Results of 10-year old Eucalyptus camaldulensis Dehn. provenance study at Peshawar

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Summary

This paper describes results of a 10-year old Eucalyptus camaldulensis provenance study at Peshawar. Detailed measurement of height, diameter, wood specific gravity and volume were made and test plantation was thinned to remove the slow growing trees for conversion into a seed stand. Large and significant differences were observed in the performance of different provenances, proving the superiority of a number of seed sources. The results were consistent with observations made earlier at 6 years age of the plantation. The fast growth rate was found to have only a slight adverse effect on wood specific gravity. Growth rate of fast growing seed sources compared favourably with yield of shisham and babul plantations under similar site conditions.

Key words: Eucalyptus camaldulensis, provenance study, seed sources, irrigated plantation, riverain forest, height, diameter and volume growth, wood specific gravity.

Zusammenfassung

Seit etwa Mitte des vorigen Jahrhunderts werden in Pakistan Eukalyptus-Arten forstlich angebaut. Hier wird über Ergebnisse aus einem Provenienzversuch mit 20 Herkünften von Eucalyptus camaldulensis aus Australien, der im Jahre 1966 an mehreren Orten Pakistans angelegt wurde, berichtet. Im Alter von 10 Jahren zeigten die Herkünfte z. T. erhebliche Unterschiede in der Höhe, im Durchmesser und in der pro ha produzierten Holzmasse sowie im spezifischen Gewicht des Holzes.

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Introduction

The introduction of Eucalyptus species in Pakistan extends back to 1860. Eucalyptus trees have been grown under a variety of ecological conditions as single trees, arboretum plots and linear plantations throughout the country. Their performance has been evaluated by a number of authors, both foreign and local. Some of the important references in this regard are those of Khan (1955), Brockway and Khan (1956), Ahmad and Iqbal (1964), Boden (1967), Pryor (1967) and Qadri (1968).

Among all the Eucalyptus species tried so far, E. *camaldulensis* has proved to be physiologically more adaptable and consequently has been planted more than other species. Currently, it is the principal species of all Eucalyptus planting Programmes in the country. Although, genetic improvement studies of a nurnber of Eucalyptus species including E. camaldulensis were suggested more than thirty years ago, systematic work was started only in late sixties. This paper presents results of a 10-year old E. *camaldulensis* provenance study at Peshawar.

Table 1. — List of Eucalyptus camaldulensis Dehn. provenances planted at Peshawar.

Sl. NO.	Seed lot NO.	Locality	Longitude	Latitude	Altitude	Soil
1.	6788	Alice Springs (N.T.)	133° 35'	23° 38'	1,900	Silty and sandy alluvial.
2.	7116	Tennant Creek (N.T.)	134° 00'	19° 30'	1,100	Sandy loam.
3.	7080	Newcastle Waters Creek (N.T.)	133° 30'	17° 30'	700	Clay to sand clay loam.
4.	6869	Katherin (N.T.)	132° 15'	14° 25'	360	Alluvial.
5.*	7033	Fortescue River (W.A.)	117° 05'	21° 35'	700	Gravelly sand.
	7037	Fortescue River (W.A.)	120° 08'	23° 05'	1,000	Gravelly red and pH. 6.5
6.	6975—79	Port Lincoln (S.A.)	135° 50'	34° 40'	100	Rendzina with limestone pH.8
7.*	6990	Darlington point (N.S.W.)	146° 01'	34° 34'	300	Heavy clay
	6955	Narangarell (N.S.W.)	147° 42'	34° 09'	1,000	Heavy clay
	6956	Forbes (N.S.W.)	147° 59'	33° 20'	780	Heavy clay
	6957	Dubbo (N.S.W.)	148° 32'	32° 11'	870	Clay over conglomerate.
8.	6980—89	Silverton (N.S.W.)	145° 58'	30° 13'	361	Heavy clay.
9.	6870	Quilpie (Qld)	145° 41'	28° 40'	610	Grey heavy soil
10.*	6871	East of Quilpie (Qld)	144° 49'	26° 52'	740	Sandy loam.
	6872	Thargoninda (Qld)	143° 43'	27° 58'	400	Sandy loam.
	6963	Quilpie (Qld)	144° 18'	26° 35'	620	Sandy loam.
11.*	6948	Bullock Creek (Qld)	144° 48'	20° 48'	1,500	Lateritic
	6949	Porcupine Creek (Qld)	144° 21'	20° 43'	1,300	Sandy loam
12.*	6953	Petford (Qld)	144° 57'	17° 20'	1,700	Sandy loam
	6954	Warrigal Creek (Qld)	145° 27'	20° 35'	1,500	Lateritic
13.	Plus trees	Burmah Forest (Vict.)	143° 00'	35° 00'	—	Sandy loam.

