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EFFECTS OF INITIAL SPACING AND THINNING ON YIELD AND BASIC DENSITY OF *EUCALYPTUS TERETICORNIS* AT LIWONDE, SOUTHERN MALAWI

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CHAPOLA, G. B. J., MWABUMBA, L. & KUYUMA, O.T. B. S. 1995. Effects of initial spacing and thinning on yield and basic density of *Eucalyptus tereticornis* at Liwonde, Southern Malawi. A *Eucalyptus tereticornis* initial spacing and thinning trial located at Liwonde, Southern Malawi, planted at square spacings of 1.2, 1.5, 1.8, 2.1, 2.4 and 2.7 m was assessed at the age of 2, 4 and 6 y. Assessment was made of diameter (at breast height), height, dominant height, basal area, basic density, crown (diameter and height) and survival. All the variables were significantly different due to spacing with the exception of survival, dominant height and crown height. Both thinning and spacing affected coppice diameter (at breast height) and height. Diameter, height, crown (height and diameter) increased with increasing spacing while standing volume and basal area showed decreasing trends with increasing spacing. After four years results showed that the closest spacings were promising in terms of volume production and basal area. Density was highest at a spacing of 2.4 m. The optimum spacings for volume and basal area after four years were 1.8 m and 1.2 m respectively. The implications of the results as a basis for decision-making on future spacing, coppicing and thinning regimes of *E. tereticornis* in dry lands of Malawi are discussed.

Key words: Initial spacing - thinning - coppicing - *Eucalyptus tereticornis* - dry lands - basic density - basal area - survival - yield

CHAPOLA, G.B.J., MWABUMBA, L. & KUYUMA, O.T.B.S. 1995. Kesan-kesan penjarakan dan penjarangan awal ke atas hasil dan ketumpatan asas *Eucalyptus tereticornis* di Liwonde, Malawi Selatan. *Eucalyptus tereticornis* di Liwonde, Malawi Selatan yang ditanam pada jarak segiempat iaitu 1.2, 1.5, 1.8, 2.1, 2.4 dan 2.7 m telah ditaksirkan pada umur 2,4 dan 6 tahun. Taksiran dibuat ke atas diameter (aras dada), ketinggian, ketinggian dominan, luas pangkal, ketumpatan asas, silara (diameter dan ketinggian) dan kemandirian. Kesemua pembolehubah ini adalah berbeza disebabkan oleh penjarakan dengan pengecualian kemandirian, ketinggian dominan dan ketinggian silara. Penjarangan dan penjarakan mempengaruhi diameter kopis (pada aras dada) dan ketinggian. Diameter, ketinggian, silara (ketinggian dan diameter) bertambah dengan pertambahan penjarakan manakala isipadu dirian dan pangkal menunjukkan kecenderungan penurunan dengan peningkatan penjarakan. Selepas empat tahun, keputusan-keputusan menunjukkan bahawa penjarakan yang paling dekat mempunyai harapan baik dari segi pengeluaran isipadu dan luas pangkal. Ketumpatan adalah paling tinggi pada penjarakan 2.4 m. Penjarakan optimum bagi isipadu dan luas pangkal selepas empat tahun masing-masing adalah 1.8 m dan 1.2 m. Implikasi keputusan sebagai asas untuk membuat keputusan bagi penjarakan di masa hadapan, regim-regim pengkopisan dan penjarangan *E. tereticornis* di tanah kering di Malawi telah dibincangkan.

Introduction

Eucalyptus tree planting started in Malawi some three decades ago. The decision was based on a few years of species/provenance trials. There were no trials on establishment and management (thinning, pruning and spacing) techniques and consequently these techniques were initially based on South African practice. South Africa was a natural choice because of her long experience with *Eucalyptus grandis,* which is commonly planted in higher and cooler elevations of Malawi. In general, spacing for eucalypts is based more on scientific literature and professional judgement than experimental results. It is believed that spacing closer than 2.0 × 2.0 m may be appropriate for domestic uses on sites with good water holding capacity.

