INFLUENCE OF SPACING ON GROWTH AND YIELD OF *TECTONA GRANDIS* LINN. F. (TEAK) AND *TERMINALIA SUPERBA* ENGL. & DIELS (AFARA)

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OLA-ADAMS, B.A. 1990. Influence of spacing on growth and yield of *Tectona grandis* Linn. f. (teak) and *Terminalia superba* Engl. & Diels (afara). The effects of spacing in relation to growth and wood production in 18-y-old *Tectona grandis* (teak) and 13-y-old *Terminalia superba* (afara) were investigated in trial plots established at Gambari Forest Reserve, southwestern Nigeria. The following spacing regimes were investigated in the *Tectona grandis* stand: 1.37 × 1.37 *m*, 1.98 × 1.98 *m*, 2.9 × 2.9 *m* and 3.96 × 3.96 *m*. For *Terminalia superba*, the spacing regimes investigated were 1.8 × 1.8 *m*, 2.8 × 2.8 *m*, 4.2 × 4.2 *m* and 6.1 × 6.1 *m*. The results showed that in both species percentage survival, diameter at breast height (dbh) and specific gravity increased with increasing espacement while merchantable height, stem volume and basal area decreased with increasing espacement.

From the results of the present and previous studies, the planting espacement in the high forest zone for *Tectona grandis* should not be less than 2.44 × 2.44 *m* or more than 2.9 × 2.9 *m*, while *Terminalia superba* should be planted no less than 4.2 × 4.2 *m* or more than 5 × 5 *m*. The planting espacement at 5 × 5 *m* will improve stem form and growth.

Key words: Spacing - *Tectona grandis* - *Terminalia superba* - tree growth - wood production

Introduction

Large scale plantations of some indigenous and exotic tree species are being established in Nigeria in order to meet the increasing demands for wood. Spacing trials were established to try to determine the required spacings at which the various species should be planted for optimum growth. Planting espacement has a considerable effect on stand development, tree form and growth rate (Lowe 1971) and can influence the value and marketability of timber produced. It is necessary to determine which planting spacings promote early canopy closure to control weed growth, reduce coarse branching and optimise wood production.

Studies carried out in Nigeria have been mainly on *Tectona grandis* (Lowe 1971, Abayomi 1977, Adegbehin 1982), *Terminalia ivorensis* (Lowe 1971), *Triplochiton sclerexylon* (Anonymous 1979), *Gmelina arborea* (Okorie 1981), *Cedrela*

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odorata (Odigie 1983), *Pinus caribaea* and *Pinus oocarpa* (Obiaga 1984) and *Terminalia superba* (Oji & Nwaigbo 1984). The studies by Oji and Nwaigbo (1984) were caried out at I Ukpom Bende, Awi and Ikom, all in southeastern Nigeria.

I studied the effects of spacing regime on growth and wood volume production of *Tectona grandis* and *Terminalia superba* in Gambari Forest Reserve of Oyo State in the southwest of Nigeria.

Study area and method

Study area

The experimental plots are located at Gambari Forest Reserve (7° 23'N, 3° 33'E) in Oyo State of southwestern Nigeria. The topography tends to be undulating. The mean daily maximum and minimum temperatures are 30.6°*C* and 20.8°*C* respectively, mean monthly rainfall 10.34 *mm*, mean relative humidity at 10:00 and 16:00, 79 and 69% respectively. The soil parent material is crystalline rocks of undifferentiated basement complex, intruded by granites, gneisses, quartsite and schists (Anonymous 1957). The soil is well drained with reddish brown loamy sand in the top soil and brown stony and gravelly clay in the subsoil. Large quantities of angular quartz, gravels and iron concretions are present in the subsoil. The topsoil is slightly alkaline (pH 7 - 7.5) progressive to slightly acidic in the subsoil (pH 6.0 - 6.5).

Each spacing trial is a 4 × 4 Latin square with plots 40.23 m^2. Each plot is 0.16 *ha*. In the case of *Terminalia*, the following spacing established by taungya in 1971 were sampled: 1.8 × 1.8 *m*, 2.8 × 2.8 *m*, 4.2 × 4.2 *m* and 6.1 × 6.1 *m*. The corresponding number of trees per hectare for the above spacings were approximately 3086, 1271, 567 and 268 respectively. Teak spacing trial was established in 1966. The plots sampled for comparisons of growth of teak were square spacings of 1.37 × 1.37 *m*, 1.98 × 1.98 *m*, 2.9 × 2.9 *m* and 3.96 × 3.96 *m* respectively. The corresponding numbers of trees per hectare for the above spacings were approximatly 5102, 2500, 1189 and 638 respectively.

