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Original article

Wood quality of Douglas fir (*Pseudotsuga menziesii* (Mirb) Franco) from three stands in the Netherlands*

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Summary – The wood quality of Douglas fir (*Pseudotsuga menziesii* (Mirb) Franco) grown in the Netherlands was studied. A total of 19 trees from three different stands was selected for this purpose. The relevant data for this research were tree age, diameter at breast height, height, branchiness, ring width and physical-mechanical properties of the sawn timber. Strength properties and density were compared with the data of other European timber species. The bending strength and density of the Dutch-grown Douglas fir gave higher values, compared with Norway spruce from central Europe. Visual quality grading of the sawn wood according to Dutch standards (NEN 5468, 1988), resulted in 60% construction timber and 40% lower grades. Considering that grading was done for the upper parts of the stem, the result can be seen as promising for the forest management and marketing of Douglas fir in the Netherlands.

Douglas fir / wood quality / the Netherlands / construction timber / grading

Résumé – La qualité du bois de douglas (*Pseudotsuga menziesii* (Mirb) Franco) dans trois peuplements des Pays-Bas. *La qualité du bois de douglas (*Pseudotsuga menziesii *(Mirb) Franco) ayant crû aux Pays-Bas a été étudiée. Un total de 19 arbres a été sélectionné dans trois parcelles. Les données recueillies pour cette étude étaient l'âge de l'arbre, son diamètre à 1,30 m, sa hauteur, son taux de ramification, sa largeur de cerne et les caractéristiques physiques et mécaniques du bois scié. Les propriétés technologiques et la masse volumique des pièces ont été comparées à celles d'autres bois d'Europe. La résistance en flexion et la masse volumique du bois de douglas des Pays-Bas sont apparues plus élevées que celles de l'épicéa commun d'Europe centrale. Le classement visuel des bois sciés d'après les normes hollandaises (Nen 5468, 1988) a conduit à classer 60 % des pièces en bois de construction et à exclure 40 % des pièces pour cet usage. Considérant que l'examen a été effectué sur des pièces provenant des parties supérieures du tronc, ces résultats sont prometteurs pour la gestion des forêts de douglas et la commercialisation de son bois aux Pays-Bas.*

douglas / qualité du bois / Pays-Bas /* construction timber */ grading

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INTRODUCTION

In the mid-19th century, Douglas fir (*Pseudotsuga menziesii* (Mirb) Franco) was introduced into western Europe. After tests in 1857, Douglas fir was planted on a larger scale in the Netherlands in 1880. The quality of the timber, however, differed considerably from the same species imported from North America under the name Oregon pine. Various European countries began to study the technical properties of the homegrown Douglas fir. In the Netherlands, the physical-mehanical properties were studied by Wisse (1968).

As part of the EC project "Growth, Yield and Quality of Douglas fir" the wood quality of the material, particularly with regard to its use as construction timber, was studied. The timber quality of trees from three different but comparable sites in the Netherlands was compared and evaluated according to the Dutch standard NEN 5468 for sawn timber (1988). Recommendations for Douglas fir forestry management are subsequently being prepared.

The present study focuses on branchiness, the tree ring width and physical-mechanical properties of the timber of trees from three stands.

MATERIALS AND METHODS

The test material (19 trees) was taken from three stands, Speulder and Sprielder (three trees), Schovenhorst (11 trees) and 't Loo (five trees) in the Veluwe area in central Netherlands. The stands were comparable with regard to soil type and climatic conditions. Due to other scientific research, only three trees were available from the stand in Speulder and Sprielder and five from the stand in 't Loo.

Before felling the test trees, increment cores were taken and the diameter at breast height, tree height, crown width and crown projection and distances to neighbouring trees were measured. After felling, measurements were made of stem diameter, the branches (diameter and location on stem), stem length (total and up to a diameter of 20 cm) and crown length (see table I). The diameter of the branches was measured lengthways in accordance with how knots are evaluated according to the Dutch standard NEN 5468 for sawn timber (1988). The stems were then cut into logs.

