

PROVENANCE VARIATION OF STEM VOLUME AND WOOD DENSITY OF *PINUS CARIBAEA* VAR. *HONDURENSIS* GROWING AT TWO LOCATIONS IN QUEENSLAND, AUSTRALIA

J.A. Wright,

Smurfit Carton de Colombia, AA 6574, Cali, Colombia

G.L. Gibson* & R.D. Barnes

Oxford Forestry Institute, South Parks Road, Oxford OX1 3RB, England, United Kingdom

Received October 1992

WRIGHT, J.A., GIBSON, G.L. & BARNES, R.D. 1994. Provenance variation of stem volume and wood density of *Pinus caribaea* var. *hondurensis* growing at two locations in Queensland, Australia. Provenance trials of *Pinus caribaea* var. *hondurensis* of the international series coordinated by the Oxford Forestry Institute, University of Oxford, were established at ten sites in Queensland, Australia. Assessments at two of the trials, Beerburrum and Byfield, established in 1973, were carried out in 1979 to determine volume under bark (VUB) and wood density (DEN). These two traits and the derived indices of within sample density variation (VAR) and dry matter index (DMI) were analyzed. Statistically, there were significant differences ($p < 0.05$) for VAR, VUB and DMI at Beerburrum as well as for VAR at Byfield. The thirteen provenances common to both locations produced 23% more VUB at Beerburrum. The provenances Guanaja and Santa Clara were ranked above the trial means for VUB and DMI while Rio Coco was ranked below the trial means for the two traits. The Queensland selections included in the trials were superior for VUB production relative to the majority of the introduced provenances.

Key words: *Pinus caribaea* var. *hondurensis* - volume production - wood density - Queensland, Australia

WRIGHT, J.A., GIBSON, G.L. & BARNES, R.D. 1994. Variasi provenans isipadu batang dan ketumpatan kayu bagi *Pinus caribaea* var. *hondurensis* yang ditanam pada dua lokasi di Queensland, Australia. Provenans *Pinus caribaea* var. *hondurensis* dari siri antarabangsa yang diselaraskan oleh Oxford Forestry Institute, University of Oxford, telah ditubuhkan di sepuluh tapak di Queensland, Australia. Penilaian di kedua tapak iaitu di Beerburrum dan Byfield, yang telah ditubuhkan pada 1973 telah dijalankan pada 1979 untuk menentukan isipadu dibawah kulit [volume under bark] (VUB) dan ketumpatan kayu (DEN). Kedua-dua ciri ini serta indeks dalam lingkungan variasi

* Died in a climbing accident in Scotland in February 1994.

ketumpatan sampel (VAR) yang diperolehi dan indeks bahan kering (DMI) dianalisis. Dari segi statistik, terdapat perbezaan yang ketara ($p < 0.05$) untuk VAR, VUB dan DMI di Beerburrum dan untuk VAR di Byfield. Tiga belas provenans yang terdapat pada kedua-dua lokasi mengeluarkan 23% lebih VUB di Beerburrum. Provenans Guanaja dan Santa Clara melebihi nilai purata percubaan provenans untuk VUB dan DMI manakala provenans Rio Coco adalah kurang daripada nilai purata percubaan provenans untuk VUB dan DMI. Penilaian Queensland yang dimasukkan ke dalam percubaan tersebut adalah lebih tinggi untuk pengeluaran VUB berbanding dengan majoriti provenans yang diperkenalkan.

Introduction

The first recorded introduction of *P. caribaea* var. *-hondurensis* Barr. and Golf. into Queensland was in 1947 (Nikles 1972). Due to its rapid growth rate relative to *P. elliottii* Engelm., plantations of *P. caribaea* var. *hondurensis* were established and most of these early plantings utilised seed collected from natural stands in Mountain Pine Ridge, Belize (Nikles 1984). Some 31 000 ha of *Pinus caribaea* var. *hondurensis* have been established in Queensland with annual plantings of approximately 3000 ha (Anonymous 1985). This makes *P. caribaea* var. *hondurensis* and its hybrids the most important exotic conifer established in Queensland.

