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Assessment of Early Growth and Silviclutural Requirements of *Brachystegia eurycoma* (HARMS)*, Afzelia africana* (SM)*, Milicia excelsa* (WELW.) C.C. BERG in Umudike, Nigeria

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Abstract
The experiment investigated early growth and the silvicultural requirements for enhancing the growth of Afzelia africana, Brachystegia eurycoma, and Milicia excelsa in Umudike, Abia State, Nigeria. Seeds of the species were collected from under parent trees and raised in the nursery. Vigorously growing seedlings of the species were used to establish a 3x3x3 factorial in RCBD experiment with manures (Cow dung, Poultry droppings, and no-manure) and planting densities (4,444; 10,000 and 40,000ha^{-1}) as the other two factors, all in three replications. Data collected on the plant's growth parameters of height, collar diameter, number of leaves, number of branches, and leaf area were subjected to statistical ANOVA. Significant means were separated at $LSD_{0.05}$. The result shows that the highest plant height was recorded with B. eurycoma at 40,000ha^{-1}with poultry manure (115.56 cm) while least height was recorded in A. africana at 4,444ha^{-i} with no-manure (44.56cm). B. eurycoma recorded the highest number of leaves (48.35), M. excelsa had the highest number of branches (4.25) and highest unit leaf area (429.00 cm^2), while A. africana had the least values. The high growth rate of B. eurycoma indicated the greater potential for establishment and colonization in forest gaps and preference over the others for forest management objectives of biomass production. The silvicultural treatments of species selection, have the most significant influence on growth parameters than spacing and manure treatments, indicating that the genetic predisposition of the plants is a key factor determining growth performance of plantations.
Keywords: ***Afzelia africana, Brachystegia eurycoma*, *Milicia excels,* Silvicultural treatments, *growth* rate**

Introduction

Deforestation is a major driver of biodiversity loss and directly or indirectly myriads of socio-economic and environmental challenges including climate change. Nigeria which was once well endowed with diverse forest types, has been reported to presently have high forests covering less than 5% of the land area, and the northern states are completely deforested (Molinos, 2013). The country has one of the highest rates of deforestation in the world (FAO, 2010) such that the forest in most places is no longer in a healthy state to sustain the economic and ecological services they provide people and communities. The foregoing is indicative of the country's vulnerability to climate change and the urgency of its need for sustainable forest management. However, the lack of adequate knowledge of the silvicultural requirements of the diverse forest species has been reported as a major reason for poor tropical forest management systems in Nigeria (Umeh, 1992; Laird, 1995; Okojie, 1997). Consequently, many Indigenous forest and tree species have been compromised for other land use such as agriculture, infrastructural development, and mineral exploitation; and thereby causing Indigenous forest species like *Afzelia africana, Brachystegia eurycoma* and, *Milicia excelsa; known respectively as Akparata*, *Achi*, *Oji in Igbo language;* to be in danger of extinction despite their enormous importance (Okojie, 1997; Meregini, 2005; Borokini *et al.*, 2012).

The importance of these tropical tree species is quite enormous. They are useful for the production of high-quality timber and other raw materials used by various industries, such as human medicine, edible fruits used as food condiments and soup thickeners, forage for livestock, browse plants for wild animals, and carbon sinks for greenhouse gasses. Hence the search for appropriate silvicultural practices to enhance their regeneration and growth. The basis of the practice of silvicultural principles and forest management operations is that the survival, growth, and development of forests depend on the interplay of site and stand management factors and by genetic factors of the species (Wong *et al.*, 1992; Unwin and Kriedemann, 2000; IPCC, 2007; Sands, 2013)his research investigated the effects of the silvicultural practices of species selection, manure application, and planting density on the growth of these important indigenous tree species of the tropical rainforest of Southeastern Nigeria.

Materials and Methods

Study area: The experiment was conducted in the arboretum of the Department of Forestry and Environmental Management (FOREM), Michael Okpara University of Agriculture, Umudike (MOUAU) Abia State, Nigeria (Fig. 1). Umudike is located between lat. $05^0 32^1$- $06^0 17^1$North and long. $07^0 11^1$ - $08^0 10^1$ East in the rainforest of Southeastern Nigeria where the climate is essentially humid tropical (Keay, 1989; Nwosu *et al.*, 2011). The zone is characterized by two distinct seasons: the rainy season from March/April to October with bimodal peaks (June and September) and a short break in August; and a dry season from November to March (Audu *et al*., 2008). Annual mean temperature ranges between 33^0C – 35^0C as maximum and 28^0C -29^0C as minimum while the mean annual rainfall ranges between 1800 and 2000mm (Audu *et al.*, 2008; Nwosu *et al.*, 2011). The soil is derived from coastal plain sands and is classified as ultiosol and haplic acrisol (Enweozor *et al*., 2009). The vegetation is rainforest even though much of the forest estate has been destroyed. Agriculture which involves over 70% of the population is the major occupation of the people.

Experimental layout: Eighty-one (81) even-aged uniformly growing vigorous seedlings of the three species respectively were transplanted from the polythene pots wherein the seedlings were raised from their seeds in the nursery of the Department of Forestry and Environmental Management, Michael Okpara University of Agriculture Umudike (Nwajiobi *et al.*, 2022) into prepared planting holes to establish a 150 m^2 experimental plot. The plot was divided into 3 blocks separated by a 1m path with the experiment laid out in a 3x3x3 factorial in RCBD design in three replications and a sample size of 3 seedlings per species (Table 1). After two weeks of acclimatization, 0.5 kg of appropriate manures was applied using the ring method. Soil auger samples at 10-20cm depth randomly collected from 9 locations across the experimental plots were bulked, and a composite sample was analyzed for physico-chemical properties using standard laboratory procedures as described by Udo *et al*., (2001) at the laboratory of National Root Crops Research Institute, Umudike. The experiment was monitored for one (1) year.