In an effort to decelerate the depletion of indigenous forest resources largely due to increasing population growth (3.7% p.a.) and the strong land pressures from development of commercial interest in agriculture, the Forestry Research Institute of Malawi (FRIM) has embarked on a species screening programme to select widely adaptable and fast-growing species. *Eucalyptus camaldulensis* and *E. tereticornis,* but not *E. grandis,* were found to be suited for afforestation in the drier and lower elevations of Malawi (Nkaonja 1985). These are the areas where most of Malawian population live, and which are particularly hard hit by effects of deforestation (Venkatesh & Kananji 1985, Ngulube 1990). Currently these species are used in a nation-wide tree planting programme aimed at averting the dwindling forest resource for fuel wood and construction.

Spacings of these species varied from one forest project to another and even within the same project. However, for most fuelwood and pole forest projects the spacings ranged from 2.0 to 2.75 m. Knowledge of the effect of these practices on yield and wood quality is of importance in determining their appropriateness in this country, where, currently, such information is lacking for many species planted.

It is against this background that *E. tereticornis* spacing, thinning and coppicing trials were initiated to find their effects on survival, tree growth, yield and basic density. *E. tereticornis* was chosen for this trial due to its good performance in terms of growth and stem form in comparison to *E. camaldulensis.*

Material and methods

Site

The experiment was established along the boundry of Liwonde Forest Reserve (15° 18' S, 35° 18'E, 560 m above sea level), at the foot of Mongolwe Hills in Machinga District, during the long rains in December 1980/January 1981.

The original vegetation was miombo dominated by *Brachystegia* species. The site has fertile, well drained alluvial calcimorphic soils that are weakly acid to neutral (pH 5.5 - 7.0). Mean annual rainfall ranges from 840 - 960 mm while mean maximum temperature is 32 °C (October) and mean minimum temperature is 13 °C (July). The site lies in the silvicultural zone C as classified by Hardcastle (1978).

Treatments and experimental designs

The trial was a split plot randomized block design with three replications, six major treatments (spacings) and three minor treatments (unthinned, thinned and coppiced). The normal stock raised in the Forestry Research Institute of Malawi nursery, Zomba, from seed number 1657 (ex West Mareeba, Queensland, Australia) was used. Tending was by complete cultivation, and NPK, borate fertilizers and aldrin were applied in the nursery as per standard practice (Anonymous 1987).

Data collection methods on the effect of spacing, thinning and coppicing for the four years growth have been described by Ingram (1983, 1985). Diameter at breast height, i.e. 1.3 m above ground (dbh), and height of both seedling growth and coppice shoots were measured in each plot. Survival, dominant height, mean dbh and basal area were calculated. After four years, measurements of crown diameter and crown depth were assessed. Unthinned plots of the widest spacings (2.1, 2.4 and 2.7 m) were assessed as were the unthinned lines of the B plots. In all other plots measurements of height and crown depth were taken on the felled trees.

For every 20th tree in the wide spacings (2.1, 2.4 and 2.7 m) and 40th tree in the close spacings (1.2, 1.5 and 1.8 m), mid circumference (over and under bark) to 5 cm over height were measured. Standing volume was determined using the calculated volume/basal area ratio found in each spacing, (coppice and seedling stems were kept separate). All assessments were carried out on inner assessment plots leaving one buffer row around each plot.

The latest assessment was carried out in August-September 1986 (after 6 y) and involved the measuring of height and diameter (dbh) on a randomly selected sample of five trees from each of the wide spacings (2.1, 2.4 and 2.7 m) and management regimes (thinned and unthinned). The trees were felled and 5 cm thick discs were taken at diameter at breast height, 50% height and 75% height for basic density determination (Kuyama 1987).

