Field results from a provenance trial of Pinus strobus L. in Australia

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Introduction

Pinus strobus L. has a wide natural distribution from Manitoba, Ontario and Newfoundland in Canada (50° N), through the Lake States of U.S.A. to the Atlantic coast and south along the Appalachian mountains to Georgia and South Carolina (34° N) (see GENYS 1968). Although most stands of white pine are below 450 m elevation, some do occur in a band along the Appalachian mountains between 400 and 1100 m. The climate within the range is cool and humid, and the distribution coincides with areas where the July temperature averages between 17° and 22° C (WILSON and MCQUILKIN 1963).

P. *strobus* is one of the important forest tree species in eastern north America. It was one of the first forest tree species introduced into Europe for plantation purposes (STEPHAN 1974). Provenance trials of P. strobus have been carried out since 1937 (PAULEY, SPURR and WHITMORE 1955) and there have been many studies of the silvicultural features and genetics of the species (WILSON and HOUGH 1966).

An extensive provenance trial was begun in 1961 by GENYS in an attempt to supply seed source data applicable to Maryland, to provide information about geographical variation in P. strobus and to study the relationships between traits.

The trial reported here, in which some of the GENYS'/seed was included, was carried out to answer three specific questions:

1. Can P. strobus be grown successfully as a wood-producing species in Australia?
2. If so, what are the most suitable provenances for introduction?
3. What features, if any, can allow early prediction of later performance of provenances under Australian conditions?

A partial answer to the first question is available from arboretum studies near Canberra (ROUT and DORAN 1974) in which P. strobus achieved a basal area of between 14 m²/ha (11 m in height) after 27 years in one arboretum, and 65 m²/ha (17 m in height) after 26 years in another. Plot sizes were .022 ha and .030 ha containing 36 and 48 trees respectively. The trees were well-formed and thrived on good sites at elevation of 800—1260 m at latitude 35° S. They are from bulked seedlots of unknown provenance. These figures are between 40% and 60% of approximately comparable production figures for P. radiata in similar arboretum plots in the same region. They indicate how, in certain circumstances, P. strobus may compare with P. radiata. It was partly for this reason that the present trial was initiated.

Material and Methods

Provenances of P. strobus used in this experiment are listed in Table 1, together with the original supplier of the seed, and the supplier's seedlot number. Most of the seed was given to the Forest Research Institute (now the Division of Forest Research) by Professor L. D. PRYOR in 1965 and 1966.

Before being sown, the weight of 400 seeds of each seedlot was determined. The seed was soaked in an 80% Thiram solution before being stratified for two months at 2° C. The seed was dried and sown unreplicated in four sterile nursery beds in October 1966. The following assessments were made on the seedlings:

- Germination (%)
- Time to terminal bud formation (days)
- Plants having secondary needles on 13 April 1967 (%)
- Height June 1967
- Height December 1967
- Height May 1968.

In July 1968, these seedlings were transplanted to a site at Toombullup, near Mansfield in Victoria. This site is 910 m above sea level at latitude 37° S, in a predominantly winter rainfall area averaging more than 680 mm per year. The site is on a uniform sloping hillside with a north-easterly aspect. The soil is a deep red-brown loam and was vegetated with bracken (Pteridium esculentum) and some grass, having been cleared for agriculture some years previously. Site preparation included ploughing and fencing. After planting the trees were chipped around on several occasions and fertilizer was applied once to each tree.

Design *and Layout*

In order to reduce the effects of suppression by larger trees of smaller ones in adjacent plots, seedlots were divided into two groups. Seedlots with smaller seedlings at planting time were planted separately in blocks which were adjacent to but downhill from the blocks of trees from the other seedlots. This procedure resulted in an unfortunate canfounding of provenances with upper or lower planting area.

Each of these two areas was a randomised block design with nine tree square plots. Spacing within and between rows was 2.75 m. Rows were laid out at right angles to the slope. There were four replications and, overall, there were 60 seedlots, each representing a seed source (provenance).

Statistical methods

Because the trial had been divided into two (albeit contiguous) areas, there is no completely satisfactory way of analysing the trial as a whole. However, the only known systematic change in the site from one area to the other was the slope of the hillside. Because the seedlots were completely randomised within each replicate in each area, any systematic change caused by the slope should be reflected in a relationship between tree performance and its position on the slope. Each plot was included in three rows of trees, so the pasition of each plot relative to the slope was represented by the group of three rows in which it occurred. An analysis of covariance was carried out between this row number variable and tree performance for both areas separately.