Cultural Practices

Pest control: The *Phytolyma lata* pest that usually attack *M.excelsa* plants was checked with an appropriately integrated pest management approach (Ugwu and Omoloye, 2014) involving mild application of pesticide CYPERCOT (Cypermethrin 10% E.C) insecticide with hand-picking out and killing of the various stages of the pest. The insecticide was collected from the FOREM Departmental Store, MOUAU. Thirty liters (30L) of 1.5mlL^{-1} of the insecticide was applied uniformly across the experimental plots using a knapsack sprayer for the first four months after transplant to effectively control the pest attack without affecting the physiology and growth of the three tree species.

Weeding: Weeding was done manually with hoe and cutlass monthly during the rainy seasons and only once during the three months of the dry season. The weeds were removed entirely from the plots so as not to interfere with the manure treatment on the soil.

Assessment of the early growth rate of the species

GrThe parameters of the plants such as plant height (cm), number of leaves, number of branches, leaf area (cm^2), and collar diameter (cm) were measured monthly for six months after transplanting. Plant height was measured with a meter rule at the distance from soil level to terminal bud. The number of leaves and the number of branches were determined by counting, while the leaf area was determined by tracing the leaves on graph paper and counting the number of 1cm squares (the grid method). Collar diameter at 2.5cm above the soil level was measured with a veneer caliper. Data collected were subjected to analysis of variance (ANOVA) and significant means separated with Duncan's multiple range test (DMRT) at $P \leq 0.05$ using SPSS 20.0.

Data analysis: Data obtained from the experiments were subjected to statistical analysis of variance (ANOVA) using SPSS 20.0. Significant means were separated using the Duncan Multiple Range Test (DMRT) and Fisher's Least Significant Difference (FLSD) at $P<0.05$.

Results and Discussion

Physico-Chemical Properties of Experimental Soil

The physicochemical analysis of the soil (Table 2) shows that the soil is relatively poor in mineral nutrients (N 0-156%, P 20 mg/kg, K 0.083 $cmol^{-1}$). It is low in organic matter (3.25%), and slightly acidic (pH. 4.4). The findings agree with Nwosu *et al*. (2011) and Osedeke (2017) who reported low nutrient status of soils in the southeast resulting from deforestation and intensification of crop production which causes soil erosion and excessive leaching of the soil nutrients. It supported Nwoboshi (1982) that acidic soils are common where rainfall is high and the soil is permeable enough to permit the leaching of appreciable amounts of exchangeable bases from the upper horizons of the soil. The findings also agree with reports that soil fertility is a crucial problem facing agricultural development and food security in Sub-Saharan Africa (SSA) (Vanlauwe *et al.,* 1999; Omotayo and Chukwuka, 2009).

Chemical composition of the organic manures

Results of laboratory analysis of the poultry manure and Cow dung used for the experiment (Table 3) show that the poultry manure has a higher composition of Nitrogen (26.20%, Potassium (24.50%), and Magnesium (31.60) than the cow dung (12.60%, 10.00%, and 28.00% respectively). Cow dung however has a greater composition of Calcium (76.20%) and Sodium (2.75%) than poultry manure (68.10%, and 1,5% respectively). The manures are rich in organic matter with poultry manure having greater amounts (218.10%) than cow dung (156.56%). The organic manures therefore have the potential for enhancing soil nutrients and plant growth. The result supports reports that organic manures contribute to soil fertility by adding organic matter and nutrients particularly nitrogen to the soil and promoting the growth of beneficial soil organisms (Tanimu *et al*. 2013; Roy *et al*., 2006; Raj *et al*., 2014).

Effects of Species, Spacing, and Manure on Seedlings Height Growth (cm)

The mean heights of the species varied significantly between experimental treatments (Table 5). At the end of data collection [10 Months after Planting (MAP)], *B. eurycoma* recorded the highest mean height (98.40cm), followed by *M. excelsa* (89.00cm) indicating that faster growth rate of the species. However, *B. eurycoma* was planted at 40,000ha^{-1} with poultry manure treatment and recorded the highest mean plant height of all the treatment combinations (115.56cm). The lowest plant height was by *A. africana* planted at 10,000 ha-1 without manure (no-manure) treatment (44.56 cm).

Planting density and species types produced significant differences in plant height while the manure effect was not significant probably because the manures had not mineralized sufficiently to significantly affect seedlings' growth in the first month of the experiment. Ewulo *et al*. (2007) also reported that manure releases nutrients slowly in the soil and the rate of release depends on the type of manure and environmental conditions. However, the findings supported Francisco *et al.* (2014) that water availability, rather than increased fertilization was the main factor controlling biomass production in trees. This may be why it is usually advised to limit manure application to amounts needed to make up for differences between crop need and existing fertility (Roy *et al*., 2006).

Plant heights varied with planting density probably because reduced planting reduces competition for nutrients by the roots. It may also be that it allows for a greater number of leaves to be directly exposed to sunlight thereby facilitating photosynthetic protein and plant growth. This supports Nwoboshi (1982) who noted that growth in the seedling stages of trees is governed by the ability of the seedlings to increase their photosynthetic area.

Height growth also significantly varied with plant species. *B. eurycoma* recorded significantly highest growth within the period of the experiment (**77.70**cm), followed by *M. excelsa* (77.60cm). The least growth in height was recorded with *A. africana* (44.53 cm). The faster growth rate of *B. eurycoma* indicates that the species will establish faster to gain dominance of a new canopy opening than *A. africana* and *M. excelsa* since fast growth is a potential mechanism for gaining early dominance of a new canopy gap (Burslem and Miller, 2001). Fast growth could be associated with differences in the leaf area of the various species. Burslem and Miller (2001) reported that a high relative growth rate was associated with a high allocation of dry mass to leaves with a high specific leaf area; combined with intermediate values of net assimilation rate per unit leaf area. It also agrees with Jansson *et al.*, (2010) that the efficiency with which solar energy is intercepted by plants is one of the most important factors for biomass production. The interactions between treatments were also significant. Interactions between the tree species and manure were not significant in the first two months but were significant after the second month. The interaction between tree species and the planting spacing was also significant.

