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Provenance Variation in Eucalyptus Tereticornis in a Field Trial within the Northern Guinea Savanna Zone of Nigeria

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Abstract

A trial involving 11 provenances of *Eucalyptus tereticornis* Sm. was established in one location within the Northern Guinea Savanna zone of Nigeria in 1969. Assessments of their total height and diameter were carried out at ages three, five and six years.

Very highly significant differences were found in the total height of the provenances at ages three and six years while such differences were only significant at the 10% level at age five. Differences in the diameter of the provenancs were not significant until after their sixth year of growth.

The N. Laura, Queensland provenance exhibited the best growth rate. The two provenances from Papua New Guinea (Port Moresby and an unknown source) and the Mysore, India provenance jointly had the least growth rate.

Key words: *Eucalyptus tereticornis*, provenances, height, diameter, ages, selection.

Introduction

Eucalyptus tereticornis Sm. is a member of the red gum group, members of which are for the most part trees of the savanna woodland. Although members of this group are not generally tall and straight, *E. tereticornis* is the tallest species in the group, with a long stem of relatively good form. It is one of the two most important commercial species of the group, the other being *E. camaldulensis* which is closely related and exhibits very similar properties and characteristics (Davidson, 1981). It produces very strong, hard, heavy and durable timbers which are used in heavy construction, building scantlings, mining timbers and posts (Hall *et al.*, 1970). It is widely used for poles and fuelwood in India.

Eucalyptus tereticornis occurs naturally along the east coast of Australia with an occurence in Papua New Guinea. It extends from latitudes 10^0 S to 38^0 S (Quadri, 1981). It has an altitudinal range from near sea level to 909 m in northern Queensland and up to 1818 m in Papua New Guinea. Because of its wide geographic distribution, it covers a wide climatic range, ranging from monsoonal with distinct wet and dry seasons in Papua New Guinea, to a predominantly summer rainfall with a very dry winter in Queensland, to an equal distribution of rainfall between winter and summer in southern New South Wales to a dry summer and wet winter in Victoria (Davidson, 1981). The annual rainfall of its area of natural occurrence ranges from 635 mm to 1524 mm (Hall *et al.*, 1970).

In using *Eucalyptus tereticornis* as an exotic species, it is necessary to know the nature and magnitude of provenance variation associated with the large geographic distribution of the species. This will ensure that the correct seed source will be used to obtain maximum yield of dry fibre which is the goal when the anticipated use is for energy and chemicals (Dost, 1983). Such knowledge will also help in the selection of the right materials for breeding work.

Eucalyptus tereticornis has long been recognized as one of the fast-growing exotic tree species that can be used for afforestation programmes in the savanna region of Nigeria (Kemp, 1969). Because of this and the likelihood of great genetic diversity associated with geographic location a provenance trial involving the species was established in 1969 at Afaka, a location within the Northern Guinea Savanna region of the country. Data on the growth rates of the provenances represented in this trial were collected in 1972, 1974 and 1975, that is at ages three, five and six years respectively.

The aim of this paper is to show the patterns and magnitudes of intraspecific variation in growth in *Eucalyptus tereticornis* grown at Afaka, Nigeria. It is also intended to identify the most suitable provenance of the species for use in afforestation programmes in this part of Nigeria.

Materials and Methods

Eleven seed sources of *Eucalyptus tereticornis* were represented in the study. A brief description of these sources is presented in *Table 1.* Although northern New South Wales, Australia may be one of the most promising regions for provenance selection of this species (F.A.O., 1976), it was not represented in the trial while eight of the provenances tried came from Queensland. This probably arose because of earlier experience with other exotic tree species grown in Nigeria that trees from areas with predominantly summer rainfall do better in the country than those from areas of predominantly winter rainfall.