The relationship between geographic variables of the seed source, early nursery performance and field performance was investigated for the Australian data using the multi-

Table 1. — Seedlot provenance, nursery and field data of *P. strobus* provenance trial.

Supplier No.	Seedlot	State	Lat. (°)	Long. (°)	Alt. (m)	Wt 400 seed (g)	Germ. (%)	Term. bud (days)	Second. needles (%)	Ht 6/67 (dm)	Ht 12/67 (dm)	Ht 5/68 (dm)	Ht 4/71 (dm)	Ht 4/74 (dm)	Surv. 4/74 (%)
Genys MdF 150	2	MN	48	92	400	6.8	43	84	3	.32	.64	.73	2.5	8.8	33
" " 1	3	"	47	94	395	7.2	53	86	3	.33	.64	.71	2.0	8.2	33
" " 577	4	"	46	94	405	6.8	65	97	1	.28	.73	.76	3.2	8.9	33
" " 757	6	WI	45	89	275	4.6	28	111	2	.30	.61	.70	3.0	3.8	33
" " 57	6A	WI	44	90	305	7.2	43	97	1	.37	.89	.95	4.1	9.6	44
" " 530	9	Ont.	46	79		5.7	30	99	12	.34	.77	.87	3.2	7.3	56
" " 3	11	Que.	46	73	215	7.5	38	105	2	.33	.71	.82	3.6	10.9	56
" " 772	14	N.Br.	47	65	840	7.4	26	99	2	.30	.67	.80	1.9	7.4	33
" " 148	15A	ME	43	71	120	8.9	39	103	5	.38	.89	1.01	4.0	12.3	56
" " 593	18	NH	43	72	260	8.8	42	101	16	.39	.96	1.01	3.9	9.8	56
" " 686	19	"	43	71	20	7.9	28	116	4	.37	.85	1.01	3.9	9.8	56
" " 584	21	VT	44	73	90	7.7	53	116	2	.35	.80	.99	3.8	12.0	33
" " 585	22	"	44	73	120	8.4	34	102	4	.34	.74	.85	3.3	13.1	44
" " 716	23	NY	44	73	215	7.8	32	105	5	.35	.81	.95	3.8	8.7	44
" " 703	24	"	44	74	230	7.8	24	109	7	.40	.91	.97	3.8	9.7	44
" " 702	26	"	44	74	395	7.5	39	116	5	.38	.91	1.01	4.1	10.5	44
" " 655	29	"	43	74	150	7.2	44	102	1	.32	.84	.93	3.8	11.5	44
" " 574	30	"	43	74	275	7.5	28	108	7	.38	.87	1.03	4.1	12.7	33
" " 725	32	CT	42	73	260	8.1	44	111	2	.41	.93	1.07	3.3	9.4	44
" " 65	36	MD	40	78		8.9	48	117	8	.41	.87	.98	3.7	9.8	44
" " 687	37B	"	40	79	710	8.4	40	117	10	.42	.89	.97	4.1	6.9	33
MSU MSFG 3571	45	WV	40	81		7.4	48	124	7	.38	.87	.96	3.6	12.1	56
" " 3581	50	"	39	81		7.7	31	123	6	.38	.81	.82	3.0	8.6	44
" " 3477	54	"	38	80	825	5.3	31	131	4	.32	.84	.95	3.3	9.6	56
" " 3460	57	"	38	80	625	7.4	51	116	3	.36	.82	.90	3.8	10.0	67
" " 3464	58	"	38	80	625	7.0	36	134	2	.38	.86	.97	3.7	9.3	78
" " 3480	59	"	38	80	700	7.2	60	114	5	.36	.85	.98	4.0	11.2	89
" " 3479	61	"	38	79	700	6.4	63	136	3	.39	.94	1.06	4.5	12.6	56
" " 3476	63	VA	39	80	450	7.2	33	126	-	.38	.87	.93	3.9	11.0	89
" " 3472	64	"	38	80	760	9.4	41	130	15	.44	.98	1.03	4.6	13.2	78
Genys MdF 81	68	"	37	81	760	5.1	44	128	17	.39	.98	1.03	3.4	7.6	44
MSU MSFG 3449	69	KY	37	84	285	6.8	57	173	1	.43	.94	1.16	4.2	11.7	78
Genys MdF 763	70	TN	37	83		9.6	31	160	4	.51	1.08	1.18	5.1	14.6	78
MSU MSFG 3420	71	"	36	82		6.5	38	124	3	.41	.94	1.02	4.2	12.6	78
" " 3533	72	"	36	84	275	7.3	47	134	14	.45	1.04	1.15	4.7	14.1	78
" " 3503	73	"	35	84	550	6.6	58	173	10	.46	1.10	1.25	4.3	8.0	56
" " 3495	74	"	35	84	450	8.7	49	154	24	.50	1.20	1.13	4.7	16.0	78
" " 3422	75	NC	36	82		6.9	43	135	4	.40	.91	.99	3.9	10.4	56
" " 3552	76	"	36	82	365	6.4	67	142	4	.41	.93	1.09	4.5	10.6	56
N.C. State F.S.	77	"	36	82	365	7.2	51	173	8	.40	.92	1.02	4.2	14.7	56
"	78	"	36	83	670	7.4	37	137	2	.43	.94	1.07	4.0	14.1	56
T.V.A.	82	"	36	83	610	9.5	49	132	27	.47	.99	1.23	5.3	11.6	56
MSU MSFG 3410	83	"	36	83		7.9	44	153	6	.45	1.04	1.10	4.1	12.2	44
Genys MdF 84	84	"	35	83	655	7.5	46	156	11	.46	1.12	1.16	5.2	10.7	67
" " 10	85	"	35	83		6.5	29	91	2	.33	.69	.83	2.8	7.0	33
" " 8	89	"	35	83	760	9.6	34	135	1	.43	1.00	1.09	3.9	10.1	67
MSU MSFG 3438	90	"	35	83		8.8	44	134	16	.48	1.09	1.27	5.0	13.3	89
Schoenike	91	SC	35	84	395	8.8	49	151	7	.48	1.20	1.34	4.6	11.0	67
T.V.A.	92	GA	35	84	530	9.1	69	173	4	.49	1.25	1.37	5.2	11.3	67
MSU MSFG 3458)	93A	"	35	84		6.6	63	173	5	.37	.91	1.00	3.7	9.2	44
Barber " ")	93B	"	35	84		6.5	52	173	1	.34	.78	.89	4.0	8.8	56
Barber MSFG 3546	94	"	35	84	550	10.4	73	131	4	.52	1.12	1.22	5.1	12.9	89
" " 3547	95	"	35	84		7.6	40	140	8	.47	.95	1.15	5.3	12.8	67
MSU MSFG 3542	96A	"	35	83	610	7.3	54	171	12	.49	1.23	1.32	5.6	16.5	56
Barber MSFG 3542	96B	"	35	84	610	7.3	75	145	15	.51	.94	1.48	6.0	13.3	89
Barber " 3543	97	"	35	84	610	7.2	44	152	6	.45	1.07	1.15	5.0	11.2	78
" " 3544	98	"	35	84	610	8.8	71	170	3	.42	1.01	1.15	4.8	14.0	67
" " 3545	99B	"	35	84	730	8.1	56	163	29	.50	1.09	1.23	4.7	13.0	78
MSU " 3513	100	"	35	84	455	8.4	52	153	9	.46	1.12	1.20	5.0	13.9	67