Sampling

Within each spacing trial, all living trees in each replicate were recorded, and numberd with red enamel paint. The girth at breast height (at 1.3 *m* above ground level) of all living trees was measured to the nearest 0.1 *cm* with a girthing tape. Merchantable height (*i.e.* tree height to the first branching) and total height were measured using the method of Horne (1962). The survival percentage was the proportion of surviving standing trees to the total loci planted; average survival percentage was obtained by dividing by the number of replicates for each spacing treatment. Mean plot values of the survival percentages were transformed by arcsin transformation before analysis of variance. For volume determination, sectional girth and bark thickness measurements were taken at 1.5 *m* intervals or less. The sum of the sectional volumes gave the total stem volume.

For determination of crown diameter, specific gravity and leaf area, ten trees from each spacing were selected on the basis of proportional allocation using the girth frequency classes as strata. The crown diameter was determined using the method of Dawkins (1963). Twenty leaves from the crown profile of each tree were sampled for the determination of leaf area. Each leaf outline was traced out on a paper and leaf area determined by hand planimeter. Specific gravity was determined by the water displacement method (Paul 1946).

Results and discussion

The trees within the various spacings varied in their dimensions for both teak and *Terminalia* (Tables 1 & 2). Such variations had been observed in studies in various monocultures (Forrest & Ovington 1970, Egunjobi 1975, Ola-Adams 1978). The variations may be attributed to genetic differences of the trees, late planting of some of the trees to replace those that died at the initial stage of the plantation establishment, and to soil variation. Bunting (1976) suggested that, in a single species stand, important variations developed bet ween individuals due, not only to random variation in the specific environment particularly in the soil to which individuals had access but also partly on heritable physiological basis such as differences in seed size and rate of initiation and expansion of new leaf and bud primodia.

The mean percentage survival increased with planting spacement in both species, though not significantly in *Terminalia*. The higher mortality rates under the closer spacings may be due to competition which sets in earlier in the closer spacings. Hamilton and Christie (1974) made similar observations in Scots pine, Sitka spruce, European larch, Japanese larch and Douglas fir.

There were significant differences in mean girth in both species. Planting espacement contributed 11.2 and 25.0% of the overall variation observed in mean girth in teak and *Terminalia*, respectively. In both species, also, mean merchantable bole appeared to decrease with increasing espacement, though not significantly in *Terminalia*. There was not much difference between spacings in mean total height in teak but *Terminalia* showed significant differences in mean total height with increasing spacing. Increase in girth with increasing espacement might be that trees at wider spacing were maintaining the early advantage gained through possession of more growing space for crown and root development before crown closure as a result of reduced competition. Differences in height might be due to varied genetypes and enhanced early development. Closer spacings could have been marginally more successful in suppressing competing vegetation to attain greater merchantable height. The variations in volume, basal area, crown diameter, leaf area and specific gravity are shown in Table 3.

Table 1. The variations in percentage survival, girth, merchantable and total heights in *Tectona grandis* at Gambari Forest Reserve

Growth parameters	1.37 x 1.37 *m*					1.98 x 1.98 *m*				
	Replicates									
	1	2	3	4	Mean	1	2	3	4	Mean
Percentage survival (%)	25.25	26.84	29.66	34.07	28.96	55.21	42.13	43.58	47.94	47.22
Mean girth (*cm*)	57.32	55.05	55.56	56.90	56.21	59.20	60.08	62.27	60.81	60.59
Mean merchantable height (*m*)	9.41	9.36	9.18	9.30	9.31	9.33	9.45	9.09	8.47	9.09
Mean total height (*m*)	13.59	13.48	13.24	13.16	13.36	13.73	12.78	13.77	13.16	13.36
Growth parameters	2.9 x 2.9 *m*					3.96 x 3.96 *m*				
	Replicates									
	1	2	3	4	Mean	1	2	3	4	Mean
Percentage survival (%)	57.22	62.89	49.48	58.76	57.09	75.49	55.88	70.59	59.80	65.44
Mean girth (*cm*)	71.37	73.79	73.71	76.27	73.79	85.08	75.46	86.98	85.46	83.25
Mean merchantable height (*m*)	7.83	9.17	7.81	8.46	8.32	8.05	7.10	7.59	7.30	7.51
Mean total height (*m*)	12.95	13.82	13.30	13.95	13.51	14.99	12.98	13.25	13.37	13.65