Information on the mother trees for three of the seedlots shows that two of them came from one mother tree each while one came from five mother trees. There is. however, no information on the number of mother trees for the remaining eight seedlots. It is suspected that none

of the seedlots came from the 25 to 30 mother trees per provenance collection recommended by BURLEY and WOOD (1976).

The seeds were sown in March, 1969 in seed trays at Savanna Forestry Research Nursery, Samaru. The resultant seedlings were pricked out into polypots about four weeks after germination. The potting medium consisted of four parts river sand to three parts of rotted cow dung with 3.5 kg 15-15-15 compound fertilizer and 360 gm dieldrin 2% dust added to evercy cubic metre of the medium.

The seedlings were planted at Afaka in July, 1969. Afaka (lat. 10°37' N, long 7°17' E) is situated in the Northern Guinea Savanna zone of Nigeria. It lies on an altitude of 600 m and experiences an annual rainfall of about 1290 mm and a mean annual temperature of 25° C. In August, 1969 about 56 gms of borate was applied to each of the seedlings.

The experimental design used was randomized blocks with four replications. However, two of the provenances (an unknown source designated Bulolo, Papua New Guinea, a place where the species does not occur naturally (ELDRIDGE, pers. comm.*) and Kennedy Creek, North Queensland) were each represented in only one block. There were 36 trees per plot with an espacement of 2.7 m × 1.8 m.

The three years total height and diameter at breast height (dbh) data being used for the purpose of this paper were collected in 1972, 1974 and 1975, when trees were three, five and six years old respectively.

*) Dr. K. G. ELDRIDGE, CSIRO, Division of Forest Research, Canberra, Australia.

Although 11 *Eucalyptus tereticornis* provenances were involved in the trial, data obtained from only nine of them were subjected to analysis of variance since the other two provenances, the unknown source from Papua New Guinea and Kennedy Creek, were each represented in only on block. Analysis of variance was carried out on plot mean basis.

Results and Discussion

The results of the analyses of variance for the three years under consideration are presented in *Table 2*. The intraspecific variation pattern for each measurement period is given below.

At age three years

There were very highly significant differences in the total height of the nine provenances involved in the analysis of variance. Their three — year mean total height ranged from 5.55 m for the Mysore provenance to 8.33 m for the Northern Laura provenance (*Table 3*). However, using the Duncan's Multiple Range test (SNEDECOR and COCHRAN, 1967) three height groups emerged. Mysore, India and Port Moresby, Papua New Guinea provenances fell in the group that exhibited the least height growth at this age. Conjuboy and Laura provenances and one seedlot from Cooktown (all of them being from Queensland) had mean total heights that fell in the second group while the best group consisted of N. Laura, Mt. Garnet, and two Cooktown provenances.

There were no detectable differences in the dbh of the provenances at age three years. However, the same trend that was obtained for total height was noticeable in their dbh figures (*Table 3*). Their dbh varied from 4.85 cm for

Table 1. — A description of the provenances *of Eucalyptus tereticornis* grown at Afaka*).

PROVENANCE	CSIRO SEEDLOT NO	LATITUDE °S	LONGITUDE °E	ALTITUDE (m)	NUMBER OF MOTHER TREES
Cooktown, North Qld.	S8214	16°10'	144°50'	430	?
Conjuboy, Qld.	S8297	17°50'	145°10'	610	5
Laura, Qld.	S8199	15°45'	145°00'	180	1
Cooktown, North Qld.	S8202	15°40'	145°15'	120	?
N. Laura, Qld.	S8211	15°31'	144°20'	150	1
Kennedy Creek, North Qld.	S8212	15°37'	144°32'	120	?
Cooktown, North Qld.	S8215	16°20'	144°50'	75	1
Mt. Garnet, Qld.	S8490	18°00'	145°12'	610	?
Port Moresby, P.N.G.	S8866	9°25'	147°25'	500	?
"P.N.G. - Source unknown"	S8768	-	-	-	?
Mysore, India	-	-	-	-	?