Provenance trials of *P. caribaea* var. *hondurensis* were first established in Queensland in 1956 at four coastal locations between latitudes 23° and 27°S (Nikles 1972). Subsequent trials as well as current and future breeding work with this species have been reviewed by Nikles (1984) as well as by Kanowski and Nikles (1988). This paper concerns data from provenance trials of *P. caribaea* var. *hondurensis* established at Beerburrum and Byfield, Queensland, in 1973 as part of the international series coordinated by the Oxford Forestry Institute (OFI), England. The results for the first 3.5 years of growth have been summarized by Nikles (1978). Variation in wood properties from one of the *P. caribaea* var. *hondurensis* trials in Queensland, Cardwell, has been previously reported on (Garcia de Leon 1982). The objectives of the present paper are to compare growth and wood properties between provenances and sites.

Materials and methods

The trial design was a randomized completed block. Environmental and experimental conditions of the trials are summarized in Table 1. Provenance details of *P. caribaea* var. *hondurensis* are summarized in Greaves (1978). Details of the provenances (and their abbreviations) of *P. caribaea* var. *hondurensis* used for these trials are given in Table 2. Two of the seedlots used in the trials were derived from selections in Queensland plantations established with seed from Mountain Pine Ridge, Belize.

Table 1. Details of experimental and environmental conditions of *P. caribaea* var. *hondurensis* trials in Queensland

Location	Lat. (°S)	Alt. (m)	Mean annual precip. (mm)	Trees/plot	No. of blocks	Spacing (m)	Length of dry season (months with <60 mm precip.)
Beerburum	27.00	12	1586	10 x 1	5	3.0 x 3.0	2
Byfield	22.83	30	1705	7 x 7	5	2.4 x 2.7	4

Table 2. Details of provenances, country of origin and abbreviations for the three varieties of *P. caribaea*

Provenance	Abbrev.	Country	Source	Lat. (°N)	Alt. (m)	Mean Precip. (mm/annum)
Alamicamba	ALA	Nicaragua	Coastal	13.57	20	2610
Briones	BRI	Honduras	Inland	15.57	600	912
Brus Lagoon	BRU	Honduras	Coastal	15.75	10	2840
Culmi	CUL	Honduras	Inland	15.10	600	1325
Guanaja	GUA	Honduras	Insular	16.47	50	2308
Karawala	KAR	Nicaragua	Coastal	12.97	10	3897
Kuakil	KUA	Nicaragua	Coastal	13.20	20	3208
Limones	LIM	Honduras	Inland	14.05	700	663
Melinda	MEL	Belize	Coastal	17.02	10	2137
Mountain Pine Ridge	MPR	Belize	Inland	17.00	400	1558
Pinar	PIN	Nicaragua	Coastal	12.22	10	4184
Poptun	POP	Guatemala	Inland	16.33	500	1688
Potosi	POT	Honduras	Inland	15.33	600	1205
Rio Coco	RIO	Nicaragua	Coastal	14.75	50	2863
R125 ¹	R125	Queensland	Inland	22.83(S)	10	1820
Santa Clara	STA	Nicaragua	Inland	13.92	700	1818
Santos	SAN	Belize	Coastal	17.57	20	1818
130R ¹	130R	Queensland	Inland	22.83(S)	10	1820

¹Derived from Mountain Pine Ridge, Belize.

In 1979 (age 6.0 years), the trials were assessed for a range of traits which have been reported in Gibson (1982). During that assessment increment cores of 8 mm diameter were taken bark to bark at breast height (1.3 m above ground) from the three largest diameter trees in each measured plot in each provenance in each block. Following shipment to the OFI the cores were oven-dried to 12% moisture content and then machined to 5 mm thickness in both the radial and axial planes. Following resin extraction the cores were subjected to densitometric analysis using procedures described by Kanowski (1985). In addition to mean densitometric density (DEN) data from the densitometer were used to calculate within sample density variation (VAR). The value of VAR has been correlated with paper strength

properties in certain tropical pine species (Wright & Burley 1990). Volume under bark (VUB) was determined for each tree sampled for DEN and this value was multiplied by the DEN to derive a dry matter index (DMI).

Analysis of variance was applied to the data for DEN, VAR, VUB and DMI. Differences between provenances within trials were tested at the 5% level using the Q statistic as described by Chew (1977). The correlation of provenance means between locations was also calculated (Snedecor & Cochran 1980).

