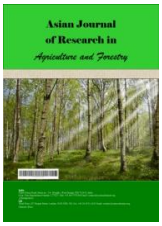

Asian Journal of Research in Agriculture and Forestry

6(2): 8-20, 2020; Article no.AJRAF.58509
ISSN: 2581-7418

Trees Mensuration in Forestry and Wildlife Nursery Plantation University of Maiduguri Campus, Borno State, Nigeria

M. R. Umar[1*]

[1]Department of Forestry and Wildlife Management, School of Agriculture and Agricultural Technology, Modibbo Adama University of Technology, Yola, Nigeria.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJRAF/2020/v6i230100
Editor(s):
(1) Dr. Nebi Bilir, Isparta University of Applied Sciences, Turkey.
Reviewers:
(1) Hiranmayee Nayak, Odisha University of Agriculture & Technology, India.
(2) Prem Prakash, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/58509

Original Research Article

Received 27 April 2020
Accepted 01 July 2020
Published 14 July 2020

ABSTRACT

A study was conducted at the premises of Faculty of Agriculture, Forestry and Wildlife Nursery Plantation University of Maiduguri situated in Sahel Savannah ecological zone of Nigeria. The area is hot and dry for a greater part of the year. The vegetation is typically Sahel Savannah consisting of mainly grasses with few drought resistance trees, total counting was used in other to obtain appropriately result of the measurements. The research was aimed at determine the optimum level growth of trees, assessment of different parameters and volume of trees and ascertain used to reduced environmental desertification. The species of trees assessed were Neem, Khaya and Gmelina, the measurement taken were DBH, Basal Area, Total height, Merchantable height, Bole height, Crown depth having mean values of 21.42 m, 404.73 m^2, 9.24 m, 1.71 m, 1.74 m and 7.5 m for Neem, khaya: 6.69 m, 35.27 m^2, 4.53 m, 1.91 m, 2.69 m and 2.87 m. Gmelina: 27.58 m, 599.61 m^2, 10.93 m, 1.69 m, 2.40 m and 8.58 m respectively and volumes for Neem, Khaya and Gmelina were 34.20 m^3, 19.87 m^3 and 30.03 m^3 respectively. From the result obtained, it was observed that Azadiracta grow higher and has larger volume than other species, followed by Gmelina and Khaya in terms of volumes. In terms of mean DBH, Basal Area, Total height, Merchantable height, Bole height and crown dept obtained on the tree species Gmelina has the highest in terms of the

**Corresponding author: E-mail: Mohammedraji11@gmail.com;*

determination of the measured followed by Neem and Khaya obtained from the results. There is need for World Bank to partner Nigerian Government and with forestry and wildlife department for the inventory of specific trees within the sub-region and also highlight the public to grow specific tree to reduce desertification within the savannah region of the Nigerian. This indicates that *Azadiracta indica* (Neem) species grow very well in region for afforestation also Khaya and Gmelina are used as anti-desertification control properties and as a good Carbon-dioxide Sink.

Keywords: Heights; DBH; tree species; volume and nursery plantation.

1. INTRODUCTION

Volume is the widely used measurement of wood quality and is usually estimated for the assessment of economic value or commercial utilization potential. The wood volume of a tree includes stem, branches, stump and root. Volume is always in cubic and usually expressed in cubic merchantable volume sometimes expressed in other unit related to commercial used [1].

Tree volume estimate serve a variety of purpose e.g scientific, economic and sporting competitions. Volume measurement can be achieved via tree climbers making direct measurement or remote method. The tree is subdivided into smaller sections, the dimension of each section is determined and the corresponding volume calculated [2]. The section volume were total to determine the overall volume of the tree or part of the tree being model, e.g frustum of cone, parabolic and neiloid where the diameter at each end the length of each section to calculate the volume. Biological volume is the volume of the stem with branches trimmed at the function with the stem, but usually excluding irregularities not part of the natural growth habit e.g malformation due to insect, fungi, fire and mechanical damage. Utilizable or merchantable volume exclude some volume within irregularities of the bole shape caused by normal growth e.g volume contained in the dwelling around a branch node may be excluded. Gross volume estimate would include defective and decayed wood. Net volume estimate exclude defective and decayed wood [3].

Azadiracta indica tree is noted for its drought resistance, it thrives in area with sub-arid to sub-humid condition with annual rainfall 400-1200 millimetre (16-47 m). It grows in region with an annual rainfall below 400 mm, but in such case it depends largely on ground water level. It typically tropical to sub- tropical tree and exit at annual mean temperature between 21-32°c (70-90°C), it tolerate high to very high temperature and does not tolerate temperature below 4°c (39°C). *Azadiracta* is used for anti-desertification control properties and possible as a good carbon – dioxide sink [4].

Azadiracta indica is woody family of plants comprising 50 genera and about 640 pecres widely distributed throughout the tropics and subtropics with only slight penetration into temperate zone ([5], Stevens, 2012). The tree has two species, *A. indica* thought to be native to dry areas of indo-Pakistan subcontinent [6] and *A. excels*, native to South-East Asia *A. indica* is a medium to large, deep rooted, evergreen trees to 15 (30) m tall with a round, large crown to 10 (20) in diameter, branches spreading, bole branchless for up to 7.5 m, up to 90 cm in diameter. *A. indica* occurs naturally in dry deciduous & thorn forest [7] and grows in mixed forest with Acacia species and Dalbergiasisso in India [4]. In its exotic range, it is reported to have become invasive in a number of habitat including fallow agricultural land, savanna & dry & arid forest (Hamilton A. world widefