GROWTH AND BIOMASS PRODUCTION OF *GMELINA ARBOREA* IN CONVENTIONAL PLANTATIONS IN GHANA

L.C. Nwoboshi[1]

Forestry Research Institute of Ghana, UST P.O.Box 63, Kumasi, Ghana.

ABSTRACT - Sixteen trees, selected from Subri and South Formangso Gmelina plantations, to represent ages (4 - 10 years) and size class distribution, were felled and their linear growth dimensions and biomass measured. In Subri, mean height increased from 16.6m at the 4th year to 19.6m at the 7th year. Corresponding growth of other dimensions were 10-23cm in diameter, 19 to $29m^2$/ha in basal area, 200 to $274m^3$/ha in volume and 68 to 119mt/ha in dry matter content. South Formangso crops were slightly lower in height and volume growth than those of Subri.

Keywords - ***Gmelina arborea*, plantations, biomass production, yield.**

INTRODUCTION

Gmelina arborea, an exotic species from the Indo-Burma region of South-East Asia, is a potential source of several types of industrial raw materials. With a medium density and strength property, Gmelina provides a general utility timber for joinery, light construction and packing (Akachukwu, 1990). It is similar to and serves the same purpose as wawa (*Triplochiton scleroxylon*) (Iyamabo, 1990). Gmelina is also suitable for plywood, particle board manufacture, mining prop wood, energy and telecommunications transmission poles, and fuelwood (Akachukwu, 1990; Iyamabo,1990) and most importantly, it holds the potential of producing for Ghana, short-fibred pulpwood for pulp and paper products manufacture.

Owing to its versatility as an industrial raw material, Gmelina has become one of the most widely planted species (second only to the Eucalypts) in the tropics. By 1990, Nigeria had established over 60,000 ha (Umeh, 1990). FAO (1989) records that by 1983, the Sahelian countries of West Africa had established about 5,850ha of Gmelina in their anti-desertification plantation schemes. In Ghana, over 5,000 ha have been established, out of which 2,000 ha was by the Subri Industrial Plantations Limited, Daboase near Sekondi - Takoradi.

Numerous studies on its growth, biomass accumulation and partitioning have been published. Nwoboshi (1990) listed nearly 150 such publications worldwide and the state of knowledge with respect to its productivity and utilization in the West African Sub-region was the main focus of a recent IUFRO Sub-regional Symposium held at the University of Ibadan in 1990. Of all these publications, only one dealing with the Subri Conversion Technique by Komla & Mather (1990) touched on the situation in Ghana.

Although a large proportion of these data report the Nigerian situation, the limited data from Ghana and elsewhere in the sub-region makes generalisation difficult.

The primary goals of this study were therefore to provide some growth data of *Gmelina arborea* in Ghana and to compare the data with those already obtained in the subregion. A subsequent aim will be

[1]World Bank consultant In silviculture
Present Address - Dept. Forest Resource Mgt.
Univ.of Ibadan, Nigeria

to pool the mensurational data from Ghana and Nigeria on Gmelina to assess their subregional usefulness in growth prediction.

MATERIALS AND METHODS

Study Area

This study was carried out in the Subri Forest Reserve near Daboase (5° 8'N, 1° 46'W) and South Formangso Plantations (6° 40'N, 0° 58' W) on the Accra-Kumasi road.

The Subri Forest Reserve is in the moist evergreen equatorial rain forest zone, characterised by a high, double-maxima rainfall (1500-2000mm per annum), uniformly high temperature (30-32°C) and relative humidity (76-93 %) throughout the year. The predominant soils in the area belong to the Asuansi-Kumasi/ Nta-Ofin Compound Association, on acidic (pH 4.8 to 5.6), moderately to well drained, gravelly and concretionary gritty clay to clay loams, on top and middle slopes, colluvial, moderately well drained clay loam in the middle and lower slopes and poorly drained, transported sands and clays in the valley bottom (Peter Agyili, Pers. Comm.). The mean nutrient status of the top 30cm of the soil are 0.46-1.24% organic carbon, 0.06 to 0.14% nitrogen, 150 to 300ppm phosphorus. Extractable cations exist in the following ranges: 0.2 to 1.14 meq/ potassium, 1.63 to 8.30 meq/ calcium, 0.78 to 2.32 meq/ magnesium and 0.21 to 0.44 meq/ sodium per 100g of soil.

