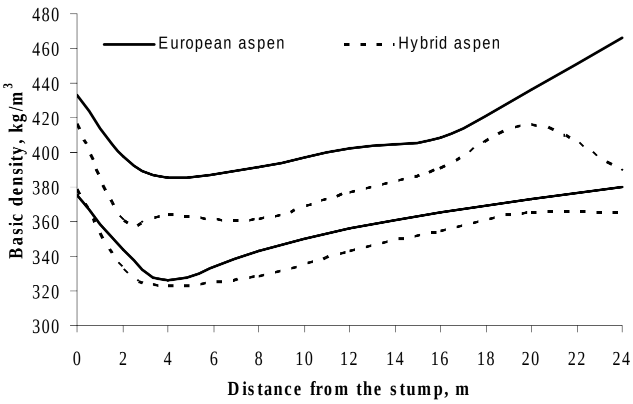

Figure. 3. Minimum and maximum values for the basic density of aspen wood

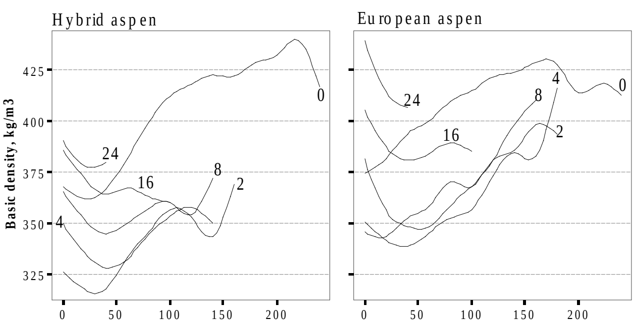

Figure 4. Basic density of hybrid (2137 specimens from 31 trees) and European aspen (2972 specimens from 44 trees) wood at different heights as a function of the distance from the pith. Line number represents the vertical location of the specimens as distance from the stump in metres

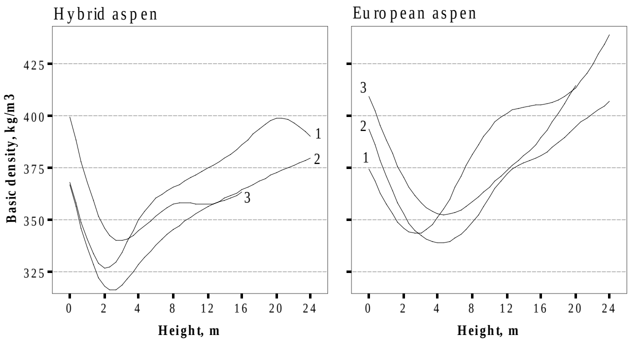

Figure 5. Basic density of hybrid and European aspen wood as a function of vertical position at pith (line 1), 40-mm-distance from the pith (2) and 80-mm-distance from the pith (3)

Wood density varied considerably between different stands and also, between different stems in one stand. The fastest grown trees had the lowest average wood density.

Discussion and Conclusions

The material of this study represented southern and central Finnish aspen stands. According to the author's experience, the material's validity and the extent of generalization are relatively good for this kind of a study, under the restriction of geographic area and site types.

There are no previous studies available concerning the rotation-time-long growth rhythms of aspens in Finland. It is evident that *P. tremula x tremuloides* can very efficiently utilise the resources available for a certain time, after which some physiological factors reduce the growth. It is unlikely that the reduction of growth would be caused by increased competition, since the same phenomenon was also observed in stands that had grown in relatively wide spacing. The fast growth of *P. tremula x tremuloides* does not last more than ca. twenty years. During this period, the trees attain their final cutting size, whereas *P. tremula* appears to require 40–50 years of growth to reach the same dimensions. Therefore, the timings of different silvicultural management practices, such as cleaning of young stands, thinnings and final cutting, differ clearly between the two aspen species. The results logically indicated that trees that had grown in more wide spacing at juvenile age represented the fastest diameter growth. In stand wise evaluation, rapid positive responses for thinning operations could be seen in the diameter growth. This was, nevertheless, true only when the thinnings had been done early enough. Postponed thinning no longer enhances the growth.

It is unclear how cultivated *P. tremula* trees would have grown in comparison to the cultivated *P. tremula x tremuloides* trees. On the basis of the material of this study, it cannot be said for sure whether the reason for the different growth rhythms was the species or the regeneration method (cultivated / natural) of the stand. In naturally born *P. tremula* stands the initial spacing of the seedlings has possibly been denser than in cultivated *P. tremula x tremuloides* stands. This obviously influences the growth rate at young age. However, it could not be taken into consideration in this study, since detailed management history of the *P. tremula* stands was not available.

The findings of previous studies performed on the basis of smaller data are generally in line with the results concerning the within-stem wood density variation patterns in this study (see: Kärki 2001, Pérez 2002). Wood density correlated negatively with the growth rate of the trees. The differences between individual trees were, however, irrelevant from the point of view of most of the current end uses. Sometimes, for instance in ice hockey stick production, the wood density is a significant factor influencing the usability of wood. In such cases it is necessary to know the within-stem density variations in order to utilise wood with most desirable properties. The dense wood in the living crown is, however, difficult to utilise due to the large living branches and small stem wood dimensions.

