SILVA FENNICA VOL. 15, 1981, N:o 1: 18—22

ON THE PROPERTIES OF ONE-YEAR SHOOTS OF BETULA PUBESCENS EHRH. AND SALIX SPP.

K. M. BHAT, ARI FERM and MATTI KÄRKKÄINEN

SELOSTE:

HIESKOIVUN JA PAJUN YKSIVUOTISTEN VESOJEN OMINAISUUKSISTA

Saapunut toimitukselle 1981-02-11

The parent trees cut during dormancy produced shoots the properties of which were measured in the autumn after one growing season. The basic density of the unbarked shoots was 443 kg/m^3 for birch and 346 kg/m^3 for willow. In the butt portion the basic density of wood was 429 kg/m^3 for birch and 364 kg/m^3 for willow. The corresponding figures for bark were 534 kg/m^3 and 490 kg/m^3. The bark percentage of dry weight was over 30.

The basic density of the unbarked shoots varied relatively little with the length of shoots. In contrast, outside the pith region the proportion of fibres increased and that of vessels decreased with the increasing length of the shoots. The ray proportion varied relatively little but was high both in birch (24 %) and in willow (26 %) compared to mature trees.

1. INTRODUCTION

JAYME et al. (1943) were the first scientists to take an interest in the properties of one-year shoots of hardwood species in a very practical sense. Since this classical work, numerous authors have published their results, especially for fast growing species like poplars, sycamore etc. However, almost no data have been published on hardwood species of slower growth especially in a cold climate.

This paper presents observations on the physical and anatomical properties of one-year shoots of *Betula pubescens* Ehrh. and *Salix* spp.

The material was collected by Ari Ferm. The laboratory work was done by K. M. Bhat and Tarja Björklund. The latter also assisted in the computations made by Matti Kärkkäinen who wrote the original manuscript. The English text was revised by L. A. Keyworth and typed by Aune Rytkönen. Comments were made by Pentti Hakkila and Juhani Salmi.

2. MATERIAL

The birch (*B. pubescens* Ehrh.) parent trees were from 30 years old peatland stands which were situated near Kannus, western Finland. The trees were cut during the dormant season 1979—1980. The shoots which developed in summer 1980 were cut in October 1980, i.e. after one growing season. The number of birch shoot samples was 22.

The willow parent stand (mixtures of *Salix phylicifolia* L., *S. pentandra* L. and *S. caprea* L.) grew along the ditches in an abandoned field near Kannus. The parent trees were 10 years old. They were cut during the dormant season 1979—1980 and the developed one-year shoots in October 1980. The number of willow shoot samples was 24.

The length and green weight of each shoot was determined in the field. In the laboratory the basic density of the shoots with bark was determined by the water displacement method. The moisture content of the sprouts and their dry weight was determined.

A butt sample was taken from each shoot for the detailed studies. From these samples the bark percentage of dry weight and the basic densities of bark and wood were determined. The method in volume measurement by water displacement was first to measure the volume of the unbarked butt piece and then, after barking, the volume of wood only. The difference was the volume of bark. Thus the basic density of wood includes the effect of the pith region.

In the anatomical studies the diameter of the pith was measured. The proportion of tissues outside the pith region were determined by the point counting method (CURTIS 1960).

3. RESULTS

The means and standard deviations are presented in Table 1.

The average shoot growth of willow was nearly twice that of birch in the dry weight comparison. In volume, the difference was still larger as the basic density of birch was much higher than that of willow. The growth of willow per hectare was of the other magnitude than that of birch due to the greater stand density. However, the number of shoots per stump was much higher for birch (43) than for willow (19).

In both species the basic density of bark was distinctly higher than that of wood. The same rule applies to many other hardwood species (e.g. LÖNNBERG 1975, KÄRKKÄINEN 1976). However, as the basic density increases in many tree species from the pith to the surface, the absolute difference is smaller in larger trees.

The moisture content was higher in willow than in birch. This difference was attributable to the difference in basic density. In fact, in another sense birch was more moist than willow: the saturation degree was 68,8 % in birch, but only 55,7 % in willow. These values are relatively low when the leafless season (October) is taken into account.

The bark percentage was 22 . . . 35 even in the butt portion of the shoots. This shows that the average bark percentage of the shoots was still higher, possibly of the magnitude of 40 %. Thus, the bark percentage of the one-year shoots is about threefold compared with mature stems.