Results and discussion

The results of the analysis of variance are summarized in Figure 1 for the Byfield location and in Figure 2 for the Beerburrum location. Provenances were significantly different ($p < 0.05$) for VAR, VUB and DMI at Beerburrum as well as for VAR at Byfield. The Q statistic exceeded the range of VUB and DMI at Byfield as well as for DEN at both locations and has not been presented for these traits. The high F ratio for blocks at Byfield is a result of a fertilizer experiment being superimposed over the trial. The performances of the thirteen provenances common to both trials were significantly correlated for VAR ($r = 0.725^{**}$), VUB ($r = 0.714^{**}$) and DMI ($r = 0.698^{**}$). As provenance mean values of DEN did not differ significantly at either location no correlation was calculated.

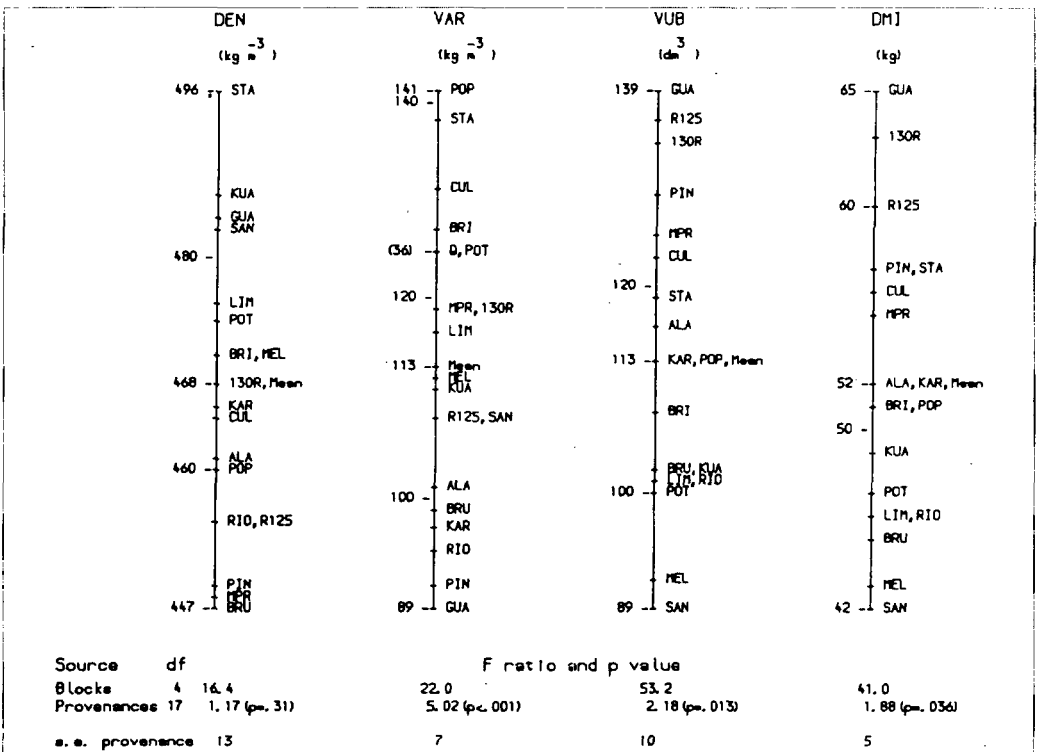


Figure 1. Analysis of variance, ranked means and the critical difference, Q, at the 5% level for densitometric density (DEN), within sample variation (VAR), volume under bark (VUB) and dry matter index (DMI) of *P. caribaea* provenances at Byfield, Australia