variate statistical techniques of principal component analysis and canonical correlation.

Principal component analysis transforms a set of raw variables (in this case all the measurements carried out since 1966) into a new set of variables, each of which is a linear combination (vector) of all of the original raw variables. This is done to maximise the variance between observations so that combinations of raw variables which contribute similarly to the transformed variables have similar factor loadings. One essential feature is that the transformed variables are independent of one another. The size of the factor loading reflects the importance of the raw variable to the linear combination (vector) concerned.

When there are two sets of variables whose relationship to one another is being investigated, the canonical correlation technique calculates linear combinations of each set such that the covariance between the two sets is maximised. Each linear combination is uncorrelated with any other. Correlation coefficients may be calculated between the raw or transformed variable of each set. This means that simple and partial correlation coefficients may be calculated describing the correlation between—

(i) raw biological variables with their own canonical vectors,

(ii) raw biological variables with geographical canonical vectors,

(iii) raw geographic variables with their own canonical vectors,

(iv) raw geographic variables with biological canonical vectors.

These correlation coefficients describe the relationship between each raw variable in turn with the compound variable (which has some functional interpretation) which is the canonical vector.

Simple correlation coefficients represent the relationship between variables taken pairwise. Partial correlation coefficients represent the correlation between variables, taking the effects of other variables into account.