Four wedges measuring 5 mm running from pith to bark at right angles to each other were cut from each disc and soaked in distilled water to fibre saturation point under simple vacuum for three days. The fully saturated wedges were lightly blotted and immediately weighed. The wedges were then dried in an oven at 103 ± 2 °C to constant weight and the oven-dry weight of each wedge was recorded. Basic density was calculated as follows:

$$\text{Basic density} = M_o/[M_o/G_{so} + (M_1 - M_o)/P_w]$$

Where M_o is oven dry mass
M_1 is water saturated specimen mass
G_{so} is cell wall density assumed constant at 1500 kg m^{-3}
P_w is density of water as 1000 kg m^{-3} at 4 °C

All the data collected were subjected to analysis of variance and significant treatment differences were tested for least significance. Survival data were transformed by arcsine transformation before analysis.

Results and discussion

Survival, tree growth and yield

Table 1 summarizes data on survival, diameter at breast height (dbh), mean height, dominant height, basal area, standing volume, crown depth, crown height and crown diameter. Spacing had significant effect on dbh, height, basal area, standing volume and crown height which is in agreement with the conclusions in extensive literature on spacing (Daniels & Schutz 1975).

Mean dbh, height, crown depth and crown diameter generally increased with spacing except at 2.1 m spacing where there was a depression for the first three parameters. These findings concur with the results of Malimbwi *et al.* (1992). Standing volume and basal area showed a decreasing trend with increasing spacing as observed by Evert (1971), and Hamilton and Christies (1974).

The mean height increment in 1982 - 83 in the unthinned plots and coppice height from thinned and clear felled trees (at two years old) were significantly affected by spacing (Tables 2 and 3). Height increment showed no clear pattern in 1981- 82 and 1983 - 84, but results of 1982-83 revealed that height increment more or less increased with increasing spacing (Figure 1). There were no significant differences in height between thinning and clear felled coppice (at age of two years) (Table 3).

Table 1. Effect of spacing on survival, diameter at breast height, mean height, dominant height, basal area, volume, crown depth %, crown height, crown diameter and crown depth in the unthinned plots of *E. tereticornis* at Liwonde, Southern Malawi

	Spacing (m)						
	1.2	1.5	1.8	2.1	2.4	2.7	ANOVA
Survival, tree growth and yield at age of four years							
Survival %	89	95	95	91	98	94	ns
Dbh (cm)	5.5 c[a]	6.4 c	7.6 b	7.4 bc	8.2 ab	8.9 a	**
Mean height (m)	7.7 bc	9.1 ab	9.3 a	8.0 bc	9.3 a	9.2 a	*
Dominant height (m)	10.0	10.3	11.1	10.2	10.8	11.1	ns
Basal area (m^2 ha^{-1})	14.7 a	13.2 a	13.4 a	9.2 ab	9.0 b	8.1 b	**
Volume (m^3 ha^{-1})	59.6 a	53.5 a	56.5 a	36.5 b	36.6 ab	33.8 b	**
Crown depth %	50.6 c	50.6 c	54.0 ab	51.6 bc	54.7 a	56.1 a	**
Crown height (m)[b]	2.9	3.2	3.8	3.4	3.3	3.1	ns
Crown diameter (m)	1.1 c	1.4 b	1.4 b	1.5 b	1.6 b	1.9 a	**
Crown depth (m)[c]	4.5 b	4.7 b	6.3 a	5.6 ab	6.5 a	6.7 a	**

[a] Within the same row, values followed by the same letter are not significantly different ($p<0.05$), l.s.d. test.
[b] Height from ground to the beginning of the crown;
[c] Height from the beginning of the crown to the top of the tree;
Significance: *, $0.01<p<0.05$; **, $0.001<p<0.01$; ns, not significantly different.

Table 2 Effect of spacing on mean height and basal area increments in the unthinned plots of *E. tereticornis*

Spacing (m)	Mean height increment (m)			Mean basal area increment (m^2 ha^{-1})	
	1981-82	1982-83	1983-84	1982-83	1983-84
1.2	2.6	1.9 c	1.8	4.3	6.7 a
1.5	2.8	2.2 c	2.2	3.9	6.4 a
1.8	3.2	2.9 b	2.2	4.8	5.0 b
2.1	2.8	3.1 ab	1.9	3.8	4.3 bc
2.4	3.0	2.9 b	2.6	3.5	3.9 cd
2.7	3.0	3.3 a	2.0	3.6	3.3 c
Anova	ns	**	ns	ns	**

* Within the same column, values followed by the same letter are not significantly different ($p<0.05$).
Significance: **, $0.001<p<0.01$; ns, not significantly different.