The proportion of fibres, 50 . . . 51 %, was quite low compared with mature wood, while the proportion of vessels was extremely high. These results are in agreement with the finding that the fibre percentage increases and vessel percentage decreases from the pith to the surface (BHAT and KÄRKKÄINEN 1981).

The diameter of the pith was quite large, especially in willow. This parenchymatous tissue was 7,5 % of the butt cross section in birch and 13,5 % in willow. Thus its effect on the shoot properties is not negligible in pulping and other uses where tissue type is important.

Many of the properties varied a great deal with the size of the shoots. Of course, the

Table 1. Means and standard deviations of the samples (n=22 for birch and 24 for willow).
Taulukko 1. Näytteiden keskiarvot ja standardipoikkeamat (koivunäytteitä 22 ja pajunäytteitä 24).

Variable *Muuttuja*	Birch *Hieskoivu*		Willow *Paju*	
	x̄	s	x̄	s
Length of shoot, mm *Vesan pituus, mm*	646	379	1182	724
Dry weight of shoot, g *Vesan kuiva massa, g*	10,2	13,4	19,9	24,3
Moisture content of dry weight, per cent *Kosteussuhde, %*	110,6	34,3	124,9	44,4
Basic density of shoot incl. bark, kg/m³ *Kuorellisen vesan kuivatuoretiheys, kg/m³*	443	33,9	346	93,0
Basic density of wood at butt portion of shoot, kg/m³ *Puun kuiva-tuoretiheys vesan tyviosassa, kg/m³*	429	36,5	364	64,6
Basic density of bark at butt portion of shoot, kg/m³ *Kuoren kuiva-tuoretiheys vesan tyviosassa, kg/m³*	534	47,8	490	64,9
Bark percentage of dry weight *Kuoren osuus kuivasta massasta, %*	35,4	5,4	33,1	9,0
Fibres, % – *Kuituja, %*	50,9	8,8	49,3	7,4
Vessels, % – *Putkiloita, %*	24,9	8,7	24,3	7,5
Rays, % – *Ydinsäteitä, %*	24,2	3,4	26,4	3,4
Pith diameter, μm *Ytimen läpimitta, μm*	1779	542	2901	1498

green and dry weight increased very distinctly with the length of the shoots. Besides this self-evident relationship there were some others, too. The moisture content decreased with the length of the shoot. In birch the correlation coefficient was – 0,383 and in willow – 0,283. One reason may be the effect of the pith. It is true that the diameter of the pith increased with the shoot length (r = 0,474 in birch, 0,797 in willow), but the proportion of pith in the cross-sectional area decreased in birch (r = – 0,389) and did not change in willow (r = – 0,096). Thus the decreasing moisture content can reflect the decreasing proportion of light pith tissue. Of course, there can be other factors behind the phenomenon, too.

The basic density of the unbarked shoots did not change very much with the length of the shoots (r = 0,100 in birch, 0,044 in willow). The basic density of the butt wood was quite constant in birch, but decreased a little in willow. The correlation with shoot length was – 0,072 in birch and – 0,296 in willow.

An interesting feature was that in birch the basic density of the bark increased with the length of the shoot (r = 0,571). As the density of wood decreased a little at the same time, the difference between the basic densities of the bark and wood increased distinctly with the length of the shoot (r = 0,524). A similar weak trend was noted in willow (r = 0,115).

The bark percentage decreased very definitely with the size of the shoots. The correlation coefficient was – 0,602 in birch and – 0,856 in willow.

The proportion of fibres increased and that of the vessels decreased with increasing shoot length. The proportion of rays remained about the same in birch, but increased in willow. The following correlation coefficients were computed from the material.

	Correlation coefficient Birch	Correlation coefficient Willow
Shoot length x fibre percentage	0,554	0,395
" vessel "	–0,530	–0,633
" ray "	–0,076	0,259

As the pith diameter and the shoot length were positively correlated, the proportion of fibres increased and that of vessels decreased with growing pith diameter. The ray percentage was quite constant whatever the diameter of the pith.

4. DISCUSSION

The high bark percentage and even the proportion of parenchymatous pith tissue make one-year shoots of birch and willow less interesting for the pulp industry. However, their relatively high basic density (due to the effect of bark) give them a potential use as a fuel. But even for burning the high bark content is not desirable due to the higher nutrient content of bark compared with wood. The high proportion of rays with living cells rich in nutrients must have a similar effect. Thus, even as a fuel one-year shoots are not to be preferred to more mature trees. This idea is supported by the high ash contents found in one-year shoots of willow (SOLANTAUSTA and ASPLUND 1979).