The material for the physical-mechanical tests was sawn from the first 2 m of the log from the lower part of all the trees sampled. After sawing, the samples were conditioned in a climate room and machined to standard dimensions. The total number and size of samples are given in table II. Bending strength and compression strength were tested following ASTM standards (1964) and using an Amsler test bench. As the moisture content of the timber varied between 14 and 16%, data were corrected for a moisture content of 15%. The density of all samples was determined (see also table III).

The 'Dorschkamp' equipment (Beek and Maessen, 1981) was used to measure increment cores. In this way, average ring width, proportion and width of latewood of all the trees sampled could be determined (Polman and Creemers,1990; see fig 1).

Logs from the upper parts of the stem were sawn into different width dimensions of construction timber and graded according to the ring width and knots criteria set out in the Dutch grading standard NEN 5468 for sawn timber (1988). The standard for these two parameters for different quality classes is given in table IV. In the Netherlands the minimum log diameter for sawn wood is limited to 20 cm.

RESULTS

Branchiness

The branchiness of the trees was examined with regard to height on the stem and its effect on the quality of sawn wood.

The relationship between branch diameters and location and their effect on the quality of sawn wood were studied using frequency diagrams. These diagrams show the average number of branches over height position and over five different diameter classes per stand (see figs 2, 3 and 4).

Table I. Overview of the measured and calculated data in accordance with the length and branches.

Stand	*Tree number*	*Total length (m)*	*Living crown starting at m (m)*	*Length to dia 20 cm (m)*	*Diameter at breast height (cm)*	*Σ dia² branches (cm²)*	*Σ dia² 8 m to dia 20 cm branches (cm²)*
Speulder and Sprielder	98	29.6	16.40	21.14	43.0	–	1 297.0
	153	28.5	16.00	18.20	41.0	–	806.0
	185	29.4	9.00	19.80	40.0	–	1 098.0
Schovenhorst	400	32.0	17.50	23.60	48.0	2005.0	1 852.0
	401	–	–	–	–	–	–
	402	30.5	17.00	19.80	38.0	1 168.0	963.5
	403	27.5	17.40	22.00	43.0	2 099.0	1 489.5
	404	30.0	15.50	20.10	40.0	1 575.0	1 307.0
	405	29.3	21.00	19.10	36.0	668.0	590.0
	406	30.6	20.55	20.30	32.5	1 190.4	984.9
	407	27.2	16.50	18.30	30.5	930.5	700.5
	408	27.1	18.50	16.70	31.5	466.6	375.0
	409	29.7	19.10	19.20	37.0	743.0	592.2
	410	27.5	14.50	18.00	36.5	1 280.5	977.0
't Loo	411	31.30	21.60	21.00	45.5	1 748.5	1 573.0
	412	32.76	17.75	22.47	47.5	1 019.7	1 384.5
	413	29.44	13.90	19.16	40.0	1 137.0	1 005.5
	414	28.5	17.00	19.70	45.5	1 489.5	1 275.5
	415	30.88	16.30	21.20	48.5	1 660.7	1 540.0

Ring width

The ring width of the trees were also studied as a control aspect when grading the sawn wood. Average ring width and the proportion and width of the latewood measured at the increment cores for each of the three stands are shown in figure 1.

Physical-mechanical properties

A comparative study on the physical-mechanical properties of European Douglas fir by Buiten (1986) showed considerable variations between the different properties, related to differences in provenances, site conditions, age of the trees and their place within the stand. The average values of some physical-mechanical properties for Douglas fir are given in table V, together with values for Scots pine and Norway spruce (Heilig, 1989).

An overview of the results of this research into the densities and some mechanical properties is given in table III.

The physical-mechanical tests with the home-grown Douglas fir resulted in a

Table II. Total number and size of samples.

