DEVELOPMENT OF *GMELINA ARBOREA* UNDER THE SUBRI CONVERSION TECHNIQUE: FIRST THREE YEARS

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ABSTRACT - Subri conversion technique is a new site preparation technique in West Africa in which the degraded natural forests are cleared, and lines are cut through the debris and planted up without any burning. Under this condition the humus layer and the extra debris on the forest floor is conserved. Evaluation of linear growth and biomass production in the first three years of growth of Gmelina raised under this technique is reported. Survival varied from 75 to 83 percent, mean height from 12 to 15m, mean diameter from 12 to 14cm and volume from 73 to 170m^3/ha. Biomass production varied from 40-56mt/ha with the stem as the dominant component. The potential crop trees grew much faster, with Mean Annual Increment (MAI) in height of 6.4 to 5.70m and in diameter of 7.3 to 6.3cm in the 2nd and 3rd years respectively.

Keywords - ***Gmelina arborea*, plantations, stocking, Subri Conversion Technique.**

INTRODUCTION

The conventional method of establishing forest plantations in the tropics is to clear and burn the pre-existing vegetation before planting. This method has increasingly come under severe criticism in recent times. As early as 1935, Craib in South Africa pointed out its detrimental effects on sheet erosion, soil dessication and site deterioration. Since then, several workers have shown that burning leads to substantial losses of gasifiable elements in the biomass such as nitrogen and sulphur, which are very vital to tree growth (Mouttapa, 1973). In a study of the effects of clearing the forest without burning on chemical and physical characteristics in Ghana, Cunningham (1973) found that much of the organic carbon, total nitrogen and organic phosphorus was rapidly lost from fully exposed soils because of increased soil temeprature and lack of additional fresh organic matter.

In these days of intensive silviculture, the nutrient cycling in the forest ecosystem is not only greater but faster. The amount of nutrients stored in the litter and organic matter is also greater indicating the burning will take away substantial amounts of nutrients out of the system by volatilization and leaching. Burning also adversely affects the microbial activities in the soil, thereby reducing the decomposition of freshly fallen litter.

According to Shonau (1988) burning is an operation attractive to a lazy or over extended forest manager and is incompatible with intensive silviculture. The argument that burning is a cheap operation is not borne out by experience at Usutu in Swaziland, where it has been found that the non-burning operation was actually cheaper and more flexible (Germishuizen, 1984).

The non-burning technique known as the Subri Conversion Technique (SCT) involves subjecting the forest to heavy salvage felling and clearing. Under this condition, the

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humus layer and the entire debris on the forest floor is conserved. Young regeneration of indigenous species as well as stream courses are protected from cutting and burning.

Another remarkable feature of the technique is that some well-formed indigenous trees of pole size or better are selected and retained as a fine bark and for better utilization. This makes it a uniquely environmentally sound technique for converting degraded natural tropical forests to useful plantations of valuable industrial raw materials.

Since 1988, the Subri Industrial Plantation Limited at Daboase, near Takoradi in Ghana, has been raising *Gmelina arborea* plantations with this technique. By 1992 an area of about 2,000 hectares had been planted with the sole objective of producing timber and pulpwood.

Because *Gmelina arborea* is one of the most widely planted in the West African Sub-region and is highly productive, the Forestry Research Institute of Ghana in collaboration with the Subri Industrial Plantations Limited, decided to establish a series of joint experiments to characterize Gmelina growth patterns and responses to normal silviculture practices under this technique.

This paper reports the early linear and biomass growth characteristics of Gmelina under this technique. Comparison with the conventional approach will be done as the plantations develop.

MATERIALS AND METHODS

Study Area

This study was carried out in the Subri Industrial Plantations Limited near Daboase, about 30 km North-east of Sekondi-Takoradi, in Western Ghana.

The climate is equatorial monsoon, with a double rainfall maxima. The main rainfall season occurs from March to July with a peak in June. This is followed by a short dry spell in August and another rainfall period from September to early November with a maximum fall in October. Mean annual rainfall ranges from 500 to 1,000mm. The dry season lasts from late November to February.

Temperatures are uniformly around 30-32°C throughout the year and the relative humidity ranges between 76 and 93 percent.