In the material of the current study, the average basic density of *P. tremula* was somewhat lower than that presented in previous studies (see: Kärkkäinen and Salmi 1978, Uusvaara and Pekkala 1979). Basic density was at its lowest near the tree pith in case of both studied species, and increased towards the cambium. Still, the innermost density specimen, thus including the tree pith, showed higher density values than the wood surrounding the pith. The average basic density of *P. tremula x tremuloides* was lower than that of *P. tremula*, but the between-stand and within-stand differences were considerable. The same was noticed also by Pérez (2002) in case of cross-bred poplars.

The highest basic density values were observed in the outer wood at the stump height. The stump height should, however, be considered as an exception. Considering the merchantable log section from 2 to 8-metre-height, the average wood density was actually at its lowest when compared to the near-stump-height or to the living crown above 10-metre-height. Einspahr *et al.* (1972), Kärki (2001) and Pérez (2002) noticed similar trends in their materials.

Juvenile wood near to the pith of a tree is mainly characterized by lower density, steeper microfibril angle in the S_2 layer of the secondary cell wall, shorter fibres and thinner cell walls than mature wood (*e.g.*, Zobel and van Buijtenen 1989). Juvenile wood is produced by immature cambium. Depending on species, maturation of the cambium takes 10–20 years, after which period it gradually starts producing normal, mature wood cells. Thus, the volume of the juvenile core in a stem is rather dependent on the growth rate of the tree at a given height after 10–20 years of the formation of the cambium, not on the growth rate per se. The proportion of mature wood is at its largest at the stump height and decreases gradually towards the top of a tree. In the top parts of a stem, where the number of annual rings is less than 10–20, the entire volume is juvenile wood. This generally acknowledged physiological property of woody plants explains the increment of wood density from the pith towards the cambium. It does not, however, explain the increment of wood density from the 2–6-metre-height to the top of trees, which was observed rather clearly in this study, and which has also been observed in case of some other species than poplars, such as *Tsuga heterophylla* (Krahmer 1966).

It is evident that the growth-regulating hormones are formed in the living crown of the tree (*e.g.*, Zobel and van Buijtenen 1989). From the crown, the hormones flow downwards the stem and, therefore, their concentration should be at its biggest in the lower parts or right below the living crown, then gradually decreasing towards the stump. In the material of this study, the living crown started on average from 10-metre-height. It is possible that the hormone content influences the cell properties in some species, such as poplars. This would partly explain the vertical density variation pattern shown in Figure 3. The cambium, thus, produces more dense wood in the upper parts of the stem with higher hormone content, and lighter wood lower in the stem with lower growth hormone content. The re-increment of the average wood density near the stump height could be explained by the higher proportion of mature wood.

Acknowledgements

This study is a part of a larger project "European and hybrid aspen as raw materials for wood *product industries", funded by Metsäliitto society and Puumiesten ammattikasvatussäätiö foundation. The authors present their warmest thanks to Pekka Järviluoto, Hannu Koivunen, Jukka Lehtimäki, Juha Metros, Erkki Salo and Veijo Salo for measuring the materials.*

References

Beaudoin, M., Hernández, R.E., Koubaa, A. and Poliquin, J. 1992. Interclonal, intraclonal, and within-tree variation in wood density of poplar hybrid clones. *Wood Fiber Sc*i. 24(2): 147–153.

DeBell, J.D., Gartner, B.L. and DeBell, D.S. 1998. Fiber length in young hybrid *Populus* stems grown at extremely different rates. *Can. J. For. Res*. 28: 603–608.

DeBell, D.S., Singleton, R., Harrington, C.A. and Gartner, B.L. 2002. Wood density and fiber length in young *Populus* stems: Relation to clone, age, growth rate, and pruning. *Wood Fiber Sci*. 34(4): 529–539.

Einspahr, D.W., Benson, M.K. and Harder, M.L. 1972. Within-tree variation in specific gravity of young quaking aspen. Rept. Inst. Paper Chem. 15. 8 p.

Heräjärvi, H. and Junkkonen, R. 2004. [Wood products made of aspen: yesterday, now, in the future]. *Metsätieteen aikakauskirja* 1/2004: 69–75. (In Finnish)

Hernández, R.E., Koubaa, A., Beaudoin, M. and Fortin, Y. 1998. Selected mechanical properties of fast-growing Poplar hybrid clones. *Wood Fiber Sci*. 30(2): 138–147.

Holm, S. 2004. [Planting of aspen in Finland and Estonia]. *Metsätieteen aikakauskirja* 1/2004: 117–118. (In Finnish)

Jalava, M. 1945. Strength properties of Finnish pine, spruce, birch and aspen. *Commun. Inst. For. Fenn*. 33(3): 1–66. (In Finnish with English summary)

Karacic, A., Werwijst, T. and Weih, M. 2003. Above-ground woody biomass production of short-rotation *Populus* plantations on agricultural land in Sweden. *Scand. J. For. Res*. 18: 427–437.

