GROWTH AND YIELDS OF *PINUS OOCARPA* SCHIEDE IN SOME PARTS OF NORTHERN NIGERIA

J.O. Adegbehin*

Abstract

Trial plantings of exotic tree species commenced in some parts of northern Nigeria over 40 years ago. Based on data from permanent sample and temporary plots, site index curves and yield tables were constructed for *Pinus oocarpa*, one of the promising exotics tried. The constructed site index curves revealed five (5) site classes at a reference age of 20 years; viz: I (24.9m); II (22.5m); III (20.1m); IV (17.7m) and V (15.3m). The growth figures derived from the yield classes resulting from the five site index classes revealed that the maximum current annual increment (MCAI) was attained between the ages of 9.3 – 13.7 years with a total volume production (TVP) of between 88 – 208 m^3/ha (volume over-bark to 7.5 cm diameter top). The maximum mean annual increment (MMAI) was attained at age 16 – 20 years for the five classes, with a TVP of about 442 m^3/ha for class I; 374 m^3/ha for class II; 290 m^3/ha for class III; 209 m^3/ha for class IV and 153 m^3/ha for class V. Among other things discussed was the application of the resulting growth figures in the management of the species.

Introduction

Intensive growth and provenance trials of pines as well other exotic tree species commenced in the savanna region of Nigeria in the late 1950's. Such efforts were directed at meeting the demand for wood and wood products and in the savanna region also to provide shelter for food crops and prevent desertification in the arid north of the country (Kemp, 1969). The encouraging results from the series of selection work that followed the trial plantings (Kemp, 1970; Iyamabo *et al*., 1972; Anon, 1974) led to the establishment of large scale plantations of some promising species among which are the pines. By 1984, over 300 hectares of plantations of pines had been established in Kaduna State which falls within the Northern Guinea savanna zone, while in 1988 the first crop of pines was harvested for the pulp and paper mill at Jebba. Other northern areas where plantations of pines have been raised include Jos Plateau, Nimbia and the Mambilla Plateau. From a preliminary evaluation of the performance of the pines tried, *Pinus oocarpa,* is one of the most promising species within the low and medium altitude areas (66-1200m) of the Northern parts of Nigeria (Adegbehin, 1980; Adegbehin *et al*., 1985). Hence this study was aimed at evaluating the growth and yields of the species in the Northern parts of Nigeria.

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* National Agricultural Extension and Research Liaison Services (NAERLS), Ahmadu Bello University, P.M.B. 1067, Zaria, Nigeria

Materials and Method

Experimental areas and data collection

The experimental areas were Afaka (Northern Guinea zone) Nimbia and Agwa-Momoh (Derived savanna pocket of land at the foot of the Jos Plateau), Ta-Hoss, and Miango, all on the Jos Plateau (Fig.1). While detailed descriptions of the original vegetation covers and soil types of the study areas have been documented by Keay (1959), Kemp (1969), and Barrera and Amujo (1971) a summary of site characteristics of these locations is given in Table 1.

Table 1. Site characteristics of study area

Study site	Afaka (Kaduna)	Agwa Momoh	Nimbia	Jos Plateau		
				Miango	Vom	Ta-Hoss
Vegetation zone	N.G. Zone	Derived Savanna	Derived Savanna			
Location	Lat 10° 37'N Long 7° 11'E	Lat 9° 32' N Long 8° 36'E	Lat 9° 30'N Long 8° 34'E	Lat 9° 51'N Long 8° 52'E	Lat 9° 44'N Long 8° 47'E	Lat 9° 38'N Long 8° 44'N
Altitude (m)	600	600	600	1300	1260	1250
Mean annual rainfall (mm)	1290	1820	1820	1570	1370	1348
Rainy days/year	180	220	220	180	190	185
Mean maximum temperature (hottest months)	35°C (March, April)	36°C March	36°C March	31°C March	31°C March	31°C March
Mean annual temperature	25°C	26°C	26°C	22°C	22°C	22°C
Mean minimum temperature (coldest months)	14°C Dec, Jan	15°C Dec, Jan	15°C Dec, Jan	13°C Dec, Jan	13°C Dec, Jan	13°C Dec, Jan
Soil type	Ferruginous tropical soils sandy loam on plinthite laye	Eutrophic dark brown soils from basalt, clay loam	Eutrophic dark brown soils from basalt, clay loam	Eutrophic dark brown soil, derived from basalt, mainly clay loam		
PH	5.3-6.2	6.0-6.8	6.0-6.8	5.2-5.6	5.2-5.6	5.2-5.8