Effects of Species, Spacing, and Manure on Seedlings Collar Diameter (cm)

Table 4.5 shows that there were significant treatment effects on the diameter growth of the three species of seedlings. At 10 MAP, *M. excelsa* planted at 40,000 ha^{-1} with poultry manure treatment recorded the highest collar diameter (5.78cm) while *A. africana* at 40,000ha^{-1} with no manure recorded the least collar diameter (2.70cm). It could be that variations in the leaf sizes of the species implied variations in photosynthetic surface area and consequently variations in plant diameter. The findings may support the opinion that the width of the growth ring and biomass production in any species is dependent upon the relative size and exposure of the crown to solar energy (Fritz and Averill, 1924; Johnson *et al*, 2010). It also supported Nwoboshi (1982), that the cambial activity is largely influenced by the available food supply. It could also be that the species vary in their growth hormone regulators, including growth promoters and inhibitors which play a major role in cambial growth. Thus, it supports Dutta (2006) that plant growth hormones influence the growth, development, and differentiation of cells and tissue in plants.

Seedlings' collar diameters were significantly affected by planting spacing. Lower planting density allows for a greater number of leaves to be directly exposed to sunlight thereby facilitating photosynthetic protein and plant growth. The findings support Nwoboshi (1982) who noted that growth in the seedling stages of trees is governed by the ability of the seedlings to increase their photosynthetic area. It may also be associated with reduced competition for plant nutrients by the seedling's root system with increasing planting density which is reflected in significant variations in seedling diameter. Although the effect of manure type on the diameter growth of the species is not significant, *B. eurycoma*, *M. excelsa* and *A. africana* treated with poultry manures recorded higher mean diameter values than those treated with cow dung and control respectively. The findings supported Francisco *et al.* (2014) that water availability, rather than increased fertilization was the main factor controlling biomass production in trees.

Effects of Species, spacing, and Manure on Seedlings Number of Leaves

Number of leaves of the seedlings varied significantly with the experimental treatments (Table 4.6). By the end of the experimental period, *B. eurycoma* recorded the highest mean number of leaves (48.35), followed by *M. excelsa* (46.13). The least mean number of leaves was recorded with *A. africana* (15.31). However, it is *B. eurycoma* treated with poultry manure and planted at 0.5m spacing that recorded the highest number of leaves (56.33), while *A. africana* treated with no fertilizer and planted at 0.5 spacing had the least number of leaves (9.67) in June, the first month of data collection. The high photosynthetic area is a characteristic of emergent trees of tropical rainforests for efficient interception of highly needed solar energy (Burslem and Miller, 2001; Jansson *et al*, 2010). Eneji *et al*. (2014) noted that higher values for dry weight of trees and CO_2 sequestered may be related to broad leaves and thick vegetation. According to Burslem and Miller (2001), a high relative growth rate was associated with a high allocation of dry matter to leaves with a high specific leaf area. The irradiance or light intensity affects tree growth through its effects on photosynthesis, stomata opening, and chlorophyll synthesis. It also affects height growth, leaf size, and structure of both leaves and stems through its effects on cell enlargement and differentiation. The findings agree with Nwoboshi (1982) and Geyer *et al* (1989) that *M. excelsa* is a non-pioneer emergent forest species.

Planting density also influenced significantly the number of leaves of the species. Higher planting distance naturally encourages lateral growth which translates into increased girth, number of branches, and leaves in the species. According to Nwoboshi (1982), lower planting density saves the plants from the stress, strain, and competition associated with higher planting density thereby encouraging lateral growth of branches and leaves. Although manure type did not significantly affect the number of leaves of the species, *A. africana, B. eurycoma* and *M. excelsa* treated with poultry manure often recorded a higher number of leaves followed by those treated with cow dung, while the no manure treatments recorded the least number of leaves. Treatment interactions were significant.

Effects of Species, Spacing, and Manure on Seedlings Number of Branches

The treatments significantly affected the branching characteristics of the seedlings (Table 4.7). *M. excelsa* recorded the highest mean number of branches (4.25) followed by *B. eurycoma* (3.14) while the least mean number of branches was by *A. africana* (0.26). Branch formation and leaf formation are influenced by similar factors in plants. It could also be a genetic mechanism for increasing photosynthetic surface area for efficient interception of solar energy for the rapid growth and establishment of emergent forest species. The result agrees with Nwoboshi (1982) who reported that irradiance or light intensity affects height growth, leaf size, and structure of both leaves and stems. Branching was also significantly affected by the planting density of the species. Lower plant density encourages lateral growth which translates into increased girth, and number of leaves and branches. This is because it tends to save plants from the stress associated with competition for light which encourages apical growth thereby encouraging greater branching and leaf development (Nwoboshi, 1982). Greater branching of *M. excelsa* may indicate greater photosynthesis and consequently higher growth rate. The findings agree with Jansson *et al*. (2010) that increased branching indicated potential for increased photosynthetic surface area which could enhance the rate of biomass accumulation and carbon sequestration in the species. Treatment interactions significantly affected branch formation in all three tree species.

