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https://doi.org/10.15017/14813

出版情報：九州大学農学部演習林報告. 52, pp.115-120, 1982-03-31. 九州大学農学部附属演習林
バージョン：
権利関係：

Specific gravity, tracheid length, and microfibril angle of sugi (*Cryptomeria japonica* D. Don): seed-grown trees compared with grafts

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INTRODUCTION

It is common in some parts of Kyushu, the southernmost major island of Japan, to establish plantations of sugi (*Cryptomeria japonica* D. Don) with seedlings or cuttings: cuttings are commonly used in Southern Kyushu, and seedlings in Northern Kyushu. On the other hand, using grafts of sugi for plantation forestry is not so usual because of the high cost of grafting, but there are a few plantations of grafts in Northern Kyushu.

It is occasionally said that both seedlings and grafts of sugi have better form and volume growth than cuttings while the full details on the subject have not yet been obtained. Moreover, it is considered that vegetative reproduction results in both greater uniformity and predictability of many important characteristics within each clone while sexual reproduction results in a high degree of variability.

Although many papers on the wood properties of sugi have been reported by a number of Japanese researchers, there are still problem areas: there is not enough basic research to clarify the effects of silvicultural treatment, climatic and edaphic factors, and reforestation techniques on the properties of wood from improved and intensively managed sugi-trees.

Nicholls and Brown[1] showed the ortet-ramet relationship in wood characteristics of *Pinus radiata*. Sweet and Harris[2] compared wood properties of seed-grown trees with those of grafts from different-aged ortets. The study described in this report was undertaken to examine wood density, tracheid length, and microfibril angle of sugi-wood samples from a plantation in Northern Kyushu to compare the growth and wood properties of graftts and seedlings because there are few infomations on the subject.

MATERIALS

Since the objectives of the study were to compare a few wood properties of seedlings and grafts, sample trees were collected from a private forest

Table 1. Details of sample trees and symbols used

Tree No.	Tree height (m)	Diameter at 2 metres above ground (cm)
S A 1H	10.26	14.5
S A 2H	9.08	11.5
S A 3H	9.14	9.5
S A 4L	6.87	8.0
G A 5H	8.20	11.0
G A 6H	9.99	13.5
G A 7H	9.40	11.0
G A 8L	7.23	9.0
S B 11H	9.75	12.0
S B 12L	5.40	5.7
G B 13H	9.62	11.5
G B 14L	5.83	7.5
C B 15H	9.65	12.0
C B 16H	7.77	9.5

S : tree from seedlings G : tree from grafts
C : tree from cuttings H : high site quality in a site
L : low site quality in a site A : 11-year-old tree from A-site
B : 12-year-old tree from B-site

situated on volcanic ash soil in Northern Kyushu. Fourteen sample trees were collected at each of two plantations and details of sample trees are listed in Table 1.

RESULTS AND DISCUSSION

Discs at 2 metres above the ground were taken from each of the sample trees. The data for specific gravity, tracheid length, and microfibril angle were from the latewood in a given growth ring.

The linear regressions ($Y=a+bX$) were calculated and tested statistically. Where Y is the dependent variable (specific gravity, tracheid length, and microfibril angle) and X is the independent variable (growth ring number from pith). Statistical results are summarised in Tables 2, 3, and 4.

1) Height growth and diameter increment

There were no significant differences between tree height and diameter at 2 metres height for trees from seedlings, grafts, and cuttings as shown in Fig. 1. The effects of site quality on tree are apparent.

2) Specific gravity

It is said that wood density and tracheid length increase outwards from the tree centre, rapidly at first and then tending to level off at some distance from the pith.