Crown diameter and depth were significantly different (Table 1). Eucalypts are crown shy trees, their crowns do not interlock because they have naked buds on their shoot tips which suffer physical damage when in contact with other shoots (Jacob 1955). Therefore, the differences in crown diameter can be attributed to this factor. Height growth took place mainly between November and June and major difference arose in 1983 which had poor rains. This can be explained by moisture stress, which would be greater in close spacing than in canopy competition. The limitations on crown diameter within the physiological limits of the species are probably due to spacing and amount of wind sway experienced by the stems.

Table 3. Effects of spacing, thinning and coppicing regimes on mean diameter at breast height, height, cumulative basal area and standing volume at 2 and 4 y growth of *E. tereticornis* at Liwonde, Southern Malawi

Regime		Spacing (m)			
		1.2	1.5	1.8	Mean
Diameter (cm)	A-unthinned	5.4	6.4	7.6	6.5
	B-thinned	6.2	7.2	8.8	7.1
	Mean	5.8	6.8	7.8	
Coppice dbh (cm) (2 y)	B-under std	2.7	3.0	3.6	3.1
	C-clearfelled	3.3	3.7	4.3	3.6
	Mean	3.0 a	3.3a	3.9 b*	
Coppice height (m) (2 y)	B-under std	4.7	4.9	5.4	5.0
	C-clearfelled	5.4	5.4	6.0	5.6
	Mean	5.0 a	5.2 a	5.7 b	
Cumulative basal area (m^2 ha^{-1}) (4 y)	A-unthinned	14.7	13.2	13.4	13.8 b
	B-thinned	13.4	11.9	10.6	12.0 a
	C-clearfelled	13.0	11.5	9.6	11.4 a
	Mean	13.7 a	12.2 ab	11.2 b	12.4
Basal area movement (m^2 ha^{-1})	A-unthinned	10.5	9.5	9.8	10.0 b
	B-thinned	8.9	8.4	7.2	8.2 a
	C-clearfelled	8.1	7.1	6.4	7.2 a
	Mean	9.2	8.4	7.8	8.4
Cumulative volume production at 4 y (m^3 ha^{-1})	A-unthinned	61.6	55.6	56.3	57.8
	B-thinned	52.5	46.7	41.9	47.0
	C-clearfelled	43.6	38.6	32.4	38.2
	Mean	52.6	47.0	43.5	47.7
Volume (m^3 ha^{-1})	A-unthinned	47.8	43.8	46.4	46.0 b
	B-thinned	37.5	85.6	32.5	35.2 a
	C-clearfelled	27.4	54.5	23.7	25.2 a
	Mean	37.6	34.7	34.2	35.4

*Within the same column and row, values followed by the same letter are not significantly different ($p<0.05$), l.s.d. test.

Initial coppice height growth was rapid when compared to seedling growth in the same plots at equivalent ages (Ingram 1985). In the second year rapid seedling height growth was experienced compared to coppice height growth. The first year rapid coppice height growth can probably be explained by the fact that coppices had more highly developed roots than seedlings.

