STUDIES ON THE DROUGHT TOLERANCE OF *EUCALYPTUS* AT SEEDLING STAGE

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Received December 1993

VINAYA RAI, R.S., PARTHIBAN, K.T. & KUMARAVELU, G. 1995. Studies on the drought tolerance of *Eucalyptus* at seedling stage. The following techniques were evaluated in the screening of seedlings for drought tolerance in species of *Eucalyptus:* (i) stress induction at seedling stage, and (ii) chlorophyll stability index (CSI). There was no correspondence between these parameters and the suitability index derived from field performance. Of the six species evaluated (*E. tereticornis, E. microtheca, E. camaldulensis, E. drepanophylla, E. exserta* and *E. urophylla*), *E. camaldulensis* performed best in field testing. However, CSI was maximum in *E. urophylla* while resistance to moisture stress at seedling stage was highest in *E. drepanophylla* and *E. microtheca.* Both techniques are thus unsuitable for screening drought tolerance in the genus.

Key words: *Eucalyptus* spp. - chlorophyll - stability index - suitability index

VINAYA RAI, R.S., PARTHIBAN, K.T. & KUMARAVELU, G. 1995. Kajian tolerans kemarau bagi *Eucalyptus* pada peringkat anak pokok. Teknik-teknik berikut telah dikaji dalam penilaian anak-anak pokok untuk tolerans kemarau bagi spesies *Eucalyptus*: (i) induksi tekanan pada peringkat anak pokok, dan (ii) indeks kemantapan klorofil (CSI). Tidak terdapat kesamaan di antara parameter-parameter berikut dengan indeks kesesuaian yang diperolehi daripada lapangan. Antara keenam-enam spesies yang dikaji (*E. tereticornis, E. microtheca, E. camaldulensis, E. drepanophylla, E. exserta* dan *E. urophylla*), *E. camaldulensis* tumbuh paling baik di lapangan. Akan tetapi nilai CSI adalah maksimum dalam *E. urophylla* manakala ketahanan terhadap tekanan kelembapan pada peringkat anak pokok adalah paling tinggi dalam *E. drepanophylla.* Kedua-dua teknik tidak sesuai untuk menilai tolerans kemarau dalam genus tersebut.

Introduction

Eucalyptus is a multipurpose tree, yielding wood, shelter and honey (Chaubal & Kotmire 1986), oxalic acid (Prabhu & Theagarajan, 1977), essential oils (Sood *et al.* 1964, Verma *et al.* 1978, Theagarajan & Rao 1970), poles, posts and bridge timber (Jain 1969, Chaturvedi 1983) besides its well-known pulp and fuel. Its popularity

is mirrored by the fact that more than 80 countries have shown an interest in this genus, planting more than four million hectares outside its natural habitat (Anonymous 1986). Of the various species evaluated in India, *E. tereticornis* has performed best under a multitude of edapho-climatic situations having covered an area of 428 000 ha up to 1977 (Ghosh *et al.* 1977a). However, its yield is highly variable, ranging from as high as 80 t ha^{-1} in the padugais (river banks) to as low as 5 t ha^{-1} in poorer sites (Kondas & Venkatesan 1986). There is a need to identify suitable species/provenances for drought-prone areas (Krishnaswami *et al.* 1982). Field testing for such a study would be desirable. However, the cost and time involved in such studies are prohibitive. Chlorophyll stability index (CSI) has been used as an indicator of drought tolerance in pines (Koleyoreas 1958). The purpose of the present study was to test a few eucalypt species for drought tolerance in the juvenile stage and relate it to their field performance.

Materials and methods

Drought tolerance of seedlings

Seeds of six species of *Eucalyptus,* viz. *E. tereticornis, E.microtheca, E.camaldulensis , E.drepanophylla, E. exserta* and *E.urophylla,* were sown in plastic containers measuring 25 ×15 cm and holding 3.5 kg of sieved, dried mixture of field soil, sand and farm yard manure in the proportion 4:1:1. Local collection of *E. tereticornis* was included for comparison. Fifteen days after germination, the seedlings were thinned to one per container. Sixty days after sowing, the seedlings were subjected to 50 and 25 % field capacity (FC). Gypsum blocks were embedded in the pots at a depth of 10 cm and the soil moisture monitored with a soil moisture meter (ELICO DM 33). A FC of 100 % served as the control. Each treatment was replicated four times. Growth attributes such as seedling height, root collar diameter and leaf number per plant were recorded 60 and 75 days after stress induction.