The predominant soils in the area are the Asuansi-Kumasi/Nta-Ofin compound Association, which is characterized by yellowish red to red, moderately well to well drained, gravelly and concretionary gritty clays and clay loams, developed over deeply weathered granite on the top and middle slope sites. Colluvial soils which are brown to yellow brown, moderately well drained clay loam and clays are found in middle to lower slopes. Valley bottoms carry brown to grey imperfectly to very poorly drained transported sands and clays. The soil reaction ranges between pH 4.8 and 5.6 and the mean nutrient status of the soil is shown in Table 1.

Field Procedures

Following a thorough reconnaissance survey of each coupe, three 20m x 20m temporary plots each were randomly located in coupes 1988 and 1989. Within each plot, diameter of all the trees were measured at the breast height (1.3m) and tallied into 4 diameter classes, using one-quarter of the diameter range on the class interval. These classes correspond to the suppressed, intermediate, co-dominant and dominant tree classes in the canopy and will be so referred to subsequently in this paper.

Four trees from each plot (i.e 12 trees per coupe) were selected to represent as closely as possible the mean size of each of the four diameter at breast height (dbh) classes. These were subsequentl, cut at ground level and their total height, bole length (to the first major branching) were measured. Three discs were cut from the butt, middle and top of each bole and used for the determination of wood

Table 1: Mean Analytical data for the Asuansi Soil Series

Depth (cm)	pH	%O.C*	%N	Pppm	Meq/100g K	Ca	Mg	Mn	Na
0 - 7.5	6.3	1.31	0.12	150	8.5	4.28	1.33	0.20	0.12
7.5 - 55	5.3	0.56	0.053	101	4.6	1.41	0.71	0.08	0.12
55 - 85	4.9	0.44	0.057	116	4.9	1.33	1.27	0.01	0.43
85 - 120	4.7	0.21	0.050	71	0.83	0.67	0.06	0.005	0.31
120 - 180	4.7	0.15	0.026	63	1.3	0.29	0.31	0.005	0.19

* Organic Carbon

to bark proportions and their respective densities under green conditions. Each tree was thereafter separated into stems, branches and leaves and weighed green in the forest. Samples of the discs, branches, and leaves were taken for dry matter determination.

Laboratory Procedures

Subsamples of the stemwood, stembark, branches and leaves were weighed, dried to a 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.

The mean biomass for each dbh class was the sum of the dry weights of the component parts of the mean tree. The stand biomass was computed as the sum of products of the mean tree value and the number of trees in each of the dbh classes expressed on per hectare basis.

RESULTS AND DISCUSSION

Stocking and Survival

The current stocking and mean linear dimensions of the second and third year plantations are presented in Table 2. Planted at 5m x 2.5m, the initial stocking was 800 trees per hectare. The mean stocking at the time of study was 600 and 650 stems per hectare of 75 and 81 percent survival in the second and third year old stands respectively. This conforms with the widely held idea that *Gmelina arborea* is a tenuous species, which once well planted, does not die easily.

Height Growth

The average total height at 2nd and 3rd year were 11.7 and 15.4m respectively and the corresponding heights for the dominant tree class were 12.8 and 17.1m. The mean annual height increment [MA (Ht) I] in this first three years thus varied from 5.8m in the 2nd to 5.1m in the 3rd year, with the potential crop trees growing even faster to 6.4m and 5.7m in the 2nd and 3rd year respectively. With the above rates of growth, these Gmelina stands will definitely be above the site quality I class of Greaves (1973). These rates are much higher than the 3.5m recorded for Gmelina in Gambari (Nwoboshi, 1985) and the 3.0m in Omo (Okorie,1987). Although the ages do not overlap for effective comparisons, these figures also appear to compare favourably with adjacent Gmelina plantations raised under the conventional slash and burn site preparation in the same reserve (Nwoboshi, 1994). The latter plantations show a mean annual increment of 4.1m at age 4 years, compared to the 5.12m at the 3rd year of the Gmelina under the Subri technique. The decline trend which has begun to manifest itself agrees with the observations that the M.A. (Ht) I declines with age in *Gmelina arborea* (Abayomi & Nwaigbo, 1985; Nwoboshi, 1985 ; Okorie, 1987), in Pinus radiata (Madgwick et al, 1977). Similar trends have been

Table 2: Mean linear growth dimensions of 2-3 year old Gmelina under the Subri Technique.