• — mixture of seed lots.

Material and Methods

Individual and mixed seed lots of a number of provenances of *Eucalyptus camaldulensis* were procured from Australia and sown in Research Nursery, Hyderabad, during September 1965 and one-year old plants were planted at various places including Peshawar. Detailed experimental plan and interim measurements regarding survival, height, diameter and basal area have been reported earlier by HAFEEZ and SHEIKH (1972). The description of the localities of the seed sources planted in Peshawar experiment is given in *Table 1*. The test site is located in the experimental area of the Pakistan Forest Institute, Peshawar. It lies at 34° 01' latitude and 71° 34' longitude at an elevation of about 400 meters. The mean minimum and maximum temperatures at Peshawar are 10.9° C in the month of January and 32.9° C in June/July respectively. Average annual precipitation is about 350 mm, most of it is received during the months of January to April. The soil of the test site is calcareous clayey loam with fair drainage. Its pH varies from 8.5 to 9.1.

Planting of one-year old plants of thirteen individual and mixed seed sources of *E. camaldulensis* was done at Peshawar in trenches at 3.3 × 3.3 meters spacing during 1966 over an area of about 1.5 hectares. Randomised complete block design with four replications was used with 30 plants per plot. Among these, 12 were experimental trees and 18 were planted in the surround. Irrigation was provided once a week during first two years of establishment of test plantation during summer (April to October) which was followed for next four years on fortnightly basis. Thereafter the supply of irrigation water to the test plantation was irregular.

Height, diameter and volume measurements were made in January, 1977 when the plantation attained an age of 10 years. Thinning was also done to remove inferior stems for conversion of test plantation into seed stand. Total over bark volume of felled trees was determined and a volume table was prepared for determination of volume of standing trees. Volume per hectare per annum was computed for each seed source. Wood specific gravity of provenances at serial Nos. 2, 3, 8, 10, 11 and 12 was determined from increment core wood samples at breast height on four trees in each provenance by maximum moisture content method (SMITH, 1954). Analysis of data was done according to a procedure suggested by WRIGHT (1962).

Table 2. — Average height, diameter and volume growth of thirteen and specific gravity of six selected provenances of *Eucalyptus camaldulensis* at the age of 10 years.

Sl. No. of seed lot.	Height (m)	Diameter (cm)	Vol/ha/year (cbm)	Specific gravity
1.	15.8	15.8	14.6	—
2.	11.3	10.4	5.5	0.635
3.	11.9	12.4	8.1	0.647
4.	13.2	11.8	8.3	—
5.	14.0	15.2	13.5	—
6.	14.5	16.3	15.4	—
7.	14.3	16.0	13.5	—
8.	12.9	14.2	10.3	0.546
9.	14.2	13.4	10.3	—
10.	14.0	15.2	12.3	0.564
11.	14.4	13.8	9.4	0.597
12.	15.8	13.7	11.3	0.605
13.	11.7	13.2	9.4	—

Results and discussion

The average height, diameter and overbark volume per hectare per annum for thirteen provenances is given in *Table 2*. The data show considerable variation in all three characters of different seed sources. For instance, provenance at serial number 6 is almost three times faster growing in volume growth than that at 2. Analysis of variance showed highly significant differences between provenances. F-values are given in *Table 3*. DUNCAN'S Multiple Range Test also indicated that the differences between fastest and slowest growing provenances as well as those between intermediate provenances are significant. Although block effects are also statistically significant for height and volume growth, their variance components are small as compared to variance due to provenances for all characters. Large variation up to ecotypic level has also been observed in provenance studies of this species in other countries (KARSCHON, 1974; BURGESS, 1975).

Comparison of the 10-year result with the interim results of HAFEEZ and SHEIKH (1972) show that provenances at serial No. 6 continues to give the best performance as far as diameter growth is concerned. The order of performance of other seed sources has slightly changed with the passage of time. However, provenances which are fast growing at 6 years age continue to do so at 10 years age. Furthermore fast growth rate does not appreciably affect wood specific gravity. Whereas the differences in diameter growth of provenances at No. 1 and 4 are almost 50%, those for wood specifc gravity is only 12½%. Wood weight loss due to low specific gravity is more than compensated by increased volume production in fast growing provenances.