Chlorophyll stability index

Chlorophyll stability index was assessed after Murty and Majumder (1962). Seedlings of the six *Eucalyptus* species were raised in polybags (20 × 15 cm), similar to Experiment (i), and leaf samples were collected from 30-day-old seedlings. Fresh leaves were comminuted and 1 g of the sample transferred to 25 ml of distilled water and heated at 65 ± 1°C over a water bath. The material was then extracted in 40 ml of 80% acetone in a blender for 5 min, filtered through Whatman No. 1 filter paper and colorimetric values of the extract read at 660 mm. Similar readings were obtained on the unheated control of each species. The difference between the two readings was designated as the CSI of the species. For each species four samples (replicates) were used to determine CSI.

Field performance of the species

The performance of the species in the nursery and pot experiments was tested and compared with field trials. Six-month-old containerised seedlings of the six species were field-planted in 30 cm^3 pits at a spacing of 2×2 m in plots measuring 14×14 m in a randomised block design with three replications. Survival, seedling height and basal diameter were recorded at six months after planting and the suitability index calculated as the summation of the percentage of their respective maxima, i.e. in each parameter the highest value was taken as a hundred and other values calculated relative to it. For each provenance, such values in respect of survival, height and diameter were summed up. This was its suitability index (Ghosh *et al.* 1981). Data were subjected to analysis of variance and treatment differences were tested with *t*-test for significance ($p < 0.05$) (Panse & Sukhatme 1967).

Results and discussion

Drought tolerance of seedlings

At 50% FC, no reduction relative to 100% FC was evident in plant height and root collar diameter 60 and 75 days after stress (Tables 1 & 2). Leaf number at 50% FC recorded a reduction of 29.6 % at 60 days after stress. At 25% FC, however, a reduction was evident in all the parameters at 60 and 75 days after stress induction. A comparison of growth attributes for 25% FC treatment with 100% FC treatment of 75 days after stress initiation indicated 37.6 % reduction in plant height, 44.8 % in root collar diameter and 46.0 % reduction in leaf number per plant. The two species which proved tolerant to stress at this stage by not manifesting any depression in either height or root coller diameter were *E. drepanophylla* and *E. microtheca.*

Chlorophyll stability index

Chlorophyll was highly stable in *E. exserta* and *E. urophylla* and more labile in *E.drepanophylla, E. camaldulensis* and *E.microtheca* (Table 3).

Table 1. Effect of various levels of moisture stress on seedling growth of six species of *Eucalyptus* 60 days after stress induction

Species	Seed lot No.**	Plant height (cm)			Root collar dia (mm)			Leaves plant^{-1}		
		100	50	25	100	50	25	100	50	25
E. tereticornis	23777	32.6	30.7	24.2	2.15	2.10	1.50	37.5	29.7	18.5
E. microtheca	12172	23.5	33.0	19.0	1.30	1.62	0.87	61.2	40.2	35.2
E. camaldulensis	12181	4.6	46.7	27.8	2.37	2.22	1.25	30.0	19.5	16.7
E. drepanophylla	11412	16.5	14.2	14.5	0.37	0.30	0.32	23.2	18.2	20.7
E. exserta	11000	32.2	19.0	14.5	1.72	0.92	1.02	48.5	34.2	28.0
E. urophylla	12899	24.0*	29.2*	17.5**	2.17*	2.37*	1.52**	33.0*	31.0*	17.0
E. tereticornis	PDKT*	30.0	30.2	24.2	2.32	2.07	1.60	36.7	18.0	20.5
Mean		29.2	29.0	20.2	1.77	1.66	1.15	38.6	27.2	22.3
			CD			CD			CD	
Stress (ST)			3.6			0.26			6.5	
Species (SP)			5.5			0.40			10.0	
ST x SP			ns			0.69			ns	

* PDKT : Pudukottai (Tamil Nadu),
**Refers to CSIRO, Australia source.