*) Courtesy of CSIRO Divison of Forest Research, Canberra Australia.

Table 2. — Analysis of variance for total height and diameter at breast height for nine provenances of *Eucalyptus tereticornis* planted at Afaka at ages three, five and six years.

SOURCE OF VARIATION	DF	MEAN SQUARE					
		AT AGE 3 YEARS		AT AGE 5 YEARS		AT AGE 6 YEARS	
		HEIGHT	DBH	HEIGHT	DBH	HEIGHT	DBH
BLOCKS	3	2.49	1.15	2.35	0.49	3.44	1.92
PROVENANCE	8	5.01***	2.04	5.84*	3.71	12.43***	9.34***
RESIDUAL	24	1.49	0.99	2.59	1.77	2.89	2.54

*) Statistically significant at 10% level of probability **) Statistically significant at 5% level of probability
***) Statistically significant at 1% level of probability

the Mysore provenance to 7.28 cm for the N. Laura provenance.

The Kennedy Creek provenance, although not involved in the analysis, recorded a mean three-year total height of 8.10 m and a mean dbh of 6.00 cm. These figures compared very well with the mean height (8.06 m) and mean dbh (6.05 cm) of the best four provenances identified above. However, the unknown source from Papua New Guinea which was not also involved in the analysis exhibited a mean height of 3.8 m and a mean dbh 2.7 cm. These figures were very much less than even those of the Mysore provenance which exhibited the least growth rate among the nine provenances involved in the analysis of variance.

At age five years

The differences in the five-year mean total height of the nine provenances were just significant at 10% level of probability. Their mean height values varied from 7.70 m for the Port Moresby, Papua New Guinea provenance to 11.58 m for the N. Laura, Queensland provenance (*Table 3*). The Duncan's Multiple Range test showed that the Port Moresby provenance alone occupied the class with the least total height while the N. Laura provenance alone occupied the class with the highest mean height. The other three provenances that were found in the best group along with the N. Laura provenance alone occupied the class with the highest mean height. The other three provenances that were found in the best group along

Table 3. — Mean total height and dbh at ages three, five and six years of eleven provenances of *Eucalyptus tereticornis* planted at Afaka*).

PROVENANCE	SEEDLOT NO	HEIGHT(m)			DBH(cm)		
		AGE 3	AGE 5	AGE 6	AGE 3	AGE 5	AGE 6
N. Laura, QLD.	S8211	8.33a**	11.58a	13.95a	7.28	8.38	11.75a
Cooktown, North QLD.	S8202	8.02a	10.98b	12.80b	6.05	7.65	11.70a
Cooktown, North QLD.	S8214	7.67a	11.03b	12.60b	6.10	8.25	11.20a
Mt. Garnet, QLD.	S8490	8.23a	10.17bc	11.60c	6.60c	7.85	10.97a
Conjuboy, QLD.	S8297	6.38b	9.85cd	10.50d	5.48	6.53	9.22b
Cooktown, North QLD.	S8215	6.33b	9.05d	10.43d	5.80	6.67	10.10b
Laura, QLD.	S8199	6.33b	9.70d	9.78de	5.95	6.93	9.40b
Mysore India	-	5.55c	9.03d	9.20e	4.85	6.05	7.78c
Port Moresby, P.N.G.	S8866	5.63c	7.70e	8.83e	5.30	5.70	7.90c
Kennedy Creek, North QLD.	S8212	8.10	9.30	10.30	6.00	5.70	7.30
"P.N.G. - Source unknown"	S8768	3.80	4.70	5.60	2.70	4.80	7.00

*) The last two provenances were not involved in the analysis of variance.
**) Groups to which the means belong using Duncan's Multiple Range test.

with the N. Laura provenance at age three years fell in the second group at age five years.

There were still no significant differences in the dbh of the nine provenances after their fifth year of growth. However, variation in their dbh followed almost the same pattern as that of their total height with the N. Laura provenance topping the list (8.38 cm) and the Port Moresby provenance at the bottom of the ladder (5.70 cm).