Effects of Species, Spacing, and Manure on Seedling Unit Leaf Area (cm^2)

Table 4.8 shows that the effects of treatments on the unit leaf area of the plants were significant. *M. excelsa* recorded the highest mean unit leaf area (429.00), followed by *B. eurycoma* (357.30). Least leaf area was recorded in *A. africana* (312.74). However, the leaf area of *M. excelsa* planted at 0.5m spacing and treated with poultry manure recorded the highest unit leaf area (469.11) among all the treatment combinations. The lowest value (305.78) was recorded in *A. africana* planted at 0.5m spacing with no manure. *M. excelsa* is relatively light demanding and its high photosynthetic area is said to be a mechanism for gaining dominance by the emergent trees in tropical forest ecosystems (Burslem and Miller, 2001). The findings agree with Eneji *et al*. (2014) who reported a relationship between the dry weight of trees to broad leaves and thick vegetation. It supports Nwoboshi (1982) and Keay *et al.* (1964) on the greater height of the *M. excelsa* tree in comparison to *B. eurycoma* and *A. africana*. The finding also suggests that differences in leaf area amongst the species could be genetic (Nwoboshi, 1982). Burslem and Miller (2001) also reported a high leaf area ratio of *M. excelsa* to *A. africana* and attributed it to a high allocation of seedling dry mass to leaves with a large specific leaf area.

Planting spacing affected the leaf area of the species significantly. Lower planting density encouraged lateral growth which translates into a greater number of leaves or enriched leaf area. It agrees with Nwoboshi (1982) that growth in seedling stages is governed by the ability of the seedling to increase its photosynthetic area. According to the author, it also affects height growth, leaf size, and structure of both leaves and stems through its effects on cell enlargement and differentiation. Manure has no significant effect on the number of leaves of the species probably because it has not adequately mineralized to exert significant effects on plant growth parameters. Ewulo *et al*. (2007) reported that manure releases nutrients slowly in the soil and the rate of release depends on the type of manure and environmental conditions.

Conclusion

The growth rate of the species varies significantly. Of the three species, *B. eurycoma* and *M. excelsa* demonstrated higher growth rates than *A. africana.* Thus, where biomass production and/or carbon storage is the object of forest management, *B. eurycoma* and *M. excelsa* should be recommended over *A. africana*. Silviculture practices of species selection, fertilizer use, and planting densities will be relevant in facilitating the regeneration of natural forests and/or establishment of new forests for whatever objective of forest management including biomass production and carbon sequestration. In other words, forest management can shape tree species into desired phenotypes. By modifying light, water, and nutrient availability through variations in stand density, one can direct growth to build tall, branchless poles or enhance crown development for seed production and subsequent stand recruitment. In the face of a global climate change regime, opportunities exist for the use of indigenous tropical tree species for biomass production and carbon storage purposes; thereby broadening the socio-economic benefits derivable from the forest species to the communities, and possibly enhancing their conservation status. Afforestation and reforestation with indigenous tree species in forest areas or on farmland should be encouraged to enhance the availability of their products and services for rural people and to enhance their conservation. *B. eurycoma* and *M. excelsa* could be recommended to forest management with the objective of biomass production and carbon storage in short rotations. Further research however is required on the growth characteristics of the three indigenous forest tree species at older stages of their growth and development. Further studies are required to compare the growth rate of indigenous species with common exotic species.

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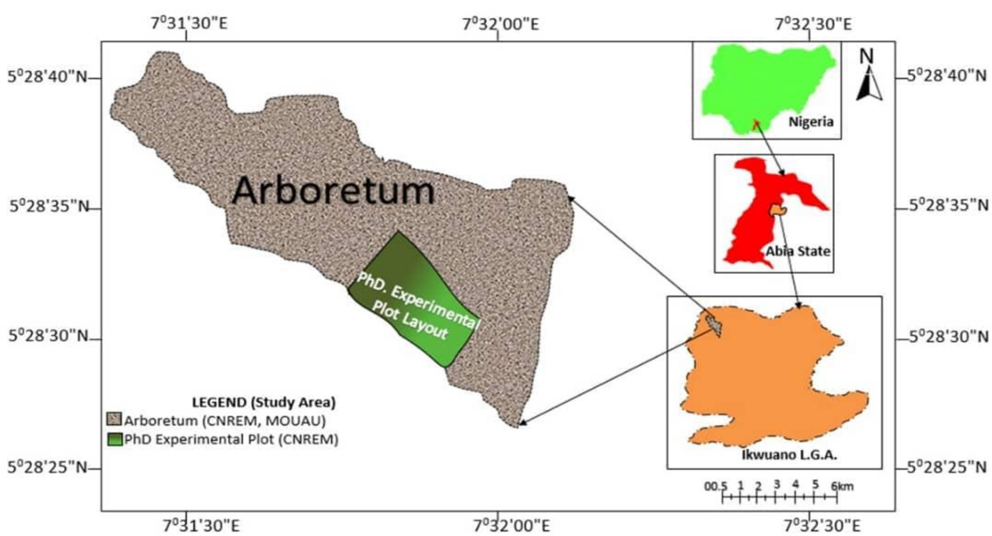

Fig. 1: Map showing the experimental plot in Ikwuano LGA, Abia State, Nigeria

Table 1: Experimental Layout, Factors and Treatments

EMX	EMY	EMZ	FMX	FMY	FMZ	GMX	GMY	GMZ
FMX	FMY	FMZ	GMX	GMY	GMZ	EMX	EMY	EMZ
GMX	GMY	GMZ	EMX	EMY	EMZ	FMX	FMY	FMZ
ENX	ENY	ENZ	FNX	FNY	FNZ	GNX	GNY	GNZ
FNX	FNY	FNZ	GNX	GNY	GNZ	ENX	ENY	ENZ
GNX	GNY	GNZ	ENX	ENY	ENZ	FNX	FNY	FNZ
EOX	EOY	EOZ	FOX	FOY	FOZ	GOX	GOY	GOZ
FOX	FOY	FOZ	GOX	GOY	GOZ	EOX	EOY	EOZ
GOX	GOY	GOZ	EOX	EOY	EOZ	FOX	FOY	FOZ