NG Zone = Northern Guinea Savanna Zone
Sources: Kowal and Knabe (1972); Iyamabo *et al.*, (1972); Anon (1971)

The data from permanent sample plots collected from 1967 to 1983 were updated in 1997 based on the re-measurements of the permanent sample plots. The data from the permanent sample plot records were supplemented by data from temporary plots. The data from the permanent sample plot records were supplemented by data from temporary plots. Plot size varied from 0.020 to 0.110 ha and the initial minimum number of trees per plot was not less than 36. The data collected in each plot include tree diameter, height and volume measurements. Data were collected from 33 permanent sample plots, 24 of which were located at Afaka, 2 at Nimbia, six (6) at Miango and one (1)at Ta-Hoss (one temporary). Data collection, calculations of top height (mean height of the largest 100 trees/ha), mean height, standing volume, total volume production (TVP) which is made up of the standing volume and thinning volume, standing basal area and total basal area production were in accordance with the sample plot procedure by Horne (1952). Volume figures were calculated overbark and up to 7.5 cm diamater top limit.

Trial fitting of the top-height-age and volume-age data

The Gompertz and the Logistic models are non-linear growth models in which the determination of the constants is usually based on the non-linear least square method using the interative procedure (Marquardt, 1963). When both models were tried on the top-height-age and volume-age data for the species, it was found that the Gompertz model gave slightly better fits, considering the values for the R^2 and the root mean square error (RMSE). This finding agrees with that of Nokoe (1978) and that of Adegbehin et al. (1991) when the two models were used for fitting top-height-age and volume-age curves for the species. Hence the Gompetz model was used in this study.
The Gompertz model as utilised in this study is expressed as:

$$D = W \exp[-\exp\{-c(A-g)\}] \qquad \text{------ Model (1)}$$

D = Top height (m) or total volume production (m^3/ha)
A = Age of the stand in years.
W, c and g are parameters to be determined.
Exp. = Exponential constant (c) = 2.71828

In forest management, the maximum current annual increment (MCAI), the maximum mean annual increment (MMAI) and the ultimate maximum yield (volume/unit area) that can be obtained are very important. The age at the MMAI influences the choice of rotation age. The ultimate maximum yield corresponds with the point at which the first derivative of the function with respect to age is zero while the point of inflection which corresponds with the age at which the second derivative is zero coincides with the age at which the MCAI is maximum (Nokoe, 1978).

By setting the second derivative to zero, it can be shown that A = g and D= W/e at the point of inflection. The coefficient g in the Gomertz model thus represents the age at which the current annual increment (CAI) is maximum and the corresponding yield divided by the exponential constant (e) gives the ultimate maximum yield.

Fitting of top height-age (Site index) curves

The curves for the average site class (the guiding curve) was fitted into the top height age data for the species using the Gompertz function. It was then observed that the plotted data were denser along the guiding curve than further away from it; they were more dispersed especially at the lower side (Fig.2). Therefore, the upper curve where the data showed better consistency was first fitted. The upper curve was then hand-fitted along the upper data margins in such a way that it followed the trend of the guiding curve. Based on the width between the upper curve and the guiding curve other three curves were extropolated at the lower side of the guiding curve to cover the range of field data. Hence a set of five curves was constructed with the guiding curve representing site class II (for average site). All the curves (except the guiding curve already modelled by the Gompertz) were then smoothened out using the Gompertz function (See Table 5 for the estimated Gompertz parameters).