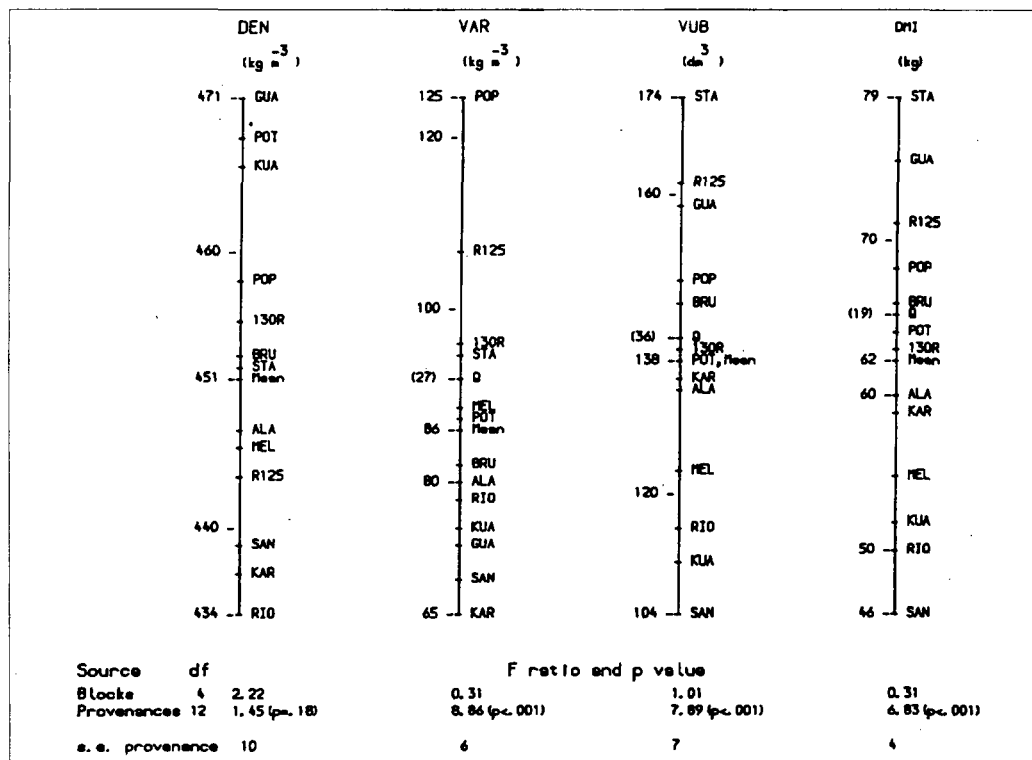


Figure 2. Analysis of variance, ranked means and the critical difference, Q, at the 5% level for densitometric density (DEN), within sample variation (VAR), volume under bark (VUB) and dry matter index (DMI) of *P. caribaea* provenances at Beerburrum, Australia

At Beerburrum, the provenances Brus Lagoon, Guanaja, Santa Clara, Poptun and 130R were ranked above the trial mean for VUB and were among the highest ranking provenances for DMI. The provenances Rio Coco and Santos were ranked near the bottom for VUB and were the two lowest ranking provenances for DMI.

The performances of certain provenances at Byfield were similar to those observed at Beerburrum. For example, the provenances Guanaja and Santa Clara were ranked above the trial mean for DEN and VUB and the provenance Rio Coco ranked below the trial mean for these two traits. However, the provenance means for the traits DEN and VUB did not differ statistically at Byfield and comparisons must be treated with caution.

The thirteen provenances common to both locations produced 23% more VUB at Beerburrum. There are at least two possible explanations for this difference. Due to the closer spacing and the block plot design of the Byfield trial it would be expected that VUB would be lower as a result of greater crown and root competition relative to that encountered in the Beerburrum trial which is at wider spacing and is a line plot design. A second explanation is that tree growth

at Byfield would be reduced due to the greater length of the dry season. Smith (1978) has made similar observations in previous provenance trials of *P. caribaea* var. *hondurensis* which produced more volume at Beerburrum relative to the same provenances grown at Byfield.

The ranking of *P. caribaea* var. *hondurensis* provenances for VUB in other trials of this series established in Queensland has allowed Eisemann *et al.* (1983) to conclude that the provenances Karawala, Guanaja, Poptun, Culmi, Brus Lagoon and Santa Clara generally grew best while the provenances Melinda, Santos, Rio Coco, Kuakil, Pinar and Limones were less vigorous. Results from this assessment generally agree with their findings for VUB production. The Queensland selections included in these trials (R125 and 130R) were ranked above the trial means for VUB and DMI at both locations. The rapid growth rate of the Queensland selections relative to the majority of the introduced provenances has also been observed in other trials of this series (Eisemann *et al.* 1984) and shows the benefits accruing from selection and breeding of a land race. It is interesting to note that the provenance Guanaja was ranked among the lowest for VAR at both locations and this confirms similar findings in Zambia (Wright *et al.* 1986a), Malaysia (Wright *et al.* 1986b), South Africa (Wright *et al.* 1987), Puerto Rico (Wright *et al.* 1988) and Fiji (Wright *et al.* 1990).