Table 2. Effect of various levels of moisture stress on seedling growth of six species of *Eucalyptus* 75 days after stress induction

Species	Seed lot No.**	Plant height (cm)			Root collar dia (mm)			Leaves plant^{-1}		
		100	50	25	100	50	25	100	50	25
E. tereticornis	12377	45.0	41.5	28.5	3.85	3.30	1.97	53.7	46.2	22.5
E. microtheca	12172	30.2	39.7	26.2	2.15	2.57	1.57	76.7	67.2	37.2
E. camaldulensis	12181	63.5	59.7	34.0	3.62	3.35	1.75	34.5	25.5	20.0
E. drepanophylla	11412	22.0	19.7	16.2	1.47	1.05	0.92	27.5	27.0	25.2
E. exserta	11000	37.5	23.7	15.5	2.25	1.50	1.20	52.5	37.7	29.2
E. urophylla	12899	29.7	37.2	20.2	2.50	2.80	1.40	45.2	53.0	22.2
E. tereticornis	PDKT*	40.7	38.2	27.0	2.95	2.52	1.57	45.2	25.2	25.0
Mean		38.3	27.1	23.9	2.68	2.44	1.48	47.9	40.2	25.9
			CD			CD			CD	
Stress (ST)			4.0			0.26			8.6	
Species (SP)			6.2			0.41			13.2	
ST x SP			10.8			0.72			ns	

* PDKT : Pudukottai (Tamil Nadu),
**Refers to CSIRO, Australia source.

Table. 3. Cholorophyll stability index (CSI) in seedlings of six species of *Eucalyptus*

Species	Seed lot No.	CSI
E. tereticornis	12377	12
E. microtheca	12172	15
C. camaldulensis	12181	16
E. drepanophylla	11412	21
E. exserta	11000	9
E. urophylla	12899	6
E. tereticornis	PDKT*	10
CD($p<0.05$)		4.6

Field performance

Under field testing, *E. camaldulensis* had the highest suitability index (Table 4). *E. urophylla* died six months after planting. The performance of other species was not better than that of the local *E. tereticornis.* In pot studies *E. drepanophylla* and *E. microtheca* were found to be tolerant to stress. CSI studies indicated that *E. exserta* and *E. urophylla* were stable. However, in field testing *E. camaldulensis* was found to be the best. Thus, there was no parallel between nursery or laboratory evaluations and field performance. Chlorophyll stability index was correlated with drought tolerance in pines (Koleyoreas 1958) and rice (Murty & Majumder 1962). However, the present study indicates that this parameter may not serve as a tool for similar prognosis in different species of *Eucalyptus* in view of the lack of correspondence between CSI values in the laboratory and the field. Juvenile response to moisture stress also did not reflect later growth under field conditions. Other techniques for early screening will have to be tested and standardised.

Table 4. Performance of six species of *Eucalyptus* six months after planting

Species	Seed lot No.	Survival (%)	Plant height (cm)	Basal diameter (mm)	Suitability index
E. tereticornis	12377	81.6(65.5)	45.4	4.48	183
E. microtheca	12172	89.8(71.5)	41.7	4.22	184
E. camaldulensis	12181	98.0(83.4)	71.4	6.83	255
E. drepanophylla	11412	85.0(67.9)	43.4	3.65	175
E. exserta	11000	51.7(46.1)	41.0	3.65	138
E. urophylla	12899	-	-	-	-
E. tereticornis		81.0(64.5)	61.5	5.88	216
CD		(9.3)	(16.5)	1.50	34

(Figures in parentheses are arc sin transformations).

In a comparison of 73 species of *Eucalyptus* at the Central Arid Zone Research Institute (CAZRI), Jodhpur, *E. camaldulensis* and *E. tereticornis* recorded maximum survival (Ghosh *et al.* 1977b). However, *E. camaldulensis* was reported to be more drought resistant than *E. tereticornis* (FAO 1979). The present study has shown the better adaptability to stress conditions of *E. camaldulensis* (seed lot No. 12181). The adaptability of this species to hostile situations is attributed to its capacity to form a massive root system under arid conditions (Awe *et al.* 1976).

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