Kärki, T. 2001. Variation of wood density and shrinkage in European aspen (*Populus tremula). Holz Roh.-u. Werkstoff* 59(2001): 79–84.

Kärkkäinen, M. 2003. Puutieteen perusteet. Metsälehti Kustannus. 451 p. (In Finnish)

Kärkkäinen, M. and Salmi, J. 1978. Studies on the measurement and technical properties of aspen logs. Folia For. 455. 45 p. (In Finnish with English summary)

Koubaa, A., Hernández, R.E., Beaudoin, M. and Poliquin, J. 1998. Interclonal, intraclonal, and within-tree variation in fiber length of poplar hybrid clones. Wood Fiber Sci. *30(1): 40–47*.

Krahmer, R.L 1966. Variation of specific gravity in western hemlock trees. Tappi 49: 227–229.

Matyas, C. and Peszlen, I. 1997. Effect of age on selected wood quality traits of poplar clones. *Silvae Genetica* 46(2–3): 64–72.

Peltola, A. 2004 (ed.) Finnish Statistical Yearbook of Forestry. SVT Agriculture, forestry and fishery. Finnish For. Res. Inst. 416 p.

Pérez, O.P. 2002. Growth and wood properties of aspen (*Populus tremula*), quaking aspen (*Populus tremuloides*) and hybrid aspen (*Populus tremula x Populus tremuloides*) in Finland and suitability for industrial processing. Master's thesis, University of Helsinki, Department of Applied Biology. 28 p. + App.

Peters, J.J., Bender, D.A., Wolcott, M.P. and Johnson, J.D. 2002. Selected properties of hybrid poplar clear wood and composite panels. *For. Prod. J.* 52(5): 45–54.

Semen, E., Kuo, M., Su, Y.-C., Hall, R.B. and Stokke, D.D. 2001. Physical properties of kraft pulp from four-year-old aspen hybrids and crosses. *Wood Fiber Sci*. 33(1): 140–147.

Tikka, P.S. 1955. [Of the structure and quality of aspen stands. II Quality]. *Commun. Inst. For. Fenn*. 45(3): 1–54. (In Finnish)

Uusvaara, O. and Pekkala, O. 1979. [Wood and pulping technical properties of some domestic and foreign tree species]. Commun. Inst. For. Fenn. 96(2): 1–59.

Yanchuk, A.D., Dancik, B.P. and Micko, M.M. 1983. Intraclonal variation in wood density of trembling aspen in Alberta. *Wood Fiber Sci.* 15: 387–394.

Yu, Q., Tigerstedt, P.M.A. and Haapanen, M. 2001. Growth and phenology of hybrid aspen clones (*Populus tremula* L. x *Populus tremuloides* Michx.). Silva Fenn. 35(1): 15–25.

Zobel, B.J. and van Buijtenen, J.P. 1989. Wood variation – its causes and control. Springer Verlag, Berlin. 363 p.

Received 04 January 2006
Accepted 19 May 2006

ПЛОТНОСТЬ ДРЕВЕСИНЫ И СКОРОСТЬ РОСТА ОСИНЫ ОБЫКНОВЕННОЙ И ГИБРИДНОЙ ОСИНЫ (*POPULUS TREMULA, P. TREMULA X TREMULOIDES*) В ЮЖНОЙ ФИНЛЯНДИИ

Х. Херяйарви, Р. Йункконен

Резюме

В Финляндии древесина различных видов осины используется, главным образом, для производства бумаги. Для увеличения потенциала заготовок в южной Финляндии была посажена гибридная осина. В данном исследовании сравнивается рост зрелой осины обыкновенной (*Populus tremusla*) и гибридной осины (*Populus tremula x tremuloides*), а также распределение плотности древесины в стволах этих видов. Материалом исследования послужили 30 естественно выросших деревьев *P. tremula* и 45 посаженных *P. tremula x tremuloides* в южной Финляндии. Ширина годовых колец замерялась на высоте пня, на высоте 2 метров и на конце товарной части ствола (диаметр 5 см). Диски для измерения плотности сухой древесины были отмечены на высоте 0, 2, 4, 8 и 12 метров и выше с интервалами каждые четыре метра до конца товарной части ствола. Образцы для измерения плотности брались от сердцевины диска по направлению к поверхности. Всего было замерено 225 дисков для сбора данных о годовых кольцах и 5109 образцов для сбора данных о плотности. Результаты показали, что после начальной фазы в 5-10 лет *P. tremula* растет относительно равномерно по 5-8 мм в год в диаметре до достижения деревом возраста примерно 50 лет. После этого рост диаметра снижается. Темпы роста *P. tremula x tremuloides* составляют в среднем 10-14 мм в год в возрасте 10-20 лет. В возрасте 25 лет рост снижается уже до 5-6 мм в год. Распределение плотности внутри ствола более равномерно в гибридной осине. Средняя плотность сухого древесного материала *P. tremula* и *P. tremula x tremuloides* составила 376 и 363 кг/м^3 соответственно.

Ключевые слова: плотность сухой древесины, осина обыкновенная, темпы роста, гибридная осина, *Populus tremula*, *Populus tremula x tremuloides*