An interesting feature is that the size of the shoots had no adverse effect on the utilisation possibilities. The change in basic density is negligible in practice. On the contrary, the bark percentage decreases, and even the small decrease in the moisture content is an advantage. As the proportion of fibres increases and that of vessels decreases, the pulping possibilities are better with the larger shoots.

The increase in the pith diameter with the length of the shoots is not meaningful in practice as the proportion of the pith decreases or remains constant at the same time. As a consequence, if it is possible to choose between a large number of shoots and a smaller number of greater size, the latter would be preferable.

The results obtained in this study are highly preliminary due to the limited material. However, even these observations add substantially to the available knowledge as the earlier Finnish results are based on still more limited materials. As an example, the averages given by SOLANTAUSTA and ASPLUND (1979) are based on 7 shoots of willow and 2 shoots of *Betula pendula* Roth.

REFERENCES

BHAT, K. M. & KÄRKKÄINEN, M. 1981. Variation in structure and selected properties of Finnish birch wood: III Proportion of wood elements in stems and branches in *Betula pendula Roth.* Seloste: Suomalaisen koivupuun rakenteen ja eräiden ominaisuuksien vaihtelu III. Rauduskoivun rungon ja oksien solulajien runsaussuhteet. Silva Fenn. 15 (1): 10–17.

CURTIS, A. S. G. 1960. Area and volume measurements by random sampling methods. Medical Biol. Illustr. 10: 261–266.

JAYME, G., HINDENBUR, K. -G., HARDERS-STEINHÄUSER, M. & BRANSCHEID, F. 1943. Über die Eignung ein- und zehnjährigen Pappelholzes zur Zellestoffgewinnung. Holz Roh- u. Werkstoff 6 (1): 1–16.

KÄRKKÄINEN, M. 1976. Kokopuuhakkeen tiheyden mittaaminen. Summary: Measurement of basic density of total tree chips. Silva Fenn. 10 (3): 198–211.

LÖNNBERG, B. 1975. Short-rotation hardwood species as whole-tree raw material for pulp and paper. 2. Wood raw material. Paperi ja Puu 57 (8): 507–516.

SOLANTAUSTA, Y. & ASPLUND, D. 1979. Puun käyttö polttoaineena. II Polttoaineominaisuudet. VTT, Poltto- ja voiteluainelaboratorio, tiedonanto 25: 1–45.

SELOSTE:

HIESKOIVUN JA PAJUN YKSIVUOTISTEN VESOJEN OMINAISUUKSISTA

Talvella 1979 . . . 1980 kaadettiin hieskoivun ja eri pajulajien (*Salix phylicifolia, S. pentandra* ja *S. caprea*) emopuut, joiden kannoista syntyneitä yksivuotisia vesoja kerättiin aineistoksi syksyllä 1980. Koivuvesoja tutkittiin 22 ja pajuvesoja 24.

Kuorellisten koivuvesojen kuiva-tuoretiheys oli keskimäärin 443 kg/m³. Pajuilla vastaava tiheys oli 346 kg/m³. Vesan tyviosasta tutkitussa näytteessä ytimen sisältävän puuaineen tiheys oli koivulla 429 kg/m³ ja pajulla 364 kg/m³. Vastaavat kuoren tiheydet olivat olennaisesti korkeammat, 534 kg/m³ ja 490 kg/m³.

Vesojen kuoriprosentti kuivasta massasta oli huomattavasti yli 30. Ytimen osuus pinta-alasta oli koivuvesan tyvessä 7,5 % ja pajuvesan 13,5 %. Näin ollen hohkaisen ytimen ominaisuudet vaikuttavat mm. keskimääräiseen tiheyteen.

Vesan pituus vaikutti vain vähän kuorellisen vesan kuiva-tuoretiheyteen. Sitä vastoin ytimen ulkopuolella kuitujen osuus lisääntyi selvästi ja putkiloiden osuus laski vesan suuretessa. Ydinsäteiden osuus ei juuri vaihdellut, mutta se oli korkea sekä koivulla (24 %) että pajulla (26 %). Arvot ovat kaksinkertaisia varttuneeseen puuhun verrattuna.