Fitting of volume–age curves

The volume-age curves were fitted via the total volume production-top height (TV-Hd) curves based on the constructed site index curves. The (TV-Hd) data were screened using the computer to eliminate odd data. For this reason, only 90 out of the 147 data sets were involved in fitting of the TV-Hd curve using the Gompertz function as shown in Model (2).

$$TV = W\exp[-\exp\{-c(Hd-g)\}] \quad \text{Model (2)}$$

W	=	1183.81	e	=	2.71828
c	=	0.0915	R^2	=	0.9718
g	=	23.1270	RMSE	=	31.20
			N	=	70

From the Gompertz-fitted TV-Hd curve, the volume-age figures were derived for the set of site index curves for the species (giving rise to the corresponding yield classes).

The derived volume-age figures were then smoothened out using the Gompertz function. The estimated Gompertz parametes for the total volume production (TVP)-age data for the set of curves (yield classes) can be found in Table 5.

Prediction of total basal production

The total basal area production (TBA) was predicted as a function of top height (Hd) using the Gompertz function. The estimated Gompertz parameters are as shown in Model (3).

From the Gompertz fitted TBA-Hd curve, the TBA-age figures were derived for the set of the five yield classes.

$$TBA = W\exp[-\exp\{-c(Hd-g)\}] \quad \text{Model (3)}$$

W	=	99.65	e.	=	2.71828
c	=	0.0827	R^2	=	0.9305
g	=	17.5417	RMSE	=	5.50m^2/ha
			N	=	90

Results and Discussion

Site index curves for *P.oocarpa*

The constructed site index curves for *P.oocarpa* revealed five site classes and at a reference age of 20 years the following were obtained: site class I (24.9m); II (22.5m); III (20.1m); IV (17.7m) and V (15.3m) (Table 2, Fig.2).

Out of the 30 plots that were 20 years old and above, 12 (40%) fell in site class I, 5 (16.6%) fell in site class II; 7(23.3%) fell in site class III, 3 (10%) in site class IV while the remaining 2 (6.7%) fell in site class V. All the two plots measured at Nimbia fell in site class I; two out of the six plots measured at Miango fell in site class I while eight of the twenty-four plots measured at Afaka (33.3%) fell in site class I (Table 3). From the fore-going discussion, based on the locations where best growth (site class I) has been observed, it can be inferred that the species has the best growth at Nimbia, Miango and Afaka.

Table 2. Site index classes (m)* for *P. oocarpa*

Age (years)	Site I (m)	Site II (m)**	Site III (m)	Site IV	Site V
2	5.3	5.0	4.7	4.4	4.1
4	8.5	7.9	7.2	6.5	5.8
6	12.0	10.9	9.7	8.6	7.4
8	15.3	13.7	12.1	10.7	9.1
10	18.0	16.1	14.2	12.4	10.5
12	20.2	18.1	16.0	13.9	11.8
14	22.0	19.7	17.4	15.2	12.9
16	23.3	20.9	18.4	16.3	13.9
18	24.2	21.8	19.4	17.1	14.6
20	24.9	22.5	20.1	17.7	15.3
22	25.4	23.0	20.6	18.3	15.8
24	25.8	23.4	21.0	18.7	16.3
26	26.0	23.6	21.2	19.0	16.5
28	26.1	23.8	21.4	19.2	16.9
30	26.4	24.0	21.7	19.4	17.3
32	26.4	24.1	21.7	19.6	17.3
34	26.4	24.1	21.8	19.7	17.5
36	26.4	24.2	21.9	19.8	17.6
38	26.4	24.2	22.0	19.9	17.8
40	26.4	24.3	22.1	20.0	17.9

* Top height figures derived from Table 5

** Represent the average site

Table 3. Sorting of *P.oocarpa* plots into site classes at the age of 20 years and above

Site classes	I	II	III	IV	V	Total
	AAAA AAAA MM NN	AAM MM	AAA AATM	AAA A	AA	
Total	12	5	7	4	2	30
Percentage	40.0%	16.6%	23.3%	13.4%	6.7%	100

A – PLOT Afaka; N – Plot at Nimbia; M – Plot at Miango; T – Plot at Ta-Hoss.