Results

The analysis of covariance showed that there was no systematic change in performance down the hill within the planting areas. Among provenances with larger seedlings (planted further up the hill than the smaller ones), the net correlation coefficient (free of block or seedlot effects) between height and row number down the hill was 0.05 (with

90 d.f., P > 0.10). Among the smaller provenances, the net correlation coefficient was 0.21 (with 30 d.f. P > 0.10). This indicated that there was no detectable systematic change in performance down the hill within blocks, and that a combined analysis of both parts of the experiment is not unreasonable.

Taken as a whole, the field data show a range of height in 1974 from 16.5 dm (96A, Georgia) to 3.8 dm (6, Wisconsin) with the southern provenances performing best. Differences between seedlots for height were highly significant (P < 0.001) and there were also significant differences between blocks (P < 0.05) for height. There were no significant differences between seedlots for survival, but the blocks differed significantly (P < 0.001). In general, the plantation performance was poor when compared with *P. radiata* plantations nearby.

There were significant differences between seedlot means for nursery characters:

Germination (%)	(P < 0.001)
Time to terminal bud formation	(P < 0.001)
Secondary needles	(P < 0.05)
Height (1 year)	(P < 0.001)
Height (1.5 year)	(P < 0.001)
Height (2 year)	(P < 0.001)

There were significant relationships between nursery characters too (see *Table 2*).

Table 2. — **Correlation coefficients (free of block effects) between seedlot means for nursery characters. Significant coefficients (at the 1% level) are underlined.**

	Germination	Terminal bud	Height 1 yr	Height 1-5 yr	Sec. needles	Height 2 yr
Seed weight	0.06	0.05	0.47	0.33	0.22	0.32
Germination		0.41	0.39	0.46	0.12	0.50
Terminal bud			0.59	0.52	0.11	0.58
Height 1 yr				0.77	0.40	0.82
Height 1-5 yr					0.34	0.83
Sec. needles						0.30

WRIGHT *et al.* (1963), GENYS (1968) and STEPHAN (1974) have shown that height growth is correlated with the latitude of the provenance. Latitude is supposed to combine the selective effects of the vegetative period with other climatic effects which have fostered the differentiation of provenances.

Table 3. — **Principal component analysis on the correlation matrix.**

Vector	1	2
Proportion of total variability (%)	60	11
Variables	**Loadings**	
Seed weight	0.22	0.60
Germination	0.21	-0.55
Terminal bud formation	0.31	-0.43
Secondary needles	0.22	-0.33
Height 6/67	0.39	0.12
Height 12/67	0.38	0.03
Height 5/68	0.38	-0.05
Height 4/71	0.38	-0.04
Height 4/74	0.30	0.14
Field survival 4/74	0.30	-0.05
Interpretation	Field performance: vigour	Bipolar component

Larger loadings are underlined for clarity

The principal component analysis is summarised in *Table 3.* The first vector is interpreted as representing general vigour since it contains all heights and the survival figure. It is interesting that the time to terminal bud formation is also included in this principal component. The second vector, accounting for only 11% of the variation, is a bipolar component representing the contrast: seed weight vs seed performance. It is clear that the only seedling characters which are involved in the field vigour vector are the nursery heights themselves and the time to terminal bud formation.

Using the factor loadings of the first principal component, a score was calculated for each provenance to represent general vigour. The most vigorous and least vigorous ten provenances were:

Provenance	State	Score
96B	Georgia	1.8
96A	Georgia	1.7
92	Georgia	1.7
99B	Georgia	1.6
74	Tennessee	1.6
94	Georgia	1.5
90	North Carolina	1.3
70	Tennessee	1.3
91	South Carolina	1.2
100	Georgia	1.1
.	.	.
.	.	.
.	.	.
37B	Maryland	—0.9
36	Maryland	—0.9
9	Ontario	—1.0
6A	Wisconsin	—1.2
4	Minnesota	—1.4
3	Minnesota	—1.7
2	Minnesota	—1.7
85	North Carolina	—1.7
14	New Brunswick	—1.9
6	Minnesota	—2.2

There are some interesting features in these two groups of provenances. Firstly, the most vigorous provenances quite clearly come from the southern States, with Georgian provenances occupying six of the first ten ranks. Secondly, the least vigorous provenances appear to come from the northern States and from Canada. The third feature relates to the presence of the North Carolina provenance 85 (MdF10) in the least vigorous category. This provenance has also appeared to be anomalous in other studies (Genys pers. comm.), and may have been incorrectly labelled.