The Kennedy Creek provenance recorded a five-year mean total height of 9.30 m and a mean dbh of 5.70 cm. These figures put this provenance at a disadvantage over the best four provenances with which it compared favourably after their third year of growth. The unknown Papua New Guinea source with a five-year mean height of 4.70 m and a mean dbh of 4.80 cm certainly still exhibited the least growth rate among the 11 provenances.

At age six years

There were very highly significant differences in both total height and dbh among the provenances after their sixth year of growth. Their mean heights varied from 8.83 m for the Port Moresby provenance to 13.95 m for the N. Laura provenance while their dbh varied from 7.78 cm for the Mysore provenance to 11.75 cm for the N. Laura provenance (*Table 3*).

While N. Laura, Mt. Garnet and two Cooktown provenances exhibited essentially the same six-year dbh, the N. Laura provenance was superior to the others in total height. The two Cooktown provenances exhibited similar mean height (12.80 m and 12.60 m respectively). The Mt. Garnet provenance only attained a six-year mean height of 11.60 m.

The Kennedy Creek provenance attained a six-year mean height of 10.30 m and a mean dbh of 7.30 cm. These figures obviously did not put this provenance at any advantage compared with most of the other provenances from Queensland. The unknown source from Papua New Guinea recorded a six-year mean height of 5.60 m and a mean dbh of 7.00 cm and therefore still exhibited the least growth rate among the provenances examined.

From the analyses of variance, it was found that it is easier to detect differences in total height among *Eucalyptus tereticornis* provenances than in dbh in their early stages of growth. The differences in total height among the provenances of this species examined were detectable as early as age three years while such differences were not detected in dbh until after sixth year of growth. This may have something to do with the observation that diameter growth in eucalypts, although quite rapid, is less dramatic than height growth (Skolmen, 1983).

Eucalyptus tereticornis provenances that showed the best performance at age three years still maintained that standard even after the age of six years. Similar results have been obtained in other species planted in the savanna region of Nigeria (Otegbeye, 1985 and 1987; Otegbeye and Shado, 1984). This shows that early dominance was maintained in the species. Thus it may be possible to use early results frgm *E. tereticornis* provenance trials to predict relative performance at older ages and for provenance selection in this species.

The results generally show that there were considerable variations in the growth rates of the *Eucalyptus tereticornis* provenances examined. This in part supports the assertion that there are significant differences between provenances of this species with regard to growth rate and tree form (Davidson, 1981; Quadri, 1981). The N. Laura Queensland provenance exhibited the best growth rate among the eleven provenances examined. In general, the Queensland sources performed better than the other three provenances from other regions. The Mysore, India provenance and the two sources from Papua New Guinea (Port Moresby and the unknown source) had the least growth rates among the provenances. Field trials from many other tropical countries have also shown that the best seed sources of *Eucalyptus tereticornis* are located within the Australian tropics (Doran and Boland, 1978; Boland, 1981). In the Congo, provenances from Herberton and Mt. Garnet areas of north Queensland have performed exceptionally well while those from Cooktown area are of major interest in Brazil (Doran and Boland, 1978). In tropical lowland Mexico, provenances from Cooktown - Laura area of north Queensland performed so well that they even exhibited growth and survival similar to that of the northern provenances of *E. camaldulensis* at age 19 months. In Sri Lanka, Laura, Mt. Garnet and Helenvale provenances (all from north Queensland) were the most promising while Kennedy River, Queensland and Laura provenances performed best in Bangladesh (Boland, 1981). In Uganda and Ivory Coast, Mt. Garnet and Cooktown provenances were among the superior provenances identified (Davidson, 1981). In the humid to sub-humid parts of Southern Africa, the seedlots from the Palmer River area of Queensland exhibits growth and form superior to that of *E. camaldulensis* (Darrow, 1981).