Comparison with site index curves from Honduras

When the set of curves was compared with the set of curves constructed for *P.oocarpa* in Honduras (Goothousen, 1980), there was a great disparity especially for the site class V curve which lies far above the corresponding Honduras curve (Fig.3). A part from the fact that the two curves do not follow a similar trend, the Honduras curve is a reflection of poorer site than in northern Nigeria. The curve for site class III for Honduras also falls below the corresponding curve for northern Nigeria except between the ages of 28-30 years where they merge. However, the deviation between the site class I curve for the northern Nigeria and the corresponding curve for Honduras was very minimal. What is note-worthy generally from the trends of the two sets of curves is that the set of curves for Honduras reflects comparatively higher growth increment at the age of 30 years and above. This is in contrast to the set of curves for northern Nigeria that tend to flatten out even before the age of 30 years.

Yield classes and yield figures

Based on the constructed site index curves for the tree species, the corresponding yield classes including the yield figures were derived. This involved deriving the yield figures for each yield class and for the species from a top-height – total volume production model via the corresponding top height age model. The derived yield figures extrapolated to some extent were tabulated at 2-year intervals from the age of about 4 years up to the ages of between 32 – 38 years. From the yield figures from each yield class and for each specie, the mean annual increment (M.A.I) and the current annual increment (C.A.I) were calculated.

Yield figures

The species was represented at several experimental sites (four locations). Five site classes were delineated for the species and consequently five yield classes were delineated (Table 4 'a-e').

It was found that the CAI culminates at the ages of about 9.3, 10.1, 10.9, 11.9 and 13.7 years for yield classes I-V respectively with the corresponding TVP of about 208.4, 176.3, 144.2, 115.3 and 88.6 m^3 (Table 5). The maximum C.A.I. attained at the ages stated are 41.8, 33.0, 26.4, 17.3 and 11.6 m^3/ha/year accordingly for yield classes I-Y.

Furthermore, it was found that the M.A.I culminates at the ages of about 16, 16, 18, 18 and 20 years for the yield classes I-V respectively with the corresponding TVP of about 442.4, 347.4, 290.2, 208.7 and 153.2 m^3/ha. The maximum M.A.I. attained at the ages of culmination stated are 27.6, 21.7, 16.1, 11.6 and 7.7 m^3/ha/year for yield classes I-V respectively (Table 5).

Table 4 (a). Yield tables for *P.oocarpa*, yield class I

Age (yrs)	Top ht (m)*	Total Vol (m^3/ha)**	Total BA (m^2/ha)****	M.A.I. (m^3/ha/yr)	C.A.I. (m^3/ha/yr)
2	5.3		6.4		
4	8.5		12.1		
6	12.0	74.3	20.5	12.4	39.4
8	15.3	153.2	29.9	19.2	43.1
10	18.0	239.4	38.0	23.9	40.5
12	20.2	320.4	44.6	26.7	35.2
14	22.0	390.7	49.9	27.0	25.8
16	23.3	442.4	53.5	27.6	17.9
18	24.2	478.2	56.0	26.6	13.8
20	24.9	505.8	57.8	25.3	9.8
22	25.4	525.4	59.1	23.9	7.8
24	25.8	541.0	60.1	22.5	3.9
26	26.0	548.8	60.6	21.1	3.1
28	26.1	554.9	60.9	19.8	2.0
30	26.4	558.8	61.6	18.6	1.3
32	26.4	561.4	61.9	17.5	

* Derived from the Gompertz parameters in Table 5

** Derived from the volume-age model (Table 5) via the top height-volume model (Model 2)

**** Derived from Gompertz parametes in Model (3)

Age of culmination of C.A.I and M.A.I. as related previous findings

There is generally lack of information at which ages the C.A.I. and M.A.I. culminate for the species. However, as experienced in the Eastern African countries, for the most commonly planted softwood species, *Pinus patula*, the age at which the maximum C.A.I. and maximum M.A.I. are attained ranges from 8-17 year and 15-25 years respectively (Adegbehin, 1977; Adlard, 1975; Wanene, 1975; Kingston, 1970; Klitgaard and Mikkelsen, 1975). Therefore the results obtained with respect to the ages of culmination of the C.A.I. and M.A.I in this study could be regarded as normal.