Factor A (Tree species): E= B.eurycoma, F= A africana, and G= M. excelsa.
Factor B (Manures): X =No manure, Y=Poultry manure, and Z= Cattle manure.
Factor C: (Density): M= 40,000ha^{-1} (0.5m x 0.5m) N=10,000ha^{-1} (1m x 1m) and O=4,444ha^{-1}(1.5m x 1.5m)

Plate 1. Seedlings of *A. Africana, B. euricoma* and *M. excelsa*

0.5 m x 0.5 m (4.444ha^{-1}) 1 mx 1 m (10.000ha^{-1}) 1.5 m x 1.5 m (40.000ha^{-1})

Plate 2. Showing seedlings of the three tree species
Tree Species at 4,444ha^{-1}, 10,000ha^{-1} and 40,000ha^{-1}planting density

Poultry Manure Cow waste No Manure

Table 2: Physico-chemical properties of soil of the experimental plot

Soil Properties	Values
Sand (%)	46.40
Silt (%)	19.40
Clay (%)	34.20
Texture	Sand Clay Loam
Ph	4.40
P (mg/kg)	20.80
N (%)	0.156
Organic Carbon (%)	1.88
Organic Matter (%)	3.25
Ca (cmol kg^{-1})	2.60
Mg (cmol kg^{-1})	1.00
K (cmol kg^{-1})	0.083
Na (cmol kg^{-1})	0.234
EA (cmol kg^{-1})	1.60
ECEC (cmol kg^{-1})	5.517
BS (%)	71.00

Table 3: Chemical Composition of Organic Fertilizers

	Composition (%)	
Chemical Properties	**Poultry**	**Cow Dung**
Nitrogen (N)	25.20	12.60
Phosphorus (P)	14.00	14.40
Potassium (K)	24.50	10.00
Calcium (Ca)	68.10	76.20
Magnesium (Mg)	31.60	28.00
Sodium (Na)	1.50	2.75
Organic Carbon (C)	126.50	90.80
Organic Matter (OM)	218.10	156.56

Table 5: Effects of Species, Spacing, and Manure on Seedlings Height (cm)

Species	Spacing	Manure	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A	0.5	CT	24.35	32.05	37.34	40.67	49.00	49.56	51.00
A	0.5	CD	27.60	31.93	37.55	45.11	46.33	49.78	49.33
A	0.5	PM	28.51	30.07	30.71	31.33	34.11	45.67	50.44
A	1.0	CT	24.32	29.97	36.44	38.22	42.56	43.56	44.56
A	1.0	CD	25.04	26.82	27.46	37.11	39.89	45.67	47.78
A	1.0	PM	27.18	31.31	35.29	36.22	42.34	49.78	47.33
A	1.5	CT	22.11	28.98	35.22	38.56	40.78	44.00	44.89
A	1.5	CD	26.47	27.30	33.89	40.44	44.11	42.67	50.44
A	1.5	PM	26.40	30.62	35.11	44.56	44.89	47.11	51.67
Mean			25.78[a]	29.97[a]	34.60[a]	38.54[a]	43.67[a]	48.53[a]	48.05[a]
B	0.5	CT	21.36	28.27	39.88	57.89	66.22	84.78	98.67
B	0.5	CD	20.89	30.39	49.45	64.56	76.75	88.56	102.00
B	0.5	PM	22.71	27.05	42.30	60.89	71.56	89.00	115.56
B	1.0	CT	21.29	29.19	44.47	50.22	67.56	78.00	85.67
B	1.0	CD	20.63	24.65	27.90	53.33	60.89	84.56	9200
B	1.0	PM	20.38	29.51	38.59	51.11	61.89	76.67	86.89
B	1.5	CT	19.69	25.32	53.11	55.33	68.55	72.22	87.33
B	1.5	CD	21.37	28.74	44.45	68.67	64.78	84.56	92.78
B	1.5	PM	20.41	30.26	35.67	61.11	57.78	77.00	90.67
Mean			20.97[b]	28.04[b]	40.76[b]	57.57[b]	72.24[b]	87.70[b]	98.40[b]
M	0.5	CT	16.60	21.21	58.19	66.67	74.33	85.67	156.00
M	0.5	CD	15.43	18.23	40.31	53.33	67.00	73.22	105.22
M	0.5	PM	12.27	16.14	33.17	50.67	71.00	81.22	104.67
M	1.0	CT	14.70	17.74	37.09	55.11	67.67	72.33	102.56
M	1.0	CD	11.88	14.91	30.90	50.22	66.00	73.33	82.56
M	1.0	PM	15.43	19.92	32.21	50.33	67.89	70.33	85.44
M	1.5	CT	9.74	12.04	30.44	48.67	60.55	69.33	36.44
M	1.5	CD	10.27	14.07	34.67	50.78	63.78	68.78	75.44
M	1.5	PM	11.05	16.22	36.11	48.34	54.33	68.22	52.67
Mean			13.04[c]	17.11[c]	48.68[c]	67.49[c]	76.95[c]	78.60[c]	89.00[c]
Total Mean			19.93	16.28	41.35	53.46	61.32	66.61	78.48
$LSD_{0.05}$T			0.88*	1.08*	1.37*	6.27*	2.65*	4.29*	5.51*
$LSD_{0.05}$S			0.88*	1.09*	1.37*	6.27*	2.65*	4.29*	5.51*
$LSD_{0.05}$M			0.88	1.09*	1.37	6.27*	2.65	4.29*	5.51*
$LSD_{0.05}$T.S			1.53*	1.88*	2.37*	10.80*	3.02*	7.39*	9.55*
$LSD_{0.05}$T.M			1.53	1.88	2.37*	10.80*	3.02*	7.39*	9.55*
$LSD_{0.05}$S.M			1.53*	1.88*	2.37*	10.80	3.02*	7.39*	9.55*
$LSD_{0.05}$T.S.M			2.64	3.26	4.11*	18.71	8.03*	12.80*	16.54*