	1988 (3 years)		1989 (2 years)	
	Values	MAI	Values	MAI
Mean Tree Values				
Total height (m)	15.37	5.12	11.67	5.84
Merch*. Height (m)	8.75	2.92	4.78	2.39
Crown depth (%)	43		58	
Dbh (cm)	14.02	4.67	11.86	5.93
Basal area (cm2)	172	57.44	147	73.5
Volume (m^3)				
Newton's	0.247	0.082	0.053	0.027
Smallian's	0.296	0.099	0.067	0.034
Stand Values				
Stocking (No/ha)	825		600	
Survival (%)	81.3		75	
Basal area (m2/ha)	13.8	4.6	7.67	3.84
Volume (m^3/ha)				
Newton's	207.1	69.0	29.4	14.7
Smallian's	282.2	94.0	32.4	16.2
Potential Crop Trees				
Total height (m)	17.10	5.70	12.82	6.41
Merch. Height (m)	8.90	2.96	5.50	2.75
Crown depth (%)	47.50	-	57.00	-
Dbh (cm)	18.20	6.06	14.73	7.37
Basal area (cm2)	262.88	87.63	182.00	87.36
Volume (cm^3)				
Newton's	0.445		0.073	
Smallian's	0.512		0.099	

* Merchantable

noted in *Cedrella odorata* in Tano Nimri, in Ghana (Nwoboshi, in press)

Diameter and Basal Area

The mean diameter at breast height (dbh) increased from 11.9cm in the 2nd to 14.0cm in the 3rd year, giving a mean annual diameter increment [M.A (Diam) I] of 5.9 and 4.7cm at the respective ages. The potential crop trees had mean values of 14.7m and 18.2m at the corresponding ages or a MA (Diam) I. of 7.3 and 6.3cm respectively. The mean basal area increased from 7.7m^2 in the 2nd to 13.8m^2 in the 3rd year, while those of the potential crop trees rose from 10.2m^2 to 21.5m^2.

Although our data on the Subri Conversion Technique are still scanty; these early diameter and basal area growth rates compare very well with growth rates recorded for plantations of similar ages in the sub-region. Figures of 9.68 to 13.93cm diameter and 11.55 to 13.5m^2 basal area presented for 2 to 3 year old Gmelina in Omo pulpwood plantations in Nigeria (Okorie, 1987) agree with the observations here. The growth rates under this technique are however

Table 3: Dry matter accumulation and distribution in *Gmelina arborea* under the Subri Technique.

Components	1988 (3 years) Wt (kg)	%	MAI	1989 (2 years) Wt (kg)	%	MAI
			Mean Tree Values			
Leaves	4.58	7.4	1.53	4.31	8.0	2.16
Branches	14.96	24.46	4.99	15.41	28.59	7.71
Stembark	5.14	8.4	1.71	3.85	7.14	1.93
Stemwood	36.50	59.69	12.17	30.32	56.25	15.16
Total Shoot	61.15	100.00	20.38	53.90	100.00	26.85
			Mean stand value (kg/ha)			
Leaves	3.92		1.31	2.89		1.45
Branches	13.22		4.41	15.92		7.96
Stembark	4.92		1.64	2.94		1.47
Stemwood	33.56		11.19	17.71		8.86
Total Shoot	55.61		18.54	39.66		19.89
			Potential Crop Trees (C & D Classes)			
Leaves	7.89		2.63	7.24		3.2
Branches	23.82		7.94	26.26		13.13
Stembark	7.00		2.33	6.02		3.01
Stemwood	56.84		18.95	35.26		17.63
Total Shoot	55.55		31.85	54.78		27.39

greater than the 11.3cm diameter and 8.7m^2 basal area reported by Fox (1967) for Sierra Leone. The remarkably high diameter growth trends noted here if maintained, would indicate that by the age of 5 to 7 years, most, if not all of the trees will have attained a dbh of 15 to 20cm and therefore be ready for clear felling as pulpwood.