Table 4(b). Yield tables for *P.oocarpa*, yield class II (average site)

Age (yrs)		Stems/ha		Volume (m^3/ha)			Basal area (m^3/ha)			M.A.I	C.A.I
		Standing	Thinned	Total	Thinned	Standing	Total	Thinned	Standing	(m^3/ha/yr)	(m^3/ha/yr)
2	5.0	1000					5.9				
4	7.9						10.8				
6	10.9			55.6			17.6			9.3	27.8
8	13.7			111.1			25.2			13.9	32.8
10	16.1	800	200	176.8	19.1	157.7	32.3	4.5	27.8	17.7	33.0
12	18.1			242.9			38.4			20.2	29.3
14	19.7			301.5			43.2			21.5	23.0
16	20.9	500	300	347.4	67.3	261.0	46.7	9.1	33.1	21.7	17.7
18	21.8			382.8			49.3			21.3	13.8
20	22.5			410.5			51.3			20.5	10.0
22	23.0			430.4			52.7			19.6	8.0
24	23.4	500		446.4		360.0	53.8		40.2	19.1	4.0 *
26	23.6			454.3			54.3			17.5	4.0
28	23.8			462.3			54.9			16.5	4.0
30	24.0			470.2			55.4			15.7	2.0
32	24.1			472.3			55.7			14.8	0.0
34	24.1			474.5			56.0			14.0	

* See Table 4(a) for the derivation of the stand parameter

Table 4(c). Yield tables for *P.oocarpa* yield class III

Age (yrs)	Top ht (m)*	Total Vol (m^3/ha)**	Total BA (m^2/ha)****	M.A.I. (m^3/ha/yr)	C.A.I. (m^3/ha/yr)
2	4.7		5.6		
4	7.2		9.5		
6	9.7	39.1	14.7	6.5	18.6
8	12.1	76.4	20.8	9.6	23.5
10	14.2	123.4	26.7	12.3	26.4
12	16.0	173.6	32.0	14.5	22.6
14	17.4	218.9	36.2	15.6	17.4
16	18.4	253.7	39.2	15.9	18.2
18	19.4	290.2	42.3	16.1	13.2
20	20.1	316.6	44.4	15.8	9.6
22	20.6	335.9	45.8	15.3	7.7
24	21.0	351.3	47.0	14.6	4.0
26	21.2	359.2	47.6	13.8	3.9
28	21.4	367.0	48.2	13.1	4.0
30	21.7	374.9	49.0	12.6	2.0
32	22.0	378.9	49.9	11.8	0.5
34	22.0	382.0	50.0	11.2	

* See Table 4(a) for the derivation of the stand parameters in asterisks

Table 4(d). Yield tables for *P.oocarpa* yield class IV

Age (yrs)	Top ht (m)*	Total Vol (m^3/ha)**	Total BA (m^2/ha)****	M.A.I. (m^3/ha/yr)	C.A.I. (m^3/ha/yr)
2	4.4		5.2		
4	6.5		8.3		
6	8.6	27.4	12.3	4.6	12.6
8	10.7	52.7	17.2	6.6	14.9
10	12.4	82.5	21.6	8.2	16.6
12	13.9	115.7	25.8	9.6	17.3
14	15.2	150.3	29.6	10.7	16.4
16	16.3	183.1	32.9	11.4	12.8
18	17.1	208.7	35.3	11.6	10.2
20	17.7	229.1	37.1	11.4	10.5
22	18.3	250.1	39.0	11.4	7.2
24	18.7	264.5	40.2	11.0	5.4
26	19.0	275.2	41.1	10.6	3.8
28	19.2	282.7	41.7	10.1	3.8
30	19.4	290.2	42.3	9.7	3.8
32	19.6	297.7	42.9	9.3	1.9
34	19.7	301.5	43.2	8.9	1.8
36	19.8	305.2	43.5	8.4	2.0
38	19.9	309.0	43.8	8.1	