Eucalyptus camaldulensis is one of the most widely planted species in the world (NAWAZ, 1963). It has given an annual yield of about 4 to 10.2 cbm per hectare in Turkey, Spain, Portugal, Brazil, and South Africa. On the other hand, the range of yield in the Peshawar study is 5.5 to 15.4 cbm which is very encouraging for the future of this species in Pakistan. The performance of the most of the provenances of this study also compare very well with that of shisham *(Dalbergia sissoo)* in irrigated plantations (6.5 cbm per hectare per annum) and of babul *(Acacia arabica)* in riverain forests (12.1 cbm per hectare per annum) under similar site conditions.

The test plantation would continue to grow after thinning both as a provenance study and as a seed stand. Since it was raised from seed from pure stands of *Eucalyptus camaldulensis* from Australia, genetically pure seed of this

Table 3. — F-values and variance components of analysis of variance.

Source of variation	Height		Diameter		Volume	
	F value	V.C.	F value	V.C.	F value	V.C.
Seed source	3.638**	0.358	2.968**	0.308	3.555**	0.358
Replication	3.401**	0.100	2.381 n.s	0.066	2.895*	0.084
Error	—	0.542	—	0.626	—	0.558

* — Significant at 5% level.
** — Significant at 1% level.
n.s — non-significant.

species would be produced in it. Most of the plantations of this species in Pakistan are a mixture of hybrids of different species of Eucalyptus, which are generally of F2 and subsequent generations as well as of back crossing, and produce considerably variable material, which is not suitable for planting purpose. The stem form of trees from such seed is especially poor. About 100 kilograms of seed was collected from the test plantations of this study and supplied to field officers during 1977. Appreciable gain is expected as there is a 3 : 1 ratio in wood volume production of the fastest and slowest growing seed sources and only the best available trees were left in the test plantation to produce seed. The plantation is sufficiently large (1.5 hectares) for seed production purpose and planting of other species of *Eucalyptus* species in its vicinity which could hybridize with *Eucalyptus camaldulensis* is being avoided.

Conclusion

Large variations in the performance of 13 seed source of *Eucalyptus camaldulensis* have been observed in a 10-year old provenance study of this species at Peshawar. The observed differences of growth among various provenances are statistically significant, consistent with earlier observations and quantitatively large enough to warrant selection of the fast growing seed sources for planting. Any reduction in wood specific gravity of fast growing provenances was found to be more than compensated by increased wood volume production in them. The growth rate of the fast growing provenances in this study compares very favourably with the yield of shisham and babul plantations under similar site conditions.

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A study of population variation and inheritance in sitka spruce

I. Results of glasshouse, nursery and early Forest progeny tests

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Summary

The juvenile height growth of 116 families derived from open-pollinated seed collected from a random sample of trees in a 34-years-old plantation of Sitka spruce of Queen Charlotte Islands origin has been studied in a nursery, glasshouse and forest tests on three sites. Annual estimates of heritability up to the sixth year are not outstandingly high. The results are discussed in relation to the reliable interpretation of juvenile assessments, the gains to be expected from a number of methods of breeding and modifications to the breeding strategy for the species.

Key words: *Picea sitchensis*, Height growth, Progeny test, Variance components, Heritability.

Zusammenfassung

150 Einzelbaum-Nachkommenschaften aus einem 34 Jahre alten Bestand von *Picea sitchensis* (Bong.) Carr. in Schottland, in denen auch solche von sog. Plusbäumen enthalten waren, wurden sowohl im Gewächshaus als zugleich in der Baumschule sowie auf drei Waldstandorten auf die Entwicklung von Höhe, Durchmesser, Anzahl der Zweige und Zweiglänge hin untersucht. Die Nachkommenschaften der sog. Plusbäume zeigten im Alter 6 einen Wachstumsvorsprung von 4,1% gegenüber dem Mittel aus allen untersuchten Nachkommenschaften, wobei jedoch das Mittel aus den 5 wüchsigsten aller Nachkommenschaften 14,2% höher lag. Bis zu diesem Alter konnte nur eine relativ niedrige Heritabilität festgestellt werden. Die Ergebnisse werden im Zusammenhang mit dem aus einigen Züchtungsmethoden zu erwartenden genetischen Gewinn besprochen.

Introduction

A soundly-based breeding strategy for any species depends on reliable information on the underlying variation and pattern of inheritance of the characters for which selection will be made. When accurate estimates of genetic variances are available, it is possible to make realistic predictions of times and costs likely to be incurred under different breeding schemes and selection intensities.

Sitka spruce (*Picea sitchensis* (Bong.) Carr.) is the most widely used conifer for commercial forestry purposes in