Conclusion

Differences among provenances of *Eucalyptus tereticornis* are more easily detected at earlier ages in total height than dbh. Since height is highly positively correlated with dbh and relative performance of the provenances at ages three, five and six years were essentially the same, early measurements of total height can be used for selecting among provenances of this species.

The North Queensland provenances, N. Laura, Cooktown and Mt. Garnet, excelled the other provenances in growth rate while the least growth rate was jointly exhibited by Mysore, Port Moresby and the unknown Papua New Guinea provenances. The North Queensland provenances are clearly the best material for any afforestation programme involving *E. tereticornis* in the Northern Guinea Savanna region of Nigeria.

However the Mysore provenance had hitherto mostly been used for afforestation programmes involving *E. tereticornis* in the region. Since this provenance has been identified as one of the slowest growing provenances of the species, suboptimal productivity should be expected from the plantations raised from seeds of the provenance. Since better material, the North Queensland provenances, has now been identified, it is hoped that the use of the Mysore provenance for raising plantations in this region will be discontinued. Moreover, the genetic improvement involving *E. tereticornis* in this region should be built around the North Queensland provenances.

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Variation in Seed Size of Acacia spp.

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Summary

In a study of Acacia species, the seed parameters of length, width and thickness of 23 genotypes were measured in millimeters. Analyses of the three traits showed significant species differences. The very low error variance component signified that the traits are highly heritable. The high %-contributions combined with the high species coefficient of variation indicated that seed size could be altered by selection and breeding.

The strong correlation between seed length and width indicated that improvement in one character would improve the other. The three seed parameters appear to be governed independently and the association between pairs of traits varied considerably.

Key words: Acacia spp., seed size, species variation, %-contributions.

Introduction

The species of Acacia commonly known as Kikkars are one of a group of important forest tree species in the arid and semi-arid regions of Northern India. They are multipurpose species which are included in agroforestry programs for increasing benefit to rural farmers. In efforts to produce seedlings for the planting programs, it was observed that: 1) Acacia seeds continued germination even after 160 days (when the experiment was concluded) from the date of seed sowing and even then some seeds remained viable; (2) Only approximately 20% of the seeds of *A. nilotica* produced healthy transplantable seedlings after 20 to 25 days from sowing; (3) bigger (heavier) seeds yield better seedling vigour. SHIV KUMAR and BANERJEE (1986) reported that the provenances of *A. nilotica* with heavier seed weight yielded plants with the best height and diameter) and (4) seeds of smaller size take longer to germinate. The protracted germination time requires longer nursery care and inhibits raising uniform seedlings for large scale plantations. With a view to this the present investigation on the variation in seed parameters and on the opportunities for improving them were taken up. The study has a direct relevance to the field forestry management. The seed size if improved will reduce the seed requirement and curtail the expenditure on seed procurement. Improved seed will require lower seed-rate and lesser seed-bed area reducing seed-sowing cost. Finally uniform germination with better seedling vigour will ensure lesser nursery management time thereby lessening the maintenance cost.

Materials and Methods

Seeds of 23 species/varieties of *Acacia* were obtained from different sources (*Table 1*). Out of these, three species (*A. nilotica* var. *nilotica, A. raddiana* and *A. catechu*) were obtained from two sources each. From the individual bulk collections of each species/variety 40 seeds in 4 batches (10 seeds per batch) were measured for length, width and thickness to the nearest tenth millimetre. The significance of the mean differences for the three traits were obtained with the help of range tests and bar diagrams. Species and error variance, species coefficient of variation, error coefficient of variation, %-contributions and correlation coefficients were estimated using the method of KEMPTHORNE (1957).

Results and Discussion

Of the 23 species and varieties mean length of seed varied between 5.0 mm and 15.42 mm, mean width between 3.64 mm and 12.3 mm, and mean thickness between 1.5 mm and 4.49 mm. Highly significant differences

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