* See Table 4(a) for the derivation of the stand parameters in asterisks

Table 4(e). Yield tables for *P.oocarpa* yield class V

Age (yrs)	Top ht (m)*	Total Vol (m^3/ha)**	Total BA (mm^2/ha)****	M.A.I. (m^3/ha/yr)	C.A.I. (m^3/ha/yr)
2	4.1		4.8		
4	5.8		7.1		
6	7.4	17.7	9.9	3.0	7.2
8	9.1	32.2	13.4	4.0	8.8
10	10.5	49.8	16.7	5.0	10.6
12	11.8	70.9	20.0	5.9	10.8
14	12.9	92.6	23.0	6.6	11.6
16	13.9	115.7	25.8	7.2	9.1
18	14.6	133.9	27.8	7.4	9.6
20	15.3	153.2	29.9	7.7	7.3
22	15.8	167.8	31.4	7.6	7.6
24	16.3	183.1	32.9	7.6	3.2
26	16.5	189.5	33.5	7.2	6.4
28	16.9	202.2	34.7	7.2	6.7
30	17.3	215.6	35.9	7.2	1.7
32	17.4	219.0	36.2	6.8	1.6
34	17.5	222.3	36.5	6.5	1.7
36	17.6	225.7	36.8	6.3	2.0
38	17.8	229.6	37.4	6.0	

* See Table 4(a) for the derivation of the stand parameters in asterisks

Plantation management and rotation age

Most of the stands were not thinned. Using data from some of the thinned stands the relationships between top height and such stand variables number of standing trees/ha, standing volume/ha, standing basal area/ha, cumulative thinning volume/ha and the cumulative basal area/ha were derived. Based on these relationships coupled with the information from the yield figures, the growth rate of the species especially the age at which the maximum M.A.I. was attained, as well as possible utilization of the species, an indication of what could be obtained on an average site (site class II in this case) for the species under a provisional management (thinning) regime is hereby discussed.

Pinus oocarpa was represented or measured at several experimental sites although only a small scale of plantation of this has been raised by the Kaduna and Plateau State Forestry Services. The species has straight clear bole and the aim of embarking on its trial in the Savanna zone of Nigeria is for pulpwood and timber production. It is less shade tolerant than *P.caribaea*.

Table 5. Estimated parameters of the Gompertz model for *P.oocarpa* for the dependent variables for top height-age and total volume production (TVP) – age

Dependent Variable (D) = Wexp. [-exp. {-c(A-g)}]

	Dependent variable	Parameter Estimates W	C	g	RMSE	Vmcai (m^3/ha)	R^2	Vmmai Vol. (m^3/ha)	Yrs	Mmai (m^3/ha/ha)	Mcai
Site Class I	Top height (m)	27.1477	0.1704	4.5012	0.1630	–	0.9998	–	–	–	–
	TVP (m^3/ha)	566.36	0.2083	9.3108	2.1840	208.35	0.9999	442040	16	27.6	41.80
Site Class II	Top height (m)	24.8633	0.1604	4.5048	0.2145	–	0.9996	–	–	–	–
	TVP (m^3/ha)	479.34	0.1921	10.0670	5.0258	176.33	0.9996	347.40	16	21.7	33.00
Site Class III	Top height (m)	22.6245	0.1488	4.8844	2.2800	–	0.9856	–	–	–	–
	TVP (m^3/ha)	391.97	0.1676	10.8727	1.9909	144.20	0.9999	290.2	18	16.1	26.4
Site Class IV	Top height (m)	20.4724	0.1347	4.6129	0.3670	–	0.9995	–	–	–	–
	TVP (m^3/ha)	313.50	0.1468	11.9432	1.3154	115.33	0.9999	208.7	18	11.6	17.3
Site Class V	Top height (m)	18.4975	0.1171	4.8180	0.4417	–	0.9993	–	–	–	–
	TVP (m^3/ha)	240.92	0.1249	13.7055	2.7955	88.63	0.9996	153.20	20	7.7	11.6

D = Top height (m) or total volume production (m^3/ha)

A = Age of stand (yrs)
W, c & g = Coefficients determined; g = Age at which C.A.I is maximum
Exp = Exponential constant (2.71828) VMMAI = W/exp.
R^2 = Proportion of variation in the dependent variable explained by the model
RMSE = Root mean square error

Vmcai = Vol. at maximum C.A.I.
Vmmai = Vol. at maximum M.A.I.
mmai = Maximum M.A.I.
Mcai = Maximum C.A.I.