A=Afzelia, B=Brachystegia, M=Milicia, T=Tree Species, S= Spacing, M=Manures

CT=Control, CD=Cow Dung, PM=Poultry Manure

Values are means of replicates±Standard Deviation. Asterisks (*) indicate a significant difference at P≤0.05

Table 5: Effects of Species, Spacing, and Manure on Seedling Collar Diameter (cm)

Species	Spacing	Manure	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A	0.5	CT	0.97	1.14	1.35	2.17	2.11	2.48	2.70
A	0.5	CD	1.08	1.33	2.08	2.51	2.78	2.98	3.23
A	0.5	PM	1.03	1.39	1.91	2.76	2.58	2.66	3.12
A	1.0	CT	1.07	1.16	1.94	2.22	2.48	2.81	2.82
A	1.0	CD	0.91	1.06	1.59	1.94	2.59	2.88	3.02
A	1.0	PM	1.04	1.31	1.71	2.54	3.12	3.03	3.41
A	1.5	CT	1.01	0.97	1.87	1.58	2.86	2.48	3.11
A	1.5	CD	0.94	1.11	1.74	2.96	2.37	2.97	3.28
A	1.5	PM	1.10	1.11	1.97	2.72	3.25	3.03	3.21
Mean			1.02^{a}	1.18^{a}	1.79^{a}	2.45^{a}	2.65^{a}	2.78^{a}	3.10^{a}
B	0.5	CT	1.19	1.70	2.06	2.39	2.54	2.69	3.64
B	0.5	CD	1.15	1.45	2.01	2.47	2.55	3.00	3.68
B	0.5	PM	1.21	1.27	1.75	2.50	2.66	2.92	3.32
B	1.0	CT	1.12	1.31	1.72	2.26	2.51	3.00	3.66
B	1.0	CD	1.18	1.14	1.57	2.70	2.99	2.83	3.12
B	1.0	PM	.99	1.47	2.05	2.83	2.78	2.61	2.72
B	1.5	CT	1.25	1.14	2.05	2.57	3.11	2.92	3.21
B	1.5	CD	0.97	1.23	2.08	3.67	3.02	2.61	3.28
B	1.5	PM	1.10	1.16	2.04	3.27	2.80	3.00	3.32
Mean			1.13^{b}	1.32^{b}	1.92^{b}	2.74^{b}	2.76^{a}	2.84^{a}	3.33^{b}
M	0.5	CT	1.95	2.39	2.66	3.23	3.38	3.73	4.07
M	0.5	CD	2.12	2.75	3.05	3.75	4.12	8.04	4.66
M	0.5	PM	2.02	2.97	3.61	5.21	5.53	5.70	5.78
M	1.0	CT	2.03	2.09	2.47	3.90	4.17	4.13	4.36
M	1.0	CD	2.00	2.26	2.32	3.62	3.53	3.73	3.99
M	1.0	PM	1.83	2.37	2.99	3.04	3.35	5.68	5.74
M	1.5	CT	1.62	2.19	2.58	2.63	3.38	3.62	3.84
M	1.5	CD	1.72	2.18	2.94	3.42	3.01	5.57	5.62
M	1.5	PM	1.96	1.91	2.25	2.97	4.21	4.24	4.58
Mean			1.92^{c}	1.44^{c}	2.76^{c}	3.52^{c}	3.85^{b}	4.94^{b}	4.74^{c}
Total Mean			1.35	1.61	2.16	2.86	3.09	3.52	3.72
$LSD_{0.05}$T			0.09*	0.06*	0.66	0.13*	0.13*	0.66*	0.15*
$LSD_{0.05}$S			0.09*	0.06	0.66	0.13*	0.13	0.66	0.15
$LSD_{0.05}$M			0.09	0.06*	0.66	0.13	0.13*	0.66	0.15
$LSD_{0.05}$T.S			0.16	0.11*	0.13*	0.22*	0.23*	1.13	0.26*
$LSD_{0.05}$T.M			0.16	0.11*	0.13*	0.22*	0.23*	1.13	0.26*
$LSD_{0.05}$S.M			0.16	0.11*	0.13*	0.22*	0.23*	1.13	0.26*
$LSD_{0.05}$T.S.M			**0.28**	**0.20**	**0.25***	**0.38***	**0.40***	**1.96**	**0.44***

A=Afzelia, B=Brachystegia, M=Milicia, T=Tree Species, S= Spacing, M=Manures

CT=Control, CD=Cow Dung, PM=Poultry Manure

Values are means of replicates±Standard Deviation. Asterisks (*) indicate a significant difference at $P\leq0.05$