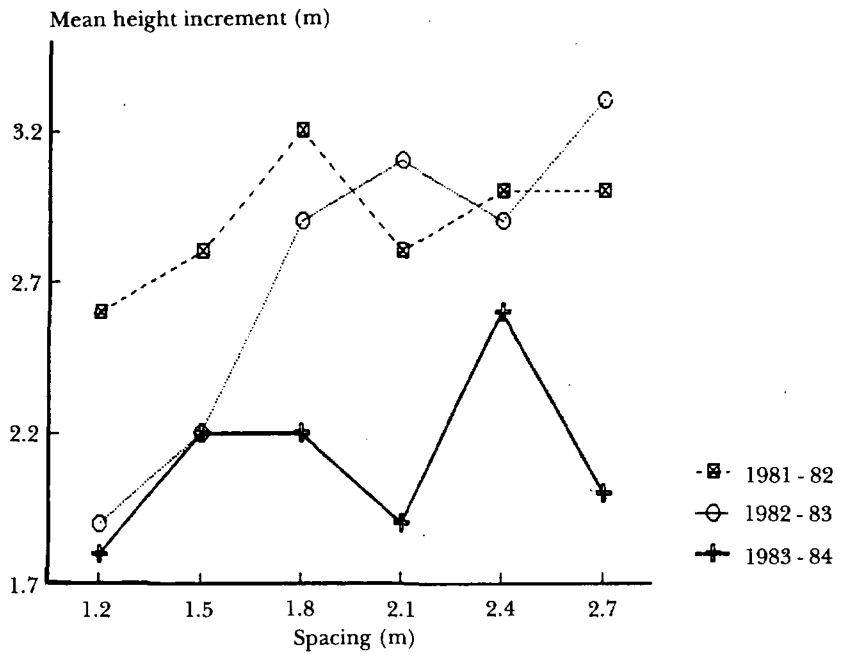

Figure 1. Effect of spacing on mean height increment at diferent periods (unthinned)

Diameter at breast height, basal area and volume were significantly different due to spacing while cumulative volume was not. Reducing spacing increased basal area. The effect of spacing on basal area increment in the unthinned plots was especially pronounced in 1983 - 84 compared to 1982 - 83 (Table 2, Figure 2). The decrease in diameter can be ascribed to the fact that the resources (nutrients) not used in stem thickening are available for height growth which is important for light interception and survival (Forward & Nolan 1961). Another way to increase relative growth in the upper position of stems is to prune (Larson 1963, 1965). The increase in basal area indicates the increase in mean annual volume increment (MAI). Since maximum MAI may not have been reached, the actual point of maximum MAI could not be determined from this trial, as all plots in the three closest spacing were felled.

Estimated cumulative basal area and volume production for all plots in the three closest spacings up to November 1984 and total production consisting of the standing volumes at the date of clear felling in November 1982 were determined (production from coppice reduction operation was excluded as this was very small). Volume/basal area ratios were determined and the overall averages for all treatments are as follows:

Seedling trees at November 1982 (2 y) 3.1 m^3 m^{-2}
Seedling trees at November 1984 (4 y) 4.2 m^3 m^{-2}
Coppice trees at November 1984 (2 y) 3.5 m^3 m^{-2}

The differences between these ratios arise from age and relative growth rates (Table 2). With large basal area per hectare and small mean height in closer spacing, the higher volume per hectare observed may also be ascribed to better form factors as the stems are more cylindrical than in wider spacings (Kalaghe 1981, Malimbwi *et al.* 1992). Compared with studies done elsewhere in species of different genera (Hamilton & Christie 1974, Malimbwi *et al.* 1992), there are some similarities in the response of *E. tereticornis* to spacing. These similarities include:

a) greater total standing volume production in closer spacings;
b) greater diameter growth in wider spacing;
c) greater basal area in closer spacing;
d) greater crown diameters and depth in wider spacing.