Results of the canonical correlation analysis are summarised in *Tables 4 and 5.* The biological variables were the same as for the principal component analysis, while the geographical variables were those considered important in earlier studies reported by GENYS (1968) i.e. latitude, longitude, altitude, frost-free period and plant hardiness zone of the seed source locality.

Table 4 shows that biological canonical variable 1 is closely related to much the same raw variables as make up vector 1 in the principal components analysis. It is therefore interpreted in a similar way as generalised vigour. Canonical variable 2 shows a positive relationship with germination, but negative with seed weight. High scores for this variable thus reflect high germination **and** low seed weight.

Table 4. — Summary of canonical correlation analysis.

Canonical variable	1	2
Canonical correlation	0.83	0.67
Portion of total variability (%)	50.5	27.4
Biological Raw A-side variable	**Correlation of raw variables with A-side canonical variable**	
Seed Weight	-0.25	-0.48
Germination	-0.53	0.42
Terminal bud formation	-0.94	-0.05
Secondary needle %	-0.37	-0.06
Height 6/67	-0.85	-0.15
Height 12/67	-0.83	-0.24
Height 5/68	-0.83	-0.30
Height 4/71	-0.81	-0.18
Height 4/74	-0.56	-0.28
Field survival 4/74	-0.67	-0.11
Interpretation	Field performance: vigour	Bipolar component
Geographical Raw B-side variable	**Correlation of raw variables with B-side canonical variable**	
Latitude	0.96	0.01
Longitude	-0.36	0.92
Altitude	-0.50	0.38
Frost-free period	-0.86	0.01
Plant hardiness zone	-0.88	-0.13
Interpretation	Latitude	Longitude

Underlined correlation coefficients significant at 0.1% level

Table 5. — Correlation coefficients (simple and partial) between raw variables and canonical variables of each set of variables. Partial correlation coefficients are in brackets.

Raw variables	Canonical variable	
Biological (A-side)	**B-side 1**	**B-side 2**
Seed Weight	-0.23 (0.17)	-0.31 (-0.42)
Germination %	-0.48 (-0.13)	0.28 (0.53)
Terminal bud formation	-0.86 (-0.59)	-0.03 (-0.18)
Secondary needles	-0.32 (0.12)	-0.04 (-0.06)
Height 6/67	-0.77 (-0.34)	-0.10 (0.41)
Height 12/67	-0.75 (-0.02)	-0.16 (0.07)
Height 5/68	-0.75 (0.11)	-0.20 (-0.46)
Height 4/71	-0.73 (-0.07)	-0.12 (0.07)
Height 4/74	-0.51 (0.03)	-0.19 (-0.11)
Field survival 4/74	-0.61 (-0.15)	-0.07 (-0.01)
Geographical (B-side)	**A-side vector 1**	**A-side vector 2**
Latitude	0.87 (0.60)	0.01 (0.15)
Longitude	-0.33 (-0.18)	0.61 (0.56)
Altitude	-0.45 (0.41)	0.25 (0.20)
Frost-free period	-0.78 (-0.18)	0.01 (0.07)
Plant hardiness zone	-0.80 (0.22)	0.09 (-0.00)

Underlined correlation coefficients are significant at 1% level

Conversely, a low (negative) score reflects low germination and high seed weight. Provenances with high scores come from Minnesota, Maryland, West Virginia, North Carolina and Georgia. On the other hand, provenances with a low score are from the east coast — New Brunswick, New Hampshire, Vermont, New York and down the coast to Georgia. This differentiation of the two arms of the sample by germination and seed weight is difficult to interpret in geographic terms, particularly as both high and low scores appear close together in the south.

For geographical variables, canonical variable 1 is most closely related to latitude, frost-free period and plant hardiness zone; whereas canonical variable 2 is related particularly to longitude and seems to reflect the Y-shaped nature of the sampling pattern (see above). However since no simple correlation coefficients for A-side canonical vector 2 are of high significance in *Table 5*, no further interpretation of this vector is attempted.