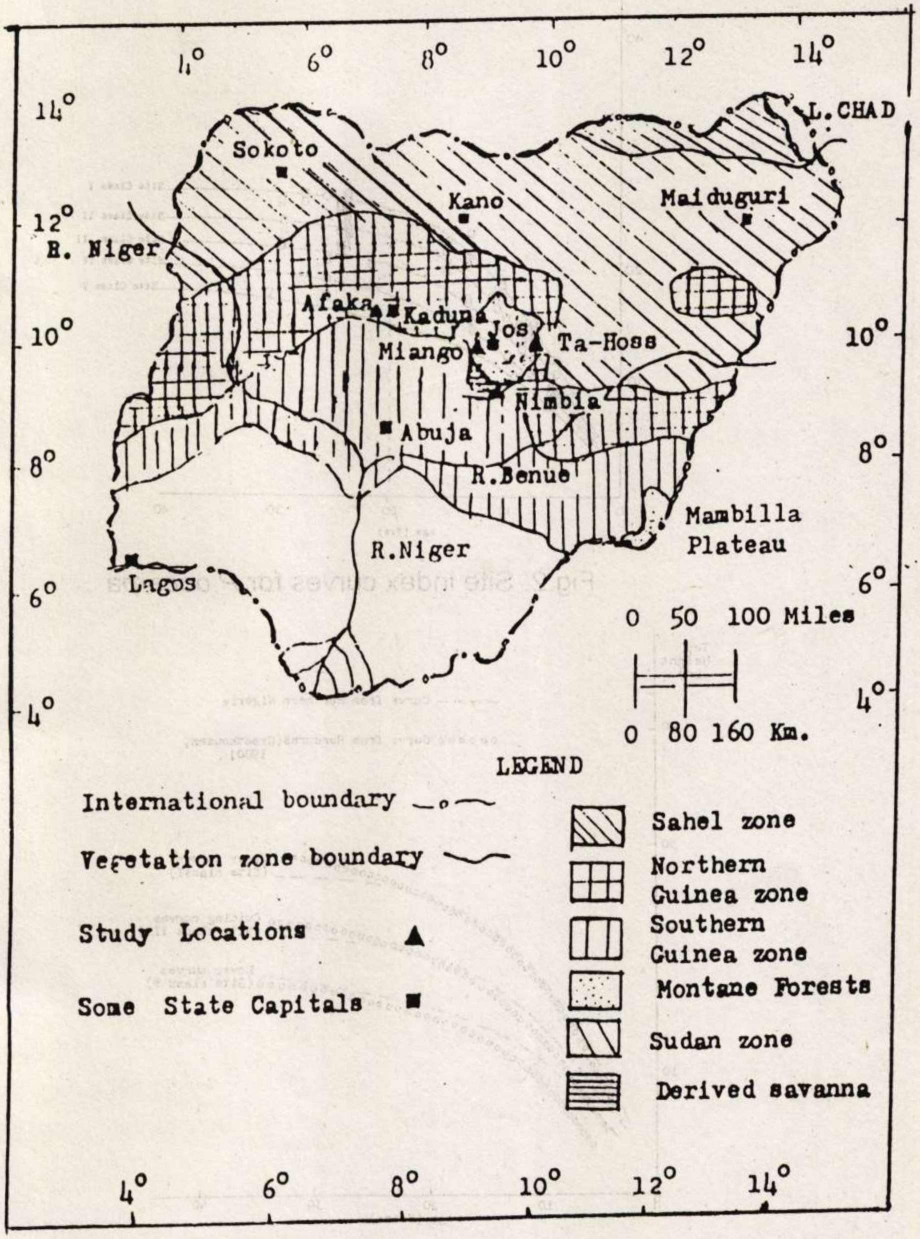

Fig.1. Map of Nigeria showing study locations.