Table 6: Effects of Species, Spacing, and Manure on Seedling's Number of Leaves

Species	Spacing	Manure	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A	0.5	CT	8.56	9.00	10.22	11.44	11.44	11.78	11.78
A	0.5	CD	9.56	11.56	11.56	12.33	12.34	13.67	13.89
A	0.5	PM	9.67	10.67	12.67	13.11	13.22	13.67	13.84
A	1.0	CT	10.22	10.33	10.45	11.12	12.11	12.78	12.78
A	1.0	CD	9.67	10.89	11.35	12.22	13.33	13.47	13.83
A	1.0	PM	10.56	11.67	11.78	12.56	13.15	13.76	14.11
A	1.5	CT	9.16	9.31	9.78	9.78	10.67	13.55	14.22
A	1.5	CD	9.33	10.45	11.11	11.22	12.58	13.74	15.25
A	1.5	PM	10.01	11.10	12.22	13.00	13.25	14.33	16.00
Mean			10.62[a]	11.64[a]	12.56[a]	13.52[a]	13.86[a]	14.32[a]	15.31[a]
B	0.5	CT	16.55	20.11	21.33	25.45	29.42	34.67	36.78
B	0.5	CD	10.56	15.00	18.78	22.00	29.22	33.11	50.56
B	0.5	PM	12.33	15.11	21.44	25.56	32.11	41.78	56.33
B	1.0	CT	11.22	15.00	17.78	18.78	23.78	28.00	37.33
B	1.0	CD	10.00	14.11	15.56	26.11	34.89	43.33	51.89
B	1.0	PM	13.33	16.89	20.89	29.78	35.33	48.22	54.11
B	1.5	CT	10.00	13.33	14.78	21.33	27.99	37.78	45.56
B	1.5	CD	11.00	13.46	16.11	23.67	34.89	36.89	50.89
B	1.5	PM	11.22	14.44	18.22	27.33	39.67	48.78	53.44
Mean			11.80[a]	15.27[b]	18.32[b]	23.33[b]	30.23[b]	38.17[b]	48.35[b]
M	0.5	CT	12.89	18.45	21.44	34.33	35.67	39.11	42.56
M	0.5	CD	10.89	13.11	23.44	34.45	37.48	40.44	48.56
M	0.5	PM	11.33	15.22	26.11	37.11	42.00	44.33	49.00
M	1.0	CT	10.33	14.56	22.00	26.00	32.22	41.00	46.56
M	1.0	CD	10.67	12.78	23.56	34.22	38.11	40.20	51.56
M	1.0	PM	13.00	16.45	32.78	36.33	46.56	51.07	55.11
M	1.5	CT	10.67	10.11	25.00	11.44	41.67	28.67	16.44
M	1.5	CD	11.00	14.11	20.55	19.56	15.33	36.56	26.67
M	1.5	PM	12.55	15.34	21.67	31.56	45.78	50.44	53.67
Mean			11.48[b]	14.46[c]	27.38[c]	35.57[c]	42.79[c]	43.62[c]	46.13[c]
Total Mean			11.30	13.46	19.42	22.58	30.71	33.26	34.15
$LSD_{0.05}T$			0.61*	0.54*	1.19*	2.64*	3.35*	6.59*	7.25*
$LSD_{0.05}S$			0.61*	0.54*	1.19*	2.71*	3.35*	6.59*	7.24*
$LSD_{0.05}M$			0.61	0.54	1.19*	2.79*	3.35	6.59*	7.24
$LSD_{0.05}T.S$			1.05*	0.95	2.07*	4.69*	5.85*	11.42*	12.53*
$LSD_{0.05}T.M$			1.05	0.95*	2.07*	4.69*	5.85*	11.42*	12.53*
$LSD_{0.05}S.M$			1.05*	0.95*	2.07*	4.69*	5.85*	11.42*	12.53*
$LSD_{0.05}T.S.M$			1.82*	1.62*	3.58*	8.13*	10.14*	19.78*	21.71*

A=Afzelia, B=Brachystegia, M=Milicia, T=Tree Species, S= Spacing, M=Manures

CT=Control, CD=Cow Dung, PM=Poultry Manure

Values are means of replicates±Standard Deviation. Asterisks (*) indicates a significant difference at P≤0.05

Table 7: Effects of Species, Spacing, and Manure on Seedling Number of Branches

Species	Spacing	Manure	June	July	Aug.	SePM.	Oct.	Nov.	Dec.
A	0.5	CT	0.22	0.33	0.00	0.00	0.00	0.00	0.00
A	0.5	CD	0.00	0.22	0.22	0.22	0.33	0.33	0.33
A	0.5	PM	0.00	0.00	0.00	0.00	0.22	0.22	0.22
A	1.0	CT	0.00	0.00	0.00	0.00	0.00	0.11	0.44
A	1.0	CD	0.00	0.00	0.00	0.00	0.00	0.33	0.33
A	1.0	PM	0.00	0.22	0.33	0.00	0.33	0.11	0.00
A	1.5	CT	0.00	0.00	0.00	0.11	0.11	0.00	0.22
A	1.5	CD	0.00	0.00	0.11	0.11	0.33	0.44	0.56
A	1.5	PM	0.00	0.00	0.22	0.33	0.11	0.33	0.78
Mean			.02[a]	0.06[a]	0.08[a]	0.16[a]	0.18[a]	0.21[a]	0.26[a]
B	0.5	CT	0.00	0.44	1.22	1.42	1.56	1.78	2.33
B	0.5	CD	0.00	0.44	1.33	2.00	2.44	2.67	2.89
B	0.5	PM	0.00	0.33	1.22	1.56	2.56	2.56	3.78
B	1.0	CT	0.33	0.56	0.89	0.89	1.44	1.78	2.22
B	1.0	CD	0.00	0.22	1.22	1.45	1.33	2.89	3.78
B	1.0	PM	0.00	0.33	1.22	1.33	1.78	3.67	3.56
B	1.5	CT	0.00	0.33	.1.10	1.33	2.00	2.10	2.78
B	1.5	CD	0.00	0.33	1.45	1.78	2.45	2.61	3.22
B	1.5	PM	0.00	0.56	1.11	1.33	2.11	3.56	3.67
Mean			0.04[a]	0.39[b]	1.09[b]	1.56[b]	1.86[b]	2.56[b]	3.14[b]
M	0.5	CT	0.00	0.22	1.33	1.22	1.33	1.44	1.33
M	0.5	CD	0.00	0.89	2.33	3.17	3.33	3.56	3.67
M	0.5	PM	0.12	1.56	2.89	4.34	5.14	5.62	6.11
M	1.0	CT	0.22	0.67	1.56	.2.00	2.44	2.56	2.78
M	1.0	CD	0.00	0.22	1.56	1.89	2.22	2.56	2.89
M	1.0	PM	0.45	0.78	1.78	2.78	3.89	4.78	4.89
M	1.5	CT	0.00	0.33	1.44	1.78	2.89	3.56	3.78
M	1.5	CD	0.00	0.56	1.78	1.33	1.89	2.67	4.44
M	1.5	PM	0.00	0.44	1.33	2.31	3.11	4.33	4.89
Mean			0.10[a]	0.63[c]	1.78[c]	1.23[c]	3.07[c]	3.64[c]	4.25[c]
Total Mean			0.05	0.36	1.02	0.96	1.71	2.12	2.55
$LSD_{0.05}T$			0.07	0.11*	0.15*	0.30*	0.31*	0.53*	0.48*
$LSD_{0.05}S$			0.07*	0.11*	0.15*	0.30*	0.31*	0.53	0.48*
$LSD_{0.05}M$			0.07	0.11*	0.15*	0.30*	0.31*	0.53	0.48*
$LSD_{0.05}T.S$			0.12	0.20*	0.25*	0.50*	0.54*	0.91	0.83
$LSD_{0.05}T.M$			0.12	0.20*	0.25*	0.50*	0.54*	0.91*	0.83*
$LSD_{0.05}S.M$			0.12	0.20*	0.25*	0.50*	0.54*	0.91*	0.83*
$LSD_{0.05}T.S.M$			0.22*	0.34*	0.44*	0.87*	0.93*	1.57*	1.45*