The two trials in Queensland compared favourably for wood density with other trial sites in this series (Wright 1990a). The wood of *P. caribaea* var. *hondurensis* should therefore find acceptance as a raw material for a variety of forest products. With regard to paper-making, hybridisation with *P. elliottii* may lead to progeny with improved tear index as has been observed in South Africa (Wright 1987, 1990b).

Acknowledgements

Seeds for the international provenance trials of *P. caribaea* were collected and distributed under Research Schemes at the Oxford Forestry Institute (OFI), University of Oxford, funded by the Overseas Development Administration of the British Government and with the cooperation of the forest authorities in various countries of Central America where the species is indigenous. The trials were established and maintained by the Department of Forestry, Queensland and their help with these assessments and permission to publish these results are gratefully acknowledged. We would also like to thank Tony Quilter of the OFI for his assistance in preparing the wood samples for densitometry. The data and analysis for this study were undertaken as part of a D.Phil. thesis by the senior author at the University of Oxford. We kindly acknowledge the review of an earlier version of this manuscript by various staff members from the Department of Forestry, Queensland.

References

- ANONYMOUS. 1985. *Queensland Department of Forestry Annual Report 1984-1985*. Brisbane, Queensland, Australia. 49 pp.

- CHEW, V. 1977. *Comparisons Among Treatment Means in an Analysis of Variance*. Agricultural Research Service of United States Department of Agriculture, Washington, DC, USA. 64 pp.
- EISEMANN, R.L., NIKLES, D.G. & NEWTON, R.S. 1983. Preliminary investigations of variation and provenance-environmental interactions in *Pinus caribaea* Mor. var. *hondurensis* Barr. and Golf. in Queensland planting trials. *Silvicultura* 8 : 62 - 68.
- EISEMANN, R.L., NIKLES, D.G. & NEWTON, R.S. 1984. The provenance question in Queensland plantings of *Pinus caribaea* var. *hondurensis*. Pp. 211-213 in Barnes, R.D. & Gibson, G.L. (Eds.) *Provenance and Genetic Improvement Strategies in Tropical Forest Trees*. Mutare, Zimbabwe, April 1984. Commonwealth Forestry Institute, Oxford, United Kingdom, & Forest Research Centre, Harare, Zimbabwe.
- GARCIA DE LEON, J.P. 1982. Genetic variation of wood properties among populations of *Pinus caribaea*. D.Phil. thesis, University of Oxford, Oxford, United Kingdom. 248 pp.
- GIBSON, G.L. 1982. *Genotype-Environment Interaction in Pinus caribaea*. Unit of Tropical Silviculture, Interim Report, Commonwealth Forestry Institute, Oxford, United Kingdom. 112 pp.
- GREAVES, A. 1978. *Description of Seed Sources and Collections for Provenances of Pinus caribaea*. Tropical Forestry Papers No. 12, Commonwealth Forestry Institute, Oxford, United Kingdom. 89 pp.
- KANOWSKI, P.J. 1985. Densitometric analysis of a large number of wood samples. *Journal of the Institute of Wood Science* 10 : 145 - 151.
- KANOWSKI, P.J. & NIKLES, D.G. 1988. A summary of plans for continuing genetic improvement of *Pinus caribaea* var. *hondurensis* in Queensland. Pp. 236-249 in Gibson, G.L., Griffin, A.R. & Matheson, A.C. (Eds.) *Breeding Tropical Trees - Population Structure and Genetic Improvement Strategy in Clonal and Seedling Forestry*. Pattaya, Thailand, 28 November - 3 December 1988. Oxford Forestry Institute, United Kingdom & Winrock International, Arlington, Virginia, USA.