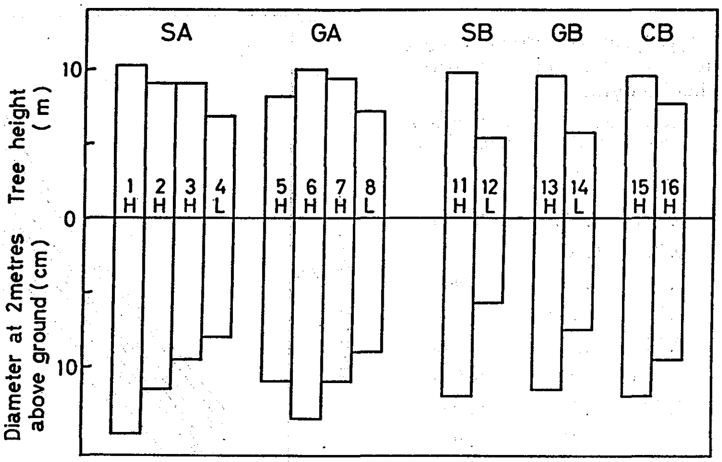

Fig. 1. Height growth and diameter increment.

Table 2. Regressions of growth ring number from pith on specific gravity.

Tree No.	Regression constants* a	b	Correlation coefficient r
SA 1H	0.460	−0.0200	—
GA 5H	0.585	−0.0151	−0.917
GA 6H	0.413	−0.0150	−0.982
GA 8L	0.447	−0.0133	—
SB 11H	0.495	−0.0325	—
GB 13H	0.410	−0.0200	—
GB 14L	0.488	−0.0140	—
CB 15H	0.645	−0.0254	—

* Regression constants are for the equation, $Y=a+bX$.
X: Growth ring number from pith
Y: Specific gravity

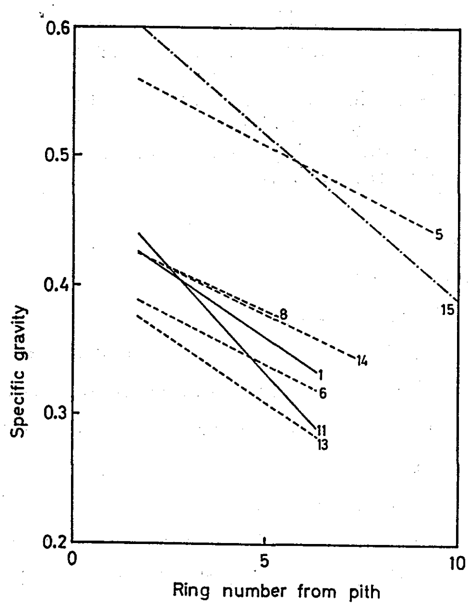

Fig. 2. Relationship between specific gravity and growth ring number from pith.
——: seedling ---: graft -·-: cutting
Numbers by curves give sample tree No. listed in Table 1.

In Fig. 2 the specific gravity values generally decrease outwards from the pith, but the regrression coefficients for seedlings and a cutting are slightly greater than those for grafts. The same radial density trends in New Zealand-grown westen red cedar (*Thuja plicata*) tree samples were reported by Cown and Bigwood[3]. Wellwood and Jurazs[4] also showed that density of western red cedar decreased outwards from the pith at all stem levels and that consequently

Table 3. Regressions of growth ring number from pith on tracheid length.

Tree No.	Regression constants* a	Regression constants* b	Correlation coefficient r
SA 1H	0.911	0.172	0.998
SA 2H	0.772	0.218	0.920
SA 4L	1.094	0.117	0.922
GA 5H	0.730	0.179	0.980
GA 6H	0.710	0.170	0.990
GA 7H	0.756	0.249	0.989
GA 8L	1.098	0.188	0.991
SB 11H	1.178	0.177	0.955
SB 12L	0.929	0.158	0.873
GB 13H	0.928	0.192	0.998
GB 14L	1.115	0.148	0.997
CB 15H	1.126	0.151	0.984

* Regression constants are for the equation, $Y=a+bX$.
X: Growth ring number from pith
Y: Tracheid length