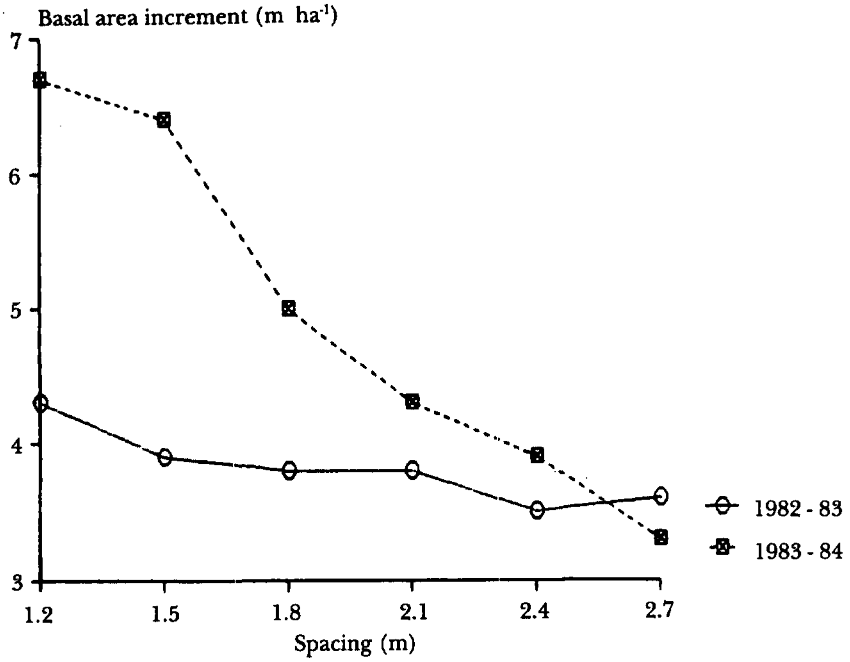

Figure 2. Effect of spacing on basal area increment at different periods (unthinned)

The mean crown diameters were expressed as proportions of spacing and the crown area as proportions of maximum potential canopy area. The 1.2 and 1.5 m spacings were approaching maximum potential crown diameter and were probably at the actual maximum, allowing for wind sway (Figure 3). Crown diameter and spacing ratio dropped from the 1.8 m spacing to reach an approximately constant level in the wider spacing and it is probable that wind sway was the limiting factor. The close spacings reduced wind sway benefiting from mutual shelter and in the 1.2 and 1.5 m spacings the lower mean heights may also be a contributory factor. At the age of 4 y, however, the closer spacings gave distinct greater canopy area as would be expected.

The tree crown dimensions data were subjected to single linear regression analysis using overall means from the unthinned and thinned plots from the 1.2 m and 1.8 m spacings and all plots for the wider spacings. Strong regressions were observed in all the parameters as shown below:

Height	=	2.39 + 1.14 crown depth	r^2 = .80**
Height	=	4.50 + 2.99 crown diameter	r^2 = .56**
Dbh	=	1.46 - height 0.79	r^2 = .86**
Dbh	=	0.66 + 4.67 crown diameter	r^2 = .69**
Dbh	=	1.13 crown depth - 2.49	r^2 = .79**
Crown diameter	=	0.26 crown depth	r^2 = .69**

(** $0.001 < p < 0.01$)

Diameter appears more closely related to crown dimension than mean height and the latter parameter is possibly related to crown diameter through the relationship with dbh.

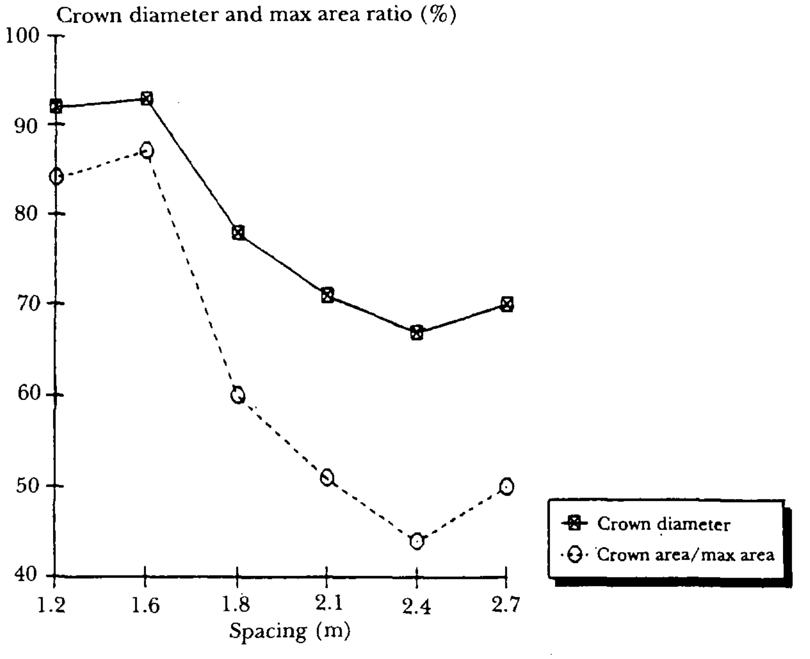

Figure 3. Effect of spacing on crown diameter and crown area/maximum crown area ratio of *Eucalyptus tereticornis*