- NIKLES, D.G. 1984. Schedules of the main activities and phase coordination in the breeding programme with *Pinus caribaea* var. *hondurensis* in Queensland 1984 - 2000. Pp. 569 - 570 in Barnes, R.D. & Gibson, G.L. (Eds.) *Provenance and Genetic Improvement Strategies in Tropical Forest Trees*. Mutare, Zimbabwe, April 1984. Commonwealth Forestry Institute, Oxford, United Kingdom, & Forest Research Centre, Harare, Zimbabwe.
- NIKLES, D.G. 1978. Establishment and early development (to 3.5 years) of the international provenance trials of *Pinus caribaea* var. *hondurensis* Barrett and Golfari in Queensland, Australia. Pp. 386-403 in Nikles, D.G., Burley, J. & Barnes, R.D. (Eds.) *Progress and Problems of Genetic Improvement of Tropical Forest Trees*. Brisbane, Australia, April 1977. Commonwealth Forestry Institute, Oxford, United Kingdom.
- NIKLES, D.G. 1972. A fifteen year provenance study of *Pinus caribaea* Morelet in sub-tropical coastal lowlands of Queensland, Australia. Pp. 400 - 417 in Burley, J. & Nikles, D.G. (Eds.) *Selection and Breeding to Improve Some Tropical Conifers*. Gainesville, Florida, USA, March, 1971. Commonwealth Forestry Institute, Oxford, United Kingdom, & Department of Forestry, Queensland, Australia.
- SMITH, W.J. 1978. Variation in wood quality and productivity of some Queensland plantation-grown softwoods. Pp. 74 - 99 in Nikles, D.G., Burley, J. & Barnes, R.D. (Eds.) *Progress and Problems of Genetic Improvement of Tropical Forest Trees*. Brisbane, Australia, April 1977. Commonwealth Forestry Institute, Oxford, United Kingdom.
- SNEDECOR, G.W. & COCHRAN, W.G. 1980. *Statistical Methods*. 7th edition. Iowa State University Press. 507 pp.
- WRIGHT, J.A. 1987. Results of micropulping wood samples of seven pine hybrid families in Zululand. Pp. 399 - 406 in SFTIC Committee (Eds.) *Proceedings 19th Southern Forest Tree Improvement Conference*. College Station, Texas, June 1987. National Technical Information Service, Arlington, Virginia, USA.
- WRIGHT, J.A. 1990a. Provenance variation in wood properties of *Pinus caribaea* var. *hondurensis*. *New Zealand Journal of Forestry Science* 20 : 111-121.
- WRIGHT, J.A. 1990b. Impact on future fibre resources of wood quality assessments in the pulp and paper-making industry. Invited paper, 19th IUFRO World Congress, Montreal, August 1990. Vol. 5 : 46 - 52.

- WRIGHT, J.A. & Burley, J. 1990. The correlation of wood uniformity with the paper-making traits of tropical pines. *Tappi* 73 : 231 - 235.
- WRIGHT, J. A., GIBSON, G.L. & BARNES, R. D. 1986a. Provenance variation in stem volume and wood density of *Pinus caribaea*, *P. oocarpa* and *P. patula* ssp. *tecunumanii* in Zambia. *Commonwealth Forestry Review* 65 : 33 - 40.
- WRIGHT, J. A., GIBSON, G.L. & BARNES, R.D. 1986b. Variation in stem volume and wood density of *Pinus caribaea* Mor. provenances growing at Bukit Tapah, Malaysia. *Malaysian Forester* 49 : 176 - 180.
- WRIGHT, J.A., GIBSON, G.L. & BARNES, R.D. 1987. Provenance variation in stem volume and wood density of *Pinus caribaea* growing at two elevations in South Africa. *South African Forestry Journal* 143 : 42 - 45.
- WRIGHT, J.A., GIBSON, G.L. & BARNES, R.D. 1988. Provenance variation in stem volume and wood density of *Pinus caribaea*, *P. oocarpa* and *P. patula* ssp. *tecunumanii* in Puerto Rico. *Turrialba* 38 : 123 - 126.
- WRIGHT, J.A., GIBSON, G.L. & BARNES, R.D. 1990. Variation of stem volume and wood density of *Pinus caribaea* Morelet provenances growing at two locations in Fiji. *Appita* 43(4): 286 - 288.