South Formangso is in the semi-deciduous rainforest belt. Annual rainfall of between 1460 - 1750mm fall in two distinct periods - March to July and September to November. There is a short dry but cool spell in August whilst the major dry season lasts from Mid-November to end of February. Temperatures are uniformly high throughout the year (32°C) and relative humidities range from about 65% in the afternoon to over 90% in the mornings.
The major soil association here is the Juaso-Pamesua (Acrisol). This is a deep red drift soil developed from quartzites and schists. Generally it is well drained; medium to heavy textured, concretional and gravelly in the middle slopes and grey sands and clays in the valley bottoms. The nutrient status in the top 0-30cm of the profile are 0.44 to 1.68% organic carbon, 0.06 to 0.145% Nitrogen, 88 to 156 ppm phosphorus. The extractable cations are (in milligram equivalent per 100g soil); 0.12 to 0.19 for potassium 0.8 to 5.3 for calcium, 0.06 to 1.65 for magnesium and 0.07 to 0.43 for sodium.

Field Procedures

In Subri Forest Reserve, plantations raised in 1981, 1984 and 1987 were sampled. In South Formangso, a 1986 plot was sampled using the following field sampling and laboratory processing procedures. Using two temporary 20m x 20m plots, laid in well stocked areas of each stand, the diameters of all the trees were measured and tallied into four diameter at breast height (dbh) classes with one-quarter of the stand diameter range as the class interval. Four sample trees, selected to represent as closely as possible the mean size of each dbh class, were cut at ground level and total bole length (to the first major branch) were measured. Each tree was subsequently separated into stems, branches and leaves and weighed green in the field. Samples of the bole taken from the butt, middle and top end were used to determine the wood to bark proportions and their respective densities. Subsamples of these discs plus those of branches and leaves were used in dry weight determination.

Laboratory Processing

The above subsamples were weighed, dried to constant weight at 70°C in an oven and reweighed. The dry weight/fresh weight ratios of the various components were used to determine the dry weight of the various parts from the field green weight.

Computations

The mean tree biomass for each class was calculated as the sum of the dry weight of the component parts. The stand biomass was computed as the sum of products of

Table 1: Mean tree and stand linear growth dimensions of some *Gmelina arborea* plantations in Ghana.

	1981(10)	1984(7)	1986*(5)	1987(4)
		Mean tree		
Total height(m)	17.06	19.65	14.99	16.60
Merch. Height(m)	7.14	8.73	9.00	9.48
Crown Depth (%)	65.86	44.08	60.04	55.94
Dbh (cm)	22.78	18.90	17.78	15.88
Basal area (cm^2)	338.19	317.60	274.55	288.36
Volume (m^3)				
Newton's	0.19	0.23	0.17	0.21
Smallian's	0.34	0.30		0.24
		Stand Value		
Stocking (No/ha)	572	900	950	825
Survival (%)	82	90	94	
Basal area (m^2)	19.33	28.58	26.03	18.84
Volume (m^3/ha)				
Newton's	136.7	203.4	157.70	174.9
Smallian's	193.91	273.6	157.70	199.7

*South Formangso

the mean tree values and the number of trees in each of the dbh classes expressed on per ha basis.

Volume of the bole was calculated using both the Newton's formula:

$$V = (S_b + S_m + S_t)/6 \times L$$

and the Smallian's formula

$$V = (S_b + S_t)/2 \times L$$

where S_b, S_m, S_t are the basal area of the butt, middle and top end of the bole, L is the length and V the volume of the bole.

The Newton's formula has been found to give a better estimate of the true volume (Nwoboshi, in press) , while the provisional dry weight table for Gmelina in Nigeria (Nwoboshi, 1986) was based on the Smallian formula. Such calculations will facilitiate comparisons of growth of Gmelina in the two countries and later in the sub-region.

RESULTS AND DISCUSSION

Stand Growth Characteristics

The mean tree and stand linear growth dimensions of Gmelina grown under conventional practice of slash-and-burn site preparation in Subri and South Formangso are shown in Table 1. The total height generally increased with age. In Subri it increased from 16.60m in the 4th year to 19.65m in the 7th year, and appeared to be decreasing thereafter for reasons that are not clearly understood. The data also showed that height growth was generally faster in Subri than in South Formangso.