Mechanical test	*No of samples*	*Size*
Bending	153	800 x 50 x 50 mm
Compression	142	150 x 50 x 50 mm
Impact bending	301	300 x 20 x 20 mm

Table III. Some physical-mechanical data of the test samples from Schovenhorst (Sch), Speulder and Sprielder (SP4) and 't Loo at moisture content 15%.

Stand	*Tree no*	*Bending*			*Compression*	
		Density (kg/m^3)	*Modulus of elasticity* (N/mm^2)	*Modulus of rupture* (N/mm^2)	*Density* (kg/m^3)	*Strenght* (N/mm^2)
SP4	98	581	12 500	80	597	42
	153	525	8 000	63	537	42
	185	597	11 700	90	617	48
Sch	400	561	11 700	81	570	41
	401	570	12 800	75	574	46
	402	560	12 300	85	566	45
	403	489	7 900	58	477	34
	404	566	12 300	81	561	43
	405	587	11 000	83	596	46
	406	599	11 500	82	661	49
	407	594	12 300	93	621	49
	408	590	11 700	88	591	46
	409	601	12 100	78	601	48
	410	603	12 900	94	614	51
't Loo	411	583	12 300	79	579	42
	412	559	11 000	73	530	41
	413	689	13 900	82	575	41
	414	528	12 500	73	525	43
	415	538	11 900	75	528	42

Table IV. Ring width and knots criteria of the Dutch standard NEN 5468.

	Defects	*Quality grade*			
		A	*B*	*C*	*D*
Growth rings	Average width of the growth rings (mm)	5	10		Not required
Knots	Sound knots	Admissible			
	Unsound knots	Not admissible	Admissible		
	Max number	Not required			
Max knot diameter	Timber width (mm)				
	< 40	20	30	45	Not required
	41–145	25	35	50	Not required
	> 145	30	50	75	Not required

Table V. Physical-mechanical properties of Douglas fir, Norway spruce and Scots pine at different moisture contents.

References	*Timber species*	*Density (MC)* (*kg/m³*)	*Bending strength (MOR) (N/mm²)*	*Compression strength (N/mm²)*
This study	Douglas	570 (15%)	82	44
Wisse (1968)	Douglas	580 (15%)	79	39
Knigge (1958)	Douglas	470 (0%)	90	37
Göhre (1958)	Douglas	540 (12%)	97	52
von Pechmann and Courtois (1970)	Douglas	610 (0%)	130	66
Neusser et al (1977)	Douglas	570 (12%)	117	55
Heilig (1989)	Spruce (northem Europe)	460 (12%)	77	49
Heilig (1989)	Spruce (central Europe)	384 (12%)	69	36
Heilig (1989)	Pine (northem Europe)	500 (12%)	70	47

somewhat lower bending and compression strength (see table V; Wisse, 1968 and our own research) at a comparable density of the material used by other researchers (Göhre, 1958; Knigge, 1958; Pechmann and Courtois, 1970; Neusser et al, 1977).

Visual grading

The sawn timber was graded visually according to the Dutch standard NEN 5468 (1988). Approximately 10% of the timber was ranked as quality class B (good quality),

Table VI. General site and test tree specific data.

Location	*Stand number*	*Soil type*	*Age (year)*	*Rainfall*		*No of trees*	*No of cores*	*Height of the test trees (m)*	*Diameter at breast height (cm)*
				Max (mm/year)	*Min (mm/year)*				
Speuler and Sprielder	117g	Brown forest soil	58	700–850	330–400	3	6	28.5–29.6	41–44
Schovenhorst	6j	Brown forest soil	65	700–850	330–400	11	22	27.0–34.5	31–48
't Loo	5f	Brown forest soil	55	700–850	330–400	5	10	28.5–32.8	40–48

50% as class C (medium quality) and 40% as class D (low quality) and below standard.