The mean volume per tree increased with planting espacement. Analysis of variance showed that there were significant differences in basal area ($F_{0.01}$ = 16.59 teak; $F_{0.01}$ = 16.25 *Terminalia*). Spacing contributed 79.58% of the variations observed in basal area in teak and 79.23% of the variations observed in *Terminalia*. There were no significant differences between leaf area and crown diameter in both teak and *Terminalia* as a result of spacing. However, there were significant differences in specific gravity between spacing ($F_{0.05}$ = 3.00 teak; $F_{0.01}$ = 16.25 *Terminalia*). The differences in specific gravity in both species might be due to vigour and variations in rings of fibre length and of proportion of fibre and vessels. These factors have been observed to affect density and specific gravity in wood (Brazier 1970, Jane 1970, Kozlowski 1971).

Table 2. The variations in percentage survival, girth merchantable and total heights in *Terminalia superba* at Gambari Forest Reserve

Growth parameters	1.8 x 1.8 *m*					2.8 x 2.8 *m*				
	Replicates									
	1	2	3	4	Mean	1	2	3	4	Mean
Percentage survival (%)	55.17	50.00	57.85	42.56	51.39	68.84	65.58	42.33	73.95	62.67
Mean girth (*cm*)	26.1	36.2	35.2	35.8	33.48	46.0	42.4	45.6	48.2	45.55
Mean merchantable height (*m*)	9.5	8.9	9.2	9.4	9.25	9.1	8.8	9.6	8.9	9.1
Mean total height (*m*)	9.9	8.8	8.3	8.6	8.90	9.9	9.4	9.4	9.9	9.65
Growth parameters	**4.2 x 4.2 *m***					**6.1 x 6.1 *m***				
	Replicates									
	1	**2**	**3**	**4**	**Mean**	**1**	**2**	**3**	**4**	**Mean**
Percentage survival (%)	79.78	50.56	77.53	56.18	64.86	68.18	79.55	52.27	84.09	71.02
Mean girth (*cm*)	70.0	55.9	61.6	55.4	60.73	76.8	65.5	72.6	52.8	66.93
Mean merchantable height (*m*)	11.4	8.2	8.5	9.1	9.3	7.9	7.7	8.7	7.4	7.93
Mean total height (*m*)	10.5	10.6	10.3	10.4	10.45	12.5	10.6	11.6	9.8	11.08

Table 3. Variations in volume, basal area, crown diameter, specific gravity and form factor in *Tectona grandis* and *Terminalia superba*

Spacing parameters	*Tectona grandis*			
	1.37 x 1.37 *m*	1.98 x 1.98 *m*	2.9 x 2.9 *m*	3.96 x 3.96 *m*
Volume underbark (m^3 ha^{-1})	269.06	285.63	263.98	177.70
Basal area (m^2 ha^{-1})	37.71	38.44	38.42	26.72
Crown diameter (*m*)	3.62	3.76	3.34	4.29
Form factor	0.447	0.383	0.393	0.370
Specific gravity	0.45	0.46	0.41	0.43
	Terminalia superba			
	1.8 x 1.8 *m*	**2.8 x 2.8 *m***	**4.2 x 4.2 *m***	**6.1 x 6.1 *m***
Volume underbark (m^3 ha^{-1})	164.16	152.46	116.57	85.98
Basal area (m^2 ha^{-1})	21.70	18.39	13.05	9.62
Crown diameter (*m*)	4.75	4.81	5.71	6.59
Form factor	0.483	0.477	0.532	0.512
Specific gravity	0.45	0.43	0.46	0.42

Conclusion

The present study confirmed the observation by Abayomi (1977) and Oji and Nwaigbo (1984) that planting espacement had a very positive relationship with diameter growth and a very strong negative relationship with volume and basal area in teak and *Terminalia.* Abayomi (1977) suggested that 2.9 × 2.9 *m* spacing appeared to give the best result in teak. The results of the present study and other studies appeared to justify the usual planting espacement of 2.44 × 2.44 *m* for teak in the high forest areas.

From the present study, there was not much difference between mean girth and distribution of girth classes on the two wider spacings (4.1 × 4.1 *m* and 6.1 × 6.1 *m*) in *Terminalia* in Gambari Forest Reserve. Oji and Nwaigbo (1984) showed that stem diameter growth of *Terminalia* did not increase significantly beyond the 5.0 × 5.0 *m* espacement in southeastern Nigeria. These studies confirmed the observation by Lowe (1971) that 5.0 × 5.0 *m* espacement was adequate for *Terminalia* at Gambari Forest Reserve.

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