Generally however, the heights compare favourably with the 21.23m (range 15.4 - 25.02m) reported for Gmelina on quality one sites in Nigeria (Nwoboshi, 1985). The mean annual height increment of 4.1m and 1.7m in the 4th and the 10th years also agree with trends reported by Nwoboshi (1985) Okorie (1987) and Kio <u>et al</u> (1990). Nwoboshi (1985) observed a height growth rate of 3.5m per year for the first 5 years and about 0.8m per year thereafter in the Gmelina plantations of Gambari in South Western Nigeria. Similar height growth rate was recorded by Okorie (1987) for the Omo Gmelina pulpwood plantation; height increasing from 3.0m per

FIG. 1: MEAN GROWTH OF *GMELINA ARBOREA* IN CONVENTIONAL PLANTATION IN GHANA

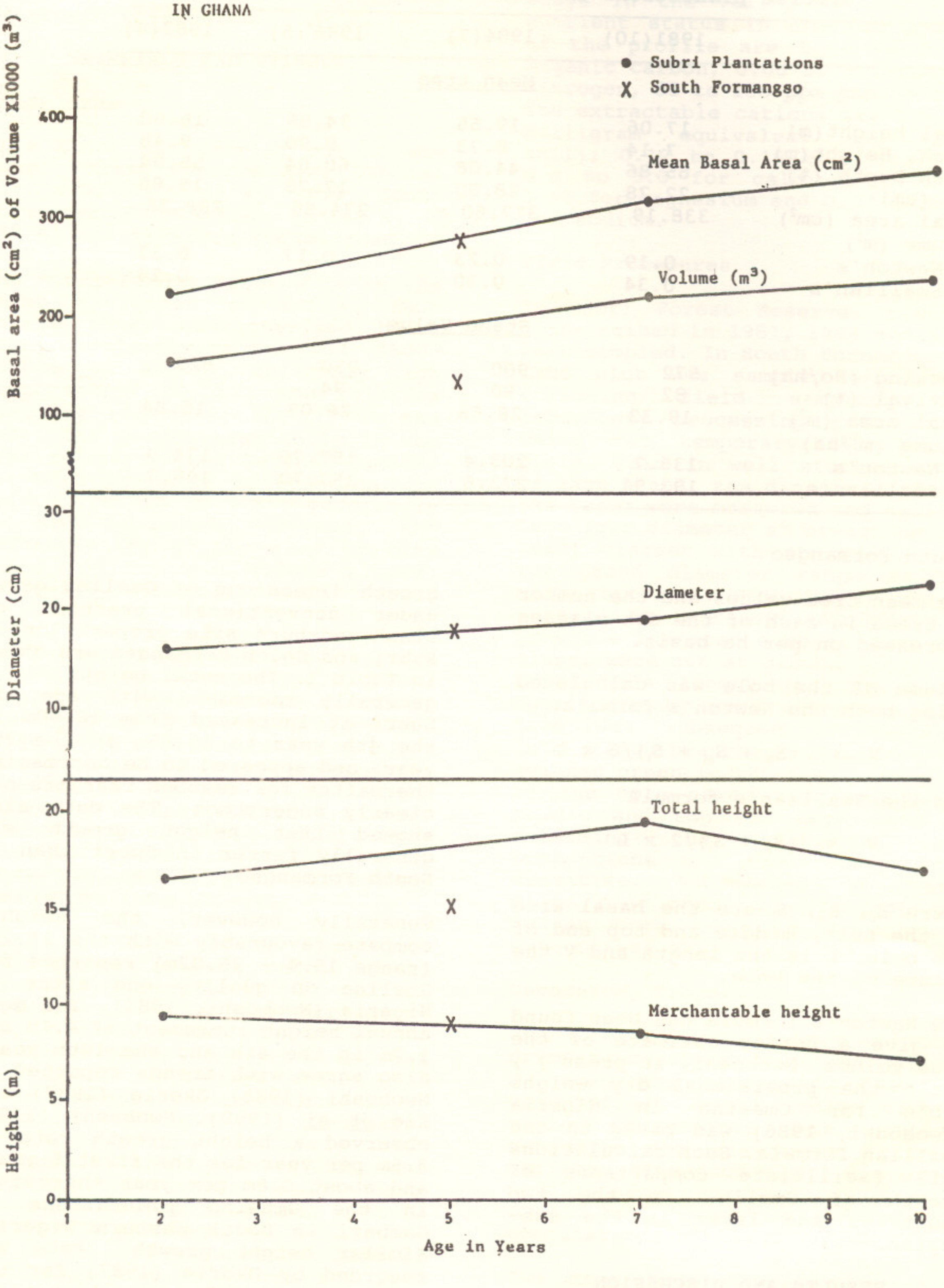

Table 2: Mean tree and stand biomass accumulation and distribution in *Gmelina arborea* grown in Ghana.

	1981		1984		1986		1987	
	Mean Tree							
Units	kg	%	kg	%	kg	%	kg	%
Stemwood	79.79	43	59.71	45	80.67	69	47.16	47
Stembark	9.80	5	23.24	18	10.64	9	9.33	11
Branches	89.46	49	46.55	35	21.12	18	20.58	25
Leaves	4.51	2	2.97	2	5.09	4	5.77	7
Total	183.56	100	132.47	100	117.52	100	82.87	100
	Stand values							
Stocking/ha	272		900		950		825	
Survival (%)	82		90		94		83	
Stemwood	45,639		53,739		76,636		38,907	
Stembark	5,605		20,916		10,108		7,697	
Branches	51,171		41,895		20,064		16,978	
Leaves	2,579		2,673		4,835		4, 76	
Total above ground	104,996		119,223		111,644		68,343	

annum in the first five years and thereafter declining to 1.0m per annum for the following five years.

The merchantable height (to the first major branching), however showed a somewhat opposite trend, decreasing from nearly 9.5m in the 4th to barely 7m in the 10th year.

This is apparently due to slowed self-pruning as the widening of the spaces between the trees by mortality will encourage greater persistence of branches.

The diameter growth also increased with age from about 16cm in the 4th year to 23cm in the 10th year. These also compared favourably with the Nigeria figures of 15.3cm in the 3rd year and 25cm in the 10th year. The mean annual diameter increment was 4cm in the 4th year. (Nwoboshi, 1985)

The basal area followed similar trends as the diameter, increasing with age. At 10 years, the mean tree basal area was 338cm^2 which compares well with those recorded by Nwoboshi (1985). The stand basal area was 18.48m^2/ha apparently due to the very low stocking of that stand.