DISCUSSION

Material from trees from three comparable stands (see table VI) were tested for strength properties and correlated with timber density (*r* value = 0.84), which are important properties in constructional use. The results of Wisse (1968) and this study resulted in comparable values concerning strength properties and densities of the timber. Wisse used timber from 25 trees in six different areas in the Netherlands. The quite good comparability in strength and density can be explained by the fact that in both studies material from comparable

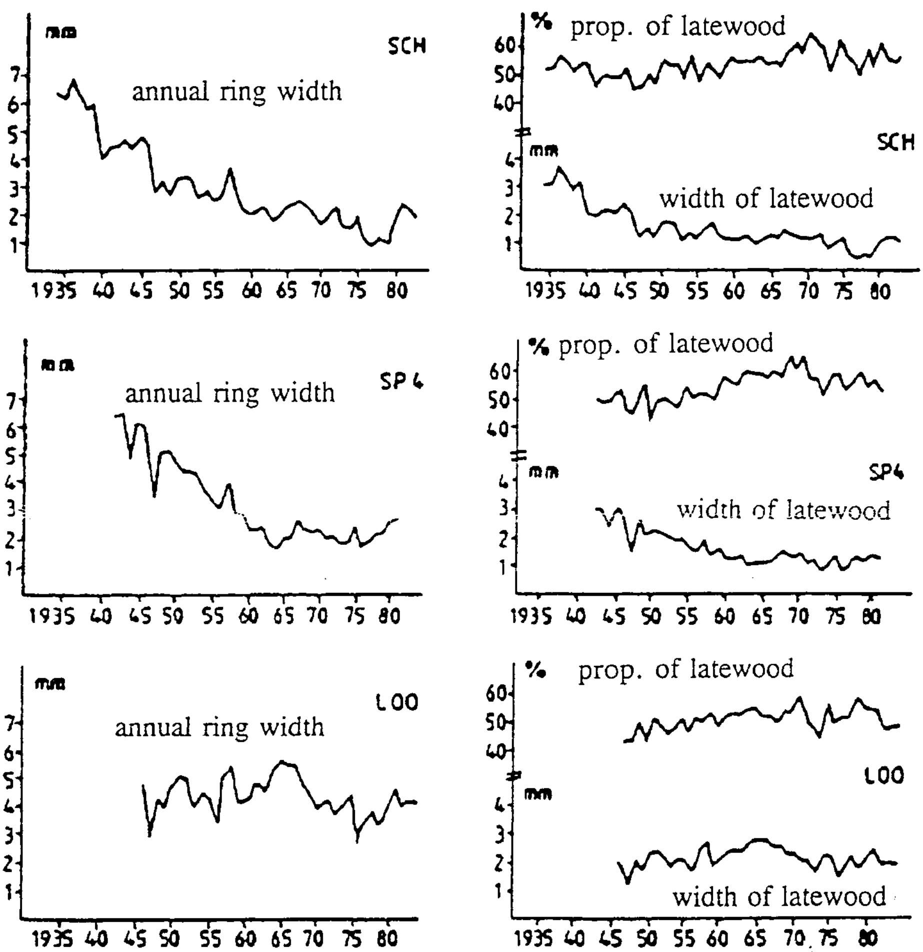

Fig 1. Average annual ring width, proportion of latewood and width of latewood in Douglas fir stands at Schovenhorst (SCH), Speulder and Sprielder (SP4) and 't Loo (LOO).