Table 5 shows the relationships between the biological (A-side) canonical variables and the geographical (B-side) raw variables; and the geographical (B-side) raw variables and the biological (A-side) raw variables. It is clear that the geographical (B-side) canonical variable 1 has high simple correlation coefficients with the height variables, terminal bud formation and germination percentage. It is also clear that the largest simple and partial correlation coefficients between the raw geographical variables and the canonical biological (A-side) variables were with latitude alone. There is a good deal of correlation among the variables (see *table 2*). Thus, a meaningful relationship between a canonical vector and a raw variable could result in statistically significant but obscure correlations between the canonical vector and other raw variables. These obscure correlations are not present in the partial correlation coefficients where, for a particular raw variable, the effects of the others are taken into account. Thus, the large simple correlation coefficients between raw geographic variables and the A-side vector in *Table 5* for all variables except longitude reduce to significant partial correlation for latitude and altitude (particularly latitude). The inclusion of altitude suggests that some overall measure of temperature may be involved in this vector since temperature is obviously a component of the effects of both latitude and altitude. The confusing array of significant simple correlations for the relationships between the raw biological variables and the B-side vector reduce to a significant partial correlation coefficient for terminal bud formation alone. The height, survival and seed germination characters are closely related to the B-side vector merely because they are correlated to the number of days to terminal bud formation.

Discussion

Compared with the climates at the seed sources of the *P. strobus* used in this experiment, the Toombullup plantation has a mild climate. The mean minimum temperature in July (winter) is about 0° C and the mean maximum at that time is about 10° C. During the summer months, the mean minimum is about 10° C and the maximum 30° C. Because of the mild climate, cold hardiness was not considered a vital factor in the response of provenances in this experiment; and from the multivariate analyses, did not turn out to be so. Survival in some parts of the trial has not been good and deaths have probably been caused by a combination of competition with bracken and browsing soon after establishment by rabbits and marsupials.

Notwithstanding this deficiency in the trial, there are some very interesting similarities between it and other trials involving some of the same seedlots. Genys (1968) reported a strong relationship between early growth and latitude. A similar result was also reported by Stephan

(1974) with similar seedlots, and by WRIGHT (1970) and WRIGHT *et al.* (1963). In the Australian trial, a similar correlation is evident. The canonical variable representing general vigour correlates well with latitude of seed source.

GENYS (1968) suggested that there might be a causal relationship between the lateness of bud set and growth rate. The partial correlation coefficients between biological variables and the canonical geographic vector *(Table 5)* show that the date of terminal bud formation is the only important growth characteristic with a large correlation coefficient when the other tree characters are taken into account. This means that the relationship between growth and latitude observed in this and perhaps other similar trials is really a reflection of the relationship between lateness of budset and latitude.

Annual growth has two components; intrinsic growth rate, and the length of the growing season. If the intrinsic growth rate was itself related to latitude, significant partial correlation coefficients for the various height measurements could be expected in *Table 5.* Since this did not occur, it must be concluded that differences in annual growth related to latitude are primarly due to differences in the length of the growing season.

The average height of the tallest trees in this experiment is only about 3½—4 m after some eight years of growth, a rather disappointing result. In the same plantation area are *P. radiata* (which has attained a height of 9—11 m over the same growth period), *P. lambertiana* (about 3 m), *P. contorta* (4—6 m), *Pseudotsuga menziesi* (4—5 m).

It is clear, then, that the planting of *P. strobus* in this district using the cultural methods employed in this trial, is not attractive.

The most vigorous provenances in these Australian conditions were the southern ones, and this vigour is primarily related to the length of the growing season. If selection amongst provenances were to be practised on seedlings for growth in Australian conditions, it is clear that the best predictor is the length of time to the formation of a terminal bud.

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Summary

A trial of *Pinus strobus* L. was analysed for differences between provenances, to see whether any provenances of this species were suitable for planting in Australia and to see whether any seedling characters could be used for early prediction of later performance. Growth was much slower than that of other species particularly *P. radiata* planted nearby and so no provenance was thought suitable for plantation use in such mild sites in Australia. The most vigorous provenances were from the southern part of the range of the species and the least vigorous were from the north. Prediction of adult growth seems possible by using the length of the growing season of seedling shoots. The strong correlation between growth and latitude seems to reflect differences in the endogenously determined length of the growing season rather than intrinsic growth rate.

Key words: Pinus strobus, provenance, multivariate analysis.

Zusammenfassung

Ergebnisse aus einem Provenienzversuch mit *Pinus strobus* L. in Australien. Die Prüfung von 59 Herkünften aus dem natürlichen Verbreitungsgebiet von *Pinus strobus* ergab, daß diese Baumart in Australien viel langsamer wächst als andere Kiefernarten, z. B. *Pinus radiata.* Herkünfte aus dem südlichen Teil des Verbreitungsgebietes waren wüchsiger als solche aus dem Norden, wobei zwischen Wachstum und geographischer Breite eine enge Korrelation festgestellt wurde.

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