Analysis of variance of crown diameter/dbh and crown depth/dbh ratio in June and November 1984 was carried out on the "A" plots and results gave no significant differences, thus confirming the regression results that spacing has little if any effect on these ratios. The implications of these results is that the closest spacings were approaching the theoretical maximum basal area, and hence maximum MAI. No significant differences were observed in crown depth/dbh ratios due to spacing or management treatments (thinned and clearfelled), but the interaction was significant ($p < 0.05$). The source of the interaction is the reverse of the order of treatments in the 1.2 m spacing. It is not clear what caused this feature nor its practical significance, if any.

Basic density of wood

Results of the effect of spacing and thinning on diameter and basic density of wood of 6-y-old *E. tereticornis* trees are presented in Tables 4 and 5 respectively. Spacing significantly influenced basic density in unthinned wood which increased when spacing was increased from 2.1 m to 2.4 m, then decreased after 2.4 m. This was true at all height levels (Table 5). The crown diameter/spacing ratio and crown area/maximum canopy ratio were 71% and 51% respectively at the age of four years (Figure 1). At six years, canopy is expected to be almost closed, resulting in competition for nutrients and sunlight. Stress growth as a result of moisture stress and plant competition results in starvation wood which is known to be lighter than normal wood (Gashumba & Klem 1982). This can be attributed to the findings here at the spacing of 2.1 m. When diameter (thinned and unthinned) was correlated to basic density (thinned and unthinned), diameter (unthinned) was positively correlated to basic density (unthinned) ($r= 0.65$, $0.001<p<0.01$), while in thinned plots this relationship was not statistically significant. Malan and Hoon (1992) found that in *E. grandis* density variation pattern is significantly affected by the degree of suppression, having pronounced inverse effect on wood formation. Therefore, these results suggest that this relationship might not be true in thinning regimes, which can be attributed to different response of individual trees on the thinned plots (at different spacings) in putting up mature wood. Basic density of wood is directly related to dry matter production. Results obtained here imply that within the range of spacing studied, basic density and dry matter would be increased by wide spacing and beyond a certain level it begins to decline.

High growth rates in thinned plots were observed at the spacing of 2.4 m (Table 4). Increased bending stress imposed by the wind promotes wood growth of great torsion (Valinger 1992). The narrow crowns at the spacing of 2.4 m and high heights might have allowed wind sway which resulted in the production of reaction wood at the middle of the stems. Therefore, this might have resulted in high mean density. This can also be the possible explanation for high densities at 50% height level (Table 5).

Table 4. Diameter of 6-y-old unthinned and thinned *E. tereticornis* at Liwonde

Spacing(m)	Diameter at breast height (cm)	
	Unthinned	Thinned
2.1	7.8 b	8.0 b
2.4	8.7 a	9.1 a
2.7	8.3 ab	9.5 a
C.V.	7.9	9.1

Within the same column values followed by the same letter are not significantly different.

Table 5. Effect of axial position on basic density of 6-y-old unthinned and thinned *E. tereticornis* wood at three spacing levels at Liwonde

Spacing (m)	Height	Basic density (kg m^{-3})	
		Unthinned	Thinned
	dbh	555 a	547 a
2.1	50%	548 a	541 a
	75%	532 b	523 b
	Mean	545	538
	C.V.	7.2	7.9
	Anova	**	**
	dbh	585 a	560
2.4	50%	581 a	566
	75%	564 b	548
	Mean	577	558
	C.V.	7.9	7.2
	Anova	**	ns
	dbh	561	556 a
2.7	50%	553	535 b
	75%	548	533 b
	Mean	554	542
	C.V.	8.0	9.8
	Anova	ns	*

Within the same column values followed by the same letter are not significantly different; significance: ns, not significantly different; *, $0.01<p<0.05$; **, $0.001<p<0.01$.