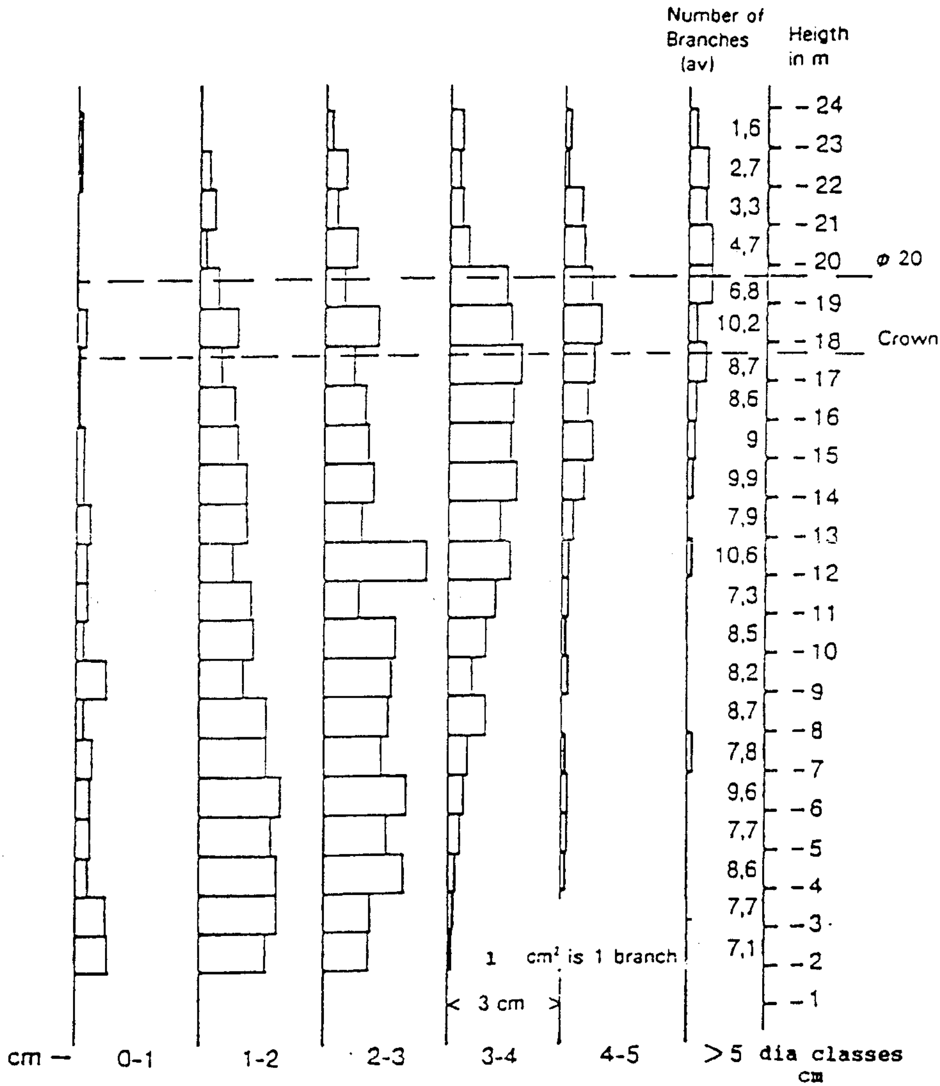

Fig 2. Frequency diagram of the average number of branches over height position for five different diameter classes for the Schovenhorst stand.