The volume, being a product of the height and basal area, both of which increased with age, also showed similar trends. At 10 years the mean tree volume was 0.337m^3 and average stand containing 572 trees per hectare carried 194 m^3/ha. The 7-year stand with higher stocking of 900 stems per ha had 274 m^3/ha, thus confirming that stand volume is a function of the stocking as well as the height and diameter growth.

The growth trends, using pooled data of the Subri and South Formangso plantations, are shown in fig 1. The near smooth curve obtained in each parameter indicate that the sites do not have any significant effect on the growth of Gmelina.

Biomass production and distribution

The biomass accumulation and distribution among the above-ground tree components are shown in Table 2. The estimated total weight of the mean trees increased from 83 to 183kg between ages 4 and 10 years. These are somewhat less than the 249kg per tree reported for the same species in Nigeria (Nwoboshi, 1985). Similarly the standing biomass of 105 to 120mt at 7-10 years is considerably less than the 272mt/ha reported in Nigeria. Although reasons for these differences are not clearly known, the differential espacements (4m x 3m to 5m x 2m in Ghana compared to 2.4m x 2.4m or 2.4m x 3m in Nigeria) and the generally weedy conditions of the plantations here could be contributory. In other words, the longer period of poor site occupancy followed by prolonged acute competition from weed species could be part of the major cause of the lower performance noted here.

The partitioning of the net photosynthate changed with age. The proportion of the stemwood, stem-bark and leaves decreased with age, while the branches showed the opposite trend. It increased from 25% in the 4th year to 49 percent in the 10th year.

As mentioned ealier the greater development of the branch wood has resulted in lower self-pruning and limited bolewood formation and such conditions are fostered mainly by poor site occupancy.

These observations suggest that the spacing and the tending operational schedules currently in use should be further examined and modified if necessary.

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