Panshin *et al.* (1964) found that in comparison to close spacing, wide spacing results in higher proportions of juvenile wood in the tree stem, larger and more frequent knots and larger taper. Juvenile wood has low density and strength properties. This could be the possible explanation for the low density in wide spacing (2.7 m). The proportions of juvenile wood and taper were not assessed in this study. The 2.4 m seems to produce wood which falls within the optimum basic density for 6 y rotation and this could be adopted for 8 y rotation age (Anonymous 1987).

Thinning as a management practice had a significant influence on basic density, by decreasing basic density in all spacings in the trial. A decrease in basic density with stem height was evident. Thinning increases spacing; therefore, there is reduction of basic density of wood by thinning regimes. Thinning is known to enhance growth, hence the reduced density can be attributed to contiguous development of juvenile wood in the stem.

Density at different heights varied significantly in all spacing and thinning regimes with the exception of thinned plots at spacing of 2.4 m and unthinned plots at spacing of 2.7 m. Basic density decreased with increasing height for both spacing and thinning. Regardless of the effect of thinning and spacing there was a gradual decrease in density from dbh to 50% of height, followed by a rapid decrease after 50% of height (Table 5). Wood formed in the crown is juvenile wood (Larson 1969, Kowlowski 1971). Therefore the decrease of basic density with height can be attributed to the increased proportion of juvenile wood with increase in height of the stem. This concurs with the findings of Chapola and Ngulube (1990).

Management implications

The significant effect of spacing on basic density observed here imply that management decisions could not be safely based on morphological and yield attributes alone. Brazier (1977) reported a decrease in basic density of wood with increasing spacing in Sitka spruce. This is contrary to the findings of this study where the departure from 2.4 m to 2.1 m or 2.7 m produced wood of low density. This implies that in order to produce wood of high strength properties 2.4 m spacing has to be adopted. With high volume production rate, close spacing should be considered where maximum biomass production without regard to quality (juvenile wood percentage) and tree size is the major objective of plantation, e.g. fuelwood. Although very close spacings at establishment of plantation are expensive and very wide ones grossly underuse the site (Evans 1982), in this country where land available for afforestation is marginal and limited, close spacing might be the best to adopt for fuelwood and polewood. Close planting ensures full stocking on a site and fullest use of its potential, which is not only efficient land use, but the high volume per hectare which results reduces harvesting cost.

The situation in the Wood Energy Project is that thinning operations are generally not done due to short rotation age and limited funds. Thinning had a negative effect on basic density. Evans (1982) reported that thinning results in the increase in juvenile wood and slightly less dense wood. This implies that in order to produce wood of high strength properties with reasonably good form, "no thinning" regime should be adopted. However, because of the generally available dead, moribund, diseased and suppressed trees in the forests, there is scope for light thinning to improve the growth and hygiene of the trees in the forests. Although no comparison was done between coppice and seedling at the age of six years, earlier results of basic density by Ingram (1985) showed no major differences at the age of two years.

Close spacing and no thinning did not cause significant mortality. Therefore, with maximum biomass production (fuelwood) and strong and straight poles (polewood) as the major objectives of our wood energy project in dry areas, close spacing and "no thinning" regimes have to be considered with regard to short rotation used in this country. This will also reduce the cost of managing wood lots.

Where practicable and where crops are grown on short rotations, regeneration from shoots (i.e. coppicing) is important. The fast coppice growth from both clear felled, thinned and unthinned tree stumps show the importance of practising this management technique. Spacing, thinning and coppicing though influencing wood quality in a small way, largely affect growth rate. Therefore, the real choice of these practices should be made according to the dictates of end-uses and economics.

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