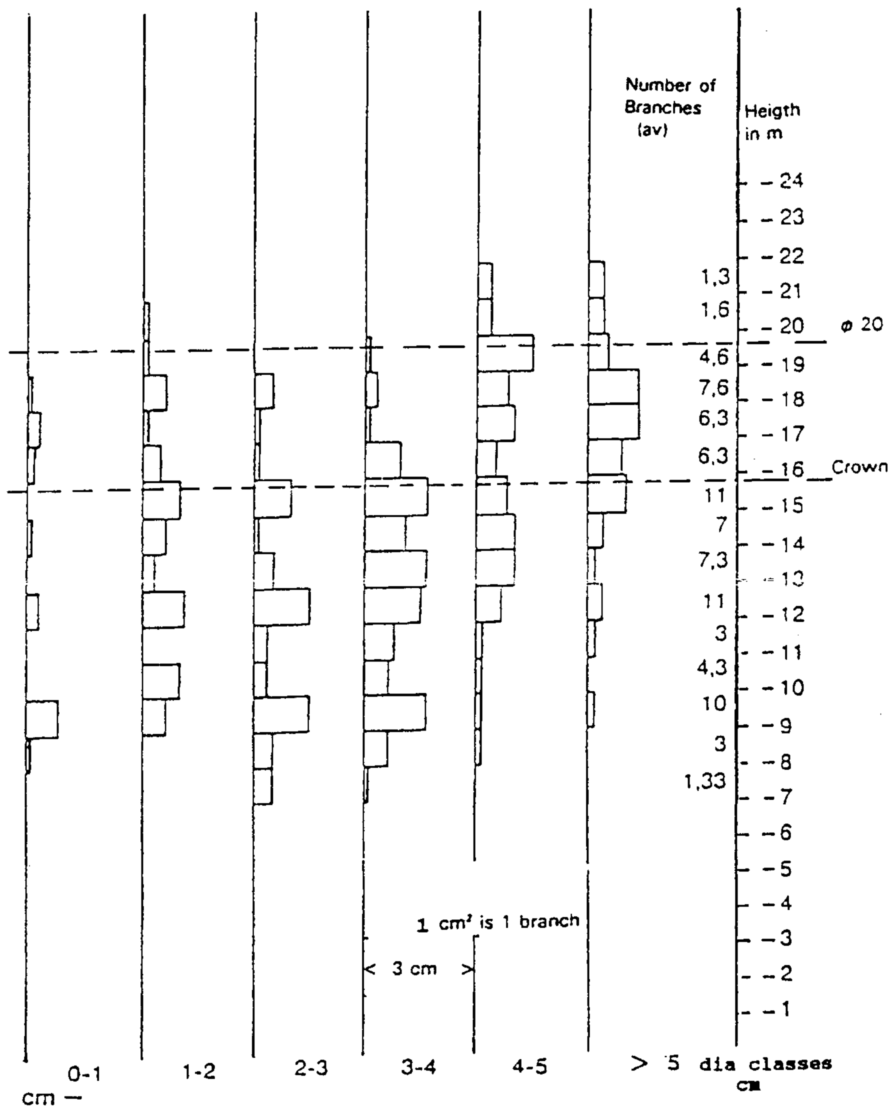

Fig 3. Frequency diagram of the average number of branches over height position for five different diameter classes for the Speulder and Sprielder stand.