A=Afzelia, B=Brachystegia, M=Milicia, T=Tree Species, S= Spacing, M=Manures
CT=Control, CD=Cow Dung, PM=Poultry Manure
Values are means of replicates $\pm$Standard Deviation. Asterisks (*) indicate a significant difference at $P \leq 0.05$

Table 8: Effects of Species, Spacing, and Manure on Seedling Unit Leaf Area (cm^2)

Species	Spacing	Manure	June	July	Aug.	Sept	Oct	Nov	Dec
A	0.5	CT	197.19	220.42	214.22	223.11	225.33	251.11	305.78
A	0.5	CD	198.75	212.17	216.44	226.00	241.11	277.89	318.11
A	0.5	PM	177.80	208.11	225.33	234.33	235.22	269.67	314.44
A	1.0	CT	201.40	206.78	216.22	238.67	248.66	261.00	313.11
A	1.0	CD	202.53	185.44	213.89	234.78	249.33	263.11	310.22
A	1.0	PM	208.17	212.33	223.33	248.11	263.56	270.22	314.00
A	1.5	CT	203.29	209.78	219.78	232.11	247.22	263.11	310.78
A	1.5	CD	184.05	214.45	216.89	235.78	269.67	272.33	315.11
A	1.5	PM	202.00	212.66	219.22	239.11	253.22	287.12	313.11
Mean			197.2 ^{a}	209.1 ^{a}	218.0 ^{a}	234.8 ^{a}	248.4 ^{a}	271.1 ^{a}	312.74 ^{a}
B	0.5	CT	204.75	240.44	246.66	256.00	268.17	279.78	347.33
B	0.5	CD	206.06	240.78	246.78	254.00	260.67	289.22	319.67
B	0.5	PM	194.71	225.33	234.56	249.45	258.22	284.33	338.33
B	1.0	CT	202.93	236.78	238.00	254.44	265.34	269.22	319.89
B	1.0	CD	206.84	221.33	229.44	250.33	260.67	284.33	311.33
B	1.0	PM	210.89	237.00	242.11	261.22	283.67	290.78	353.89
B	1.5	CT	208.80	218.78	217.00	250.22	272.89	285.00	312.11
B	1.5	CD	201.78	249.89	241.22	259.44	282.00	290.78	352.78
B	1.5	PM	198.09	237.33	231.44	255.11	262.78	293.67	319.89
Mean			203.9 ^{a}	234.2 ^{b}	236.4 ^{b}	254.5 ^{b}	268.3 ^{b}	285.2 ^{b}	357.30 ^{b}
M	0.5	CT	224.29	310.33	345.22	362.55	369.67	402.22	431.67
M	0.5	CD	269.59	361.56	369.45	380.55	394.34	418.67	446.67
M	0.5	PM	265.79	395.11	400.55	412.44	422.44	443.78	469.11
M	1.0	CT	304.73	359.22	366.67	400.67	380.56	402.22	420.89
M	1.0	CD	291.47	344.67	354.22	381.38	405.44	418.56	436.89
M	1.0	PM	323.73	353.89	368.11	397.67	410.00	421.22	449.11
M	1.5	CT	314.38	343.33	360.89	367.44	383.89	402.78	430.89
M	1.5	CD	321.08	363.33	359.78	393.00	414.33	418.67	436.67
M	1.5	PM	334.46	383.55	379.11	408.11	412.44	425.89	439.15
Mean			282.4 ^{b}	350.6 ^{c}	369.3 ^{c}	391.6 ^{c}	402.4 ^{c}	411.0 ^{c}	429.0 ^{c}
Total Mean			211.17	267.96	274.58	287.81	305.89	325.78	363.00
$LSD_{0.05}T$			13.13*	5.62*	2.76*	5.11*	3.00*	7.04*	4.82*
$LSD_{0.05}S$			13.13*	5.62	2.76*	5.24*	3.00*	7.04	4.82
$LSD_{0.05}M$			13.13	5.62	2.76*	5.41*	3.00	7.04	4.82
$LSD_{0.05}T.S$			22.74*	9.73	4.79*	9.08	5.23*	12.29	8.35
$LSD_{0.05}T.M$			22.74*	9.73*	4.79*	9.08	5.23*	12.29	8.35
$LSD_{0.05}S.M$			22.74*	9.73*	4.79*	9.08*	5.23*	12.29*	8.35*
$LSD_{0.05}T.S.M$			39.39*	16.85*	8.29*	15.73*	3.66*	21.28*	14.46*

A=Afzelia, B=Brachystegia, M=Milicia, T=Tree Species, S= Spacing, M=Manures

CT=Control, CD=Cow Dung, PM=Poultry Manure

Values are means of replicates±Standard Deviation. Asterisks (*) indicate a significant difference at $P \leq 0.05$