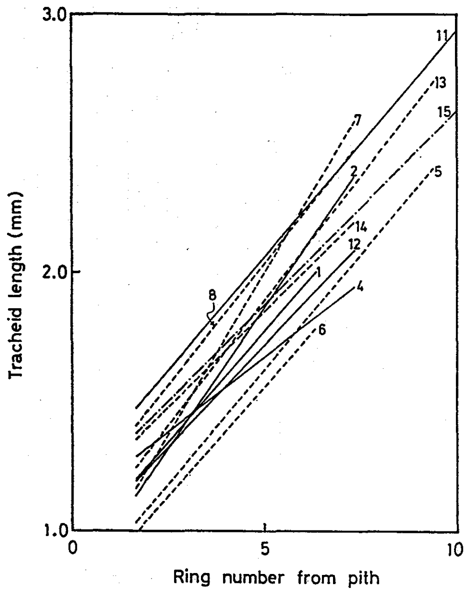

Fig. 3. Relationship between tracheid length and growth ring number from pith.
——: seedling - - -: graft –•–: cutting
Numbers by curves give sample tree No. listed in Table 1.

there was an increase in mean density with height in the tree.

3) Tracheid length

Table 3 shows very high correlation coefficients between tracheid length and the growth ring number from pith. As may be seen from Fig. 3, there are no marked effects between plant types (seedlings or grafts) on the tracheid length.

4) Microfibril angle

The strong relationship between microfibril angle and the physical and mechanical properties[5)6)] of solid wood have been discussed and the microfibril angle[7)] has been regarded as one of the useful single index of intrinsic wood quality of sugi.

The relationship between the microfibril angle and the ring number from pith is shown in Table 4, and most of the correlation coefficient values are statistically significant. Microfibril angle values decrease outwards from the pith as shown in Fig. 4, and regression coefficient values for seedlings except SB 11H tree are smaller than those for grafts.

Table 4. Regressions of growth ring number from pith on microfibril angle.

Tree No.	Regression constants* a	b	Correlation coefficient r
SA 1H	41.6	−1.20	−0.587
SA 2H	32.1	−1.20	—
SA 4L	38.4	−1.41	−0.946
GA 5H	47.0	−2.75	−0.987
GA 6H	42.9	−2.09	−0.966
GA 8L	40.7	−2.81	−0.996
SB 11H	39.3	−2.68	−0.974
SB 12L	30.5	−0.96	−0.857
GB 13H	41.2	−3.19	−0.965
GB 14L	37.4	−2.44	−0.987
CB 15H	35.3	−2.19	−0.879
CB 16H	39.5	−2.95	−0.878

* Regression constants are for the equation, $Y=a+bX$.
X: Growth ring number from pith
Y: Microfibril angle

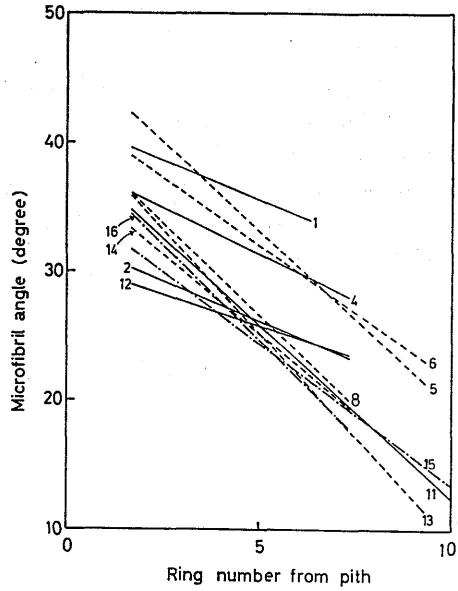

Fig. 4. Relationship between microfibril angle and growth ring number from pitn.
——: seedling ---: graft -·-: cutting
Numbers by curves give sample tree No. listed in Table 1.

CONCLUSION

Differences between plant types (seedlings and grafts) were not statistically significant for specific gravity or tracheid length. On the other hand, the difference between seedlings and grafts for microfibril angle were remarkable.

In conclusion it may be said that there are only small differences in spcific gravity and tracheid length of sample trees, but larger difference for microfibril angle.

Further experiments will be carried out.

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