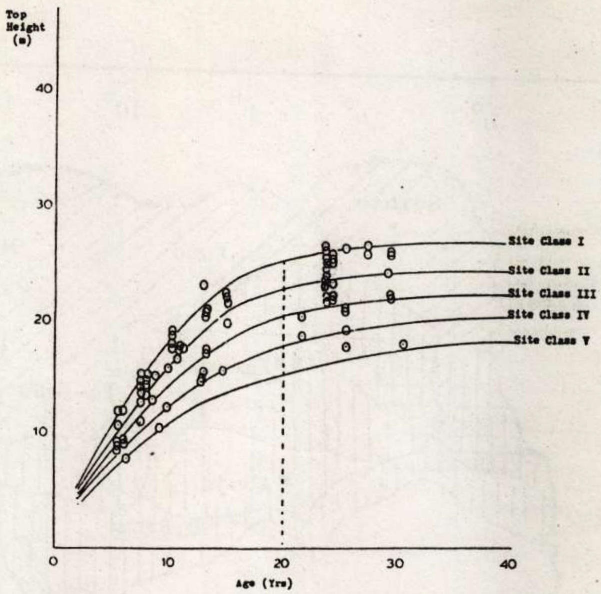

Fig.2. Site index curves for *P.oocarpa*

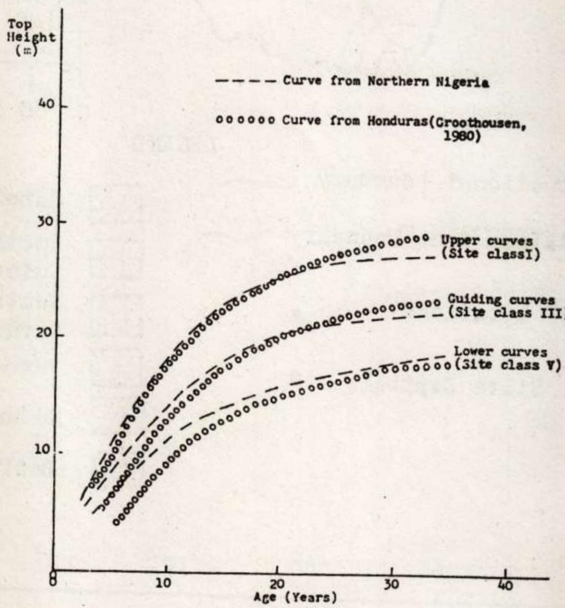

Fig.3. Comparison of the set of curves for *P.oocarpa* with the Set of curves from Honduras (Groothousen, 1980)

Four yield classes were delineated for the species with the maximum M.A.I. attained at the age of 16 years for yield classes I and II; 18 years for yield classes III and IV and 20 years for yield class V. Considering the average site (yield class II), it is possible to have about 1000 trees/ha survival at establishment (1370 plants/ha at the initial spacing of 2.7 m by 2.7 m). This could be thinned to about 800 trees/ha at the age of 10 years. This could again be thinned to about 500 trees/ha at age 16 years and then clear-felled at the age of 24 years when a standing volume of about 360^3/ha and a tree mean diameter of about 32 cm would have been attained (Table 4 'b').

Conclusion and Recommendations

The rotation age recommended for each of the species was based on volume increment point of view. Further research will need to be conducted to determine financial rotation ages for the species if possible based on site classes or the yield classes. The growth and yield figures for the species investigated in this study are tentative and it is recommended that further investigations should be carried out to obtain further growth data on the species especially from the older age groups. Tentative yield figures have been derived for the average site for each species based on provisional management (thinning) regime. Further research work should also be carried to determine yield figures for each of the species under different thinning regimes.

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