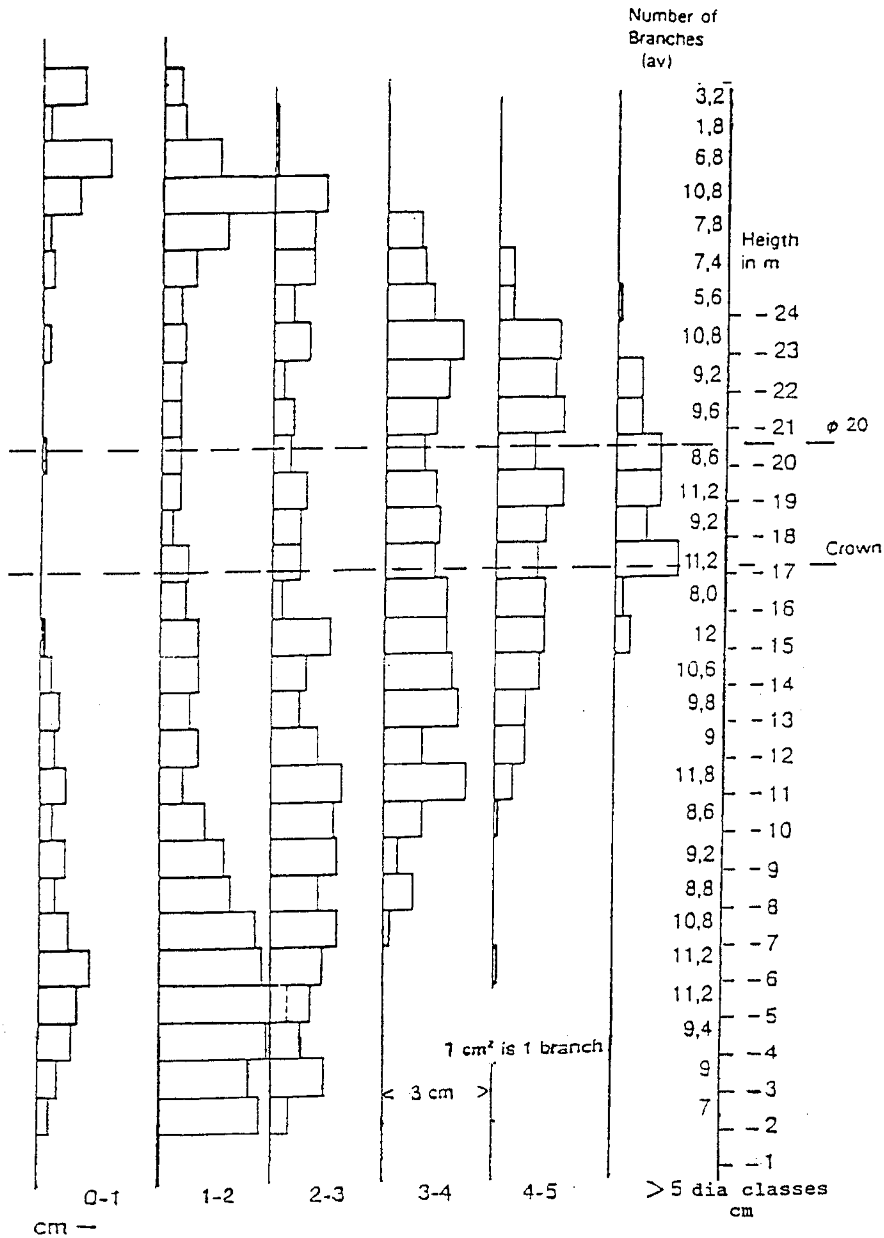

Fig 4. Frequency diagram of the average number of branches over height position for five different diameter classes for the 't Loo stand.

soils and with the same average ring width in the Netherlands was used.

The differences in properties between the other published values (table III) might be explained by differences in provenances, site conditions and situation in the stand.

The Dutch Douglas fir has a higher bending strength and similar compression strength to Norway spruce and Scots pine from central and northern Europe. It can also be confirmed that Douglas fir has a higher wood density.

A possible disadvantage of home-grown Douglas fir seems to be the presence of reaction tissue which can lead to undesirable and unpredictable deformation in the latter use of the timber (Buiten, 1986); this was not measured in our study. Löffer (1966) reported reduced qualities of the Douglas fir at ring widths greater than 6–7 mm.

The average ring width measured from cores at breast height ranged from 2.2 to 4.9 mm and therefore met the criteria for the quality class A of the Dutch standard NEN 5468 (see table IV).

Differences in frequencies of the branch diameters between the stands (see figs 2–4) can be explained mainly by the number of plants at the time of stand establishment and thinning regime.

In one stand (Spreulder and Sprielder) the trees were pruned to about 8 m. Most branch diameters of the logs from the lower parts of the stems were less than 5 mm. Because there is a close relationship between branch diameter and knot diameters in the sawn timber, it can be concluded that good timber qualities (classes A and B, NEN 5468; 1988) can be expected from the lower parts of the stem. Based on wider ring width and thicker branches (see also figs 2–4) lower qualities (class B, C, D) are to be expected from higher parts of the stem.

The grading of logs according to the Dutch standard NEN 5468 (1988) resulted in 60% constructional timber (classes B and C) and 40% lower qualities (class D and lower). Taking into account that grading was done for the lower valued upper part of the stem, the result can be seen as promising for the forest management and marketing of Douglas fir in the Netherlands.

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