Volume growth

The standing volume increased from 73.3m^3/ha in the 2nd to 170.3m^3/ha in the 3rd year. This is much greater than the 136m^3/ha for Gambari (Nwoboshi, 1985) and 83m^3/ha for Omo (Okorie, 1987) or 63m^3/ha for Sierra Leone (Fox, 1967) recorded for three year old Gmelina plantations. Volume is however a function of stocking as well as diameter and height growth. The near exponential increase in volume growth in the third year can at least partially be attributed to the greater stocking of the 3rd year stand.

Biomass Production and Distribution

The above ground biomass achieved in these first three years of growth are shown in Table 3. The mean tree biomass was 54kg in the 2nd year and 61kg in the 3rd year. The average total weight of the above-ground portion of live trees in the stand were 40 and 56 mt/ha in the 2nd and 3rd years respectively. The mean potential crop tree had about the same mass as the stand mean tree up to 2nd year but accumulated more than 50 percent more biomass than the average tree in the 3rd year. Although still very young, marked changes in the relative distribution of standing biomass with age has begun to appear. At the 2nd year, leaves and branches comprised 8 and 29 per cent respectively of the total above-ground biomass. By the 3rd year, leaves comprised 7.4 percent and branches 24 per cent of the above-ground dry matter. The bole (stemwood plus stembark) showed the opposite trend, increasing from 63

Table 4: Growth at different levels of the canopy

	1988 (3 years)				1989 (2 years)			
	A	B	C	D	A	B	C	D
				Dry Matter Production				
Leaves	0.36	2.17	5.40	10.38	1.15	1.59	6.69	7.79
Branches	5.90	6.29	20.53	27.11	5.29	14.88	30.44	22.07
Stembark	2.07	4.25	5.60	8.40	0.97	2.41	4.61	7.41
Stemwood	6.88	25.33	43.67	70.01	6.28	14.13	25.91	45.51
Total Shoot	15.21	38.04	75.20	115.90	13.69	33.01	66.75	82.78
				Linear Dimension				
Total ht.	12.70	15.00	16.80	17.40	9.66	10.40	12.63	13.00
Merch. ht.	7.13	9.97	9.03	8.86	4.01	4.50	5.50	5.50
Crown Depth	43.00	33.00	46.00	49.00	55.00	59.00	51.00	63.00
DBH	7.76	11.90	16.40	20.00	7.40	10.60	13.70	15.75
Basal area	48.00	112.00	210.00	315.00	43.01	118.63	150.25	199.16
Volume	255.00	924.00	1433.00	1973.00	139.00	334.00	650.00	816.00

A = suppressed
B = intermediate
C = co-dominant
D = dominant trees

per cent on the 2nd year to 68 per cent in the 3rd year. The mean annual increment (MAI) of the above-ground biomass varied between 19.83 mt/ha/year to 18.5mt /ha/year between the 2nd and the 3rd years of the plantation (Table 3). Young as these stands may be, the observations made on them seem to agree with observations of others on biomass accumulation and distribution patterns. Marked changes in relative distribution of biomass with age has been noted for several eucalypts (Madgwick et al, 1977; Frederick et al, 1985), for *Pinus radiata* (Madgwick and Oliver, 1985) for teak Nwoboshi (1985) and Okorie (1987) have noted that the stem portion of the biomass increased with age. Nwoboshi (1985) for instance showed that stemwood increased from 33 percent in the first year to 73 percent from the 7th year upwards, and that both leaf and branch biomass decreased with age. It has also been shown for some eucalypts (Frederick et al, 1985) and radiata pines (Madgwick et al, 1977) that with increasing age, stands generally had a decreasing fraction of their above-ground biomass in leaves and branches.

Impacts of Canopy Stratification

The effects of competition as reflected by the position of the tree in the canopy or the differentiation into suppressed, intermediate, co-dominant and dominant trees, on linear and biomass growth are shown in Table 4. All the trees, irrespective of their crown class, grew in both linear dimensions and dry matter production with age. The rates however increased from the suppressed through the intermediate to the dominant trees. At the end of the 3rd year, even the suppressed trees were growing at about 3.5cm in diameter per annum indicating that most, if not all the Gmelina raised under this technique in Subri Reserve, can by the age of 5-7 years attain a diameter of 15cm and therefore be ready for pulpwood harvesting either by thinning or clear felling. The dominant and the co-dominant members which grew much faster than the mean tree, have already passed the 15cm diameter size by the end of the third year. Heights, basal area and volume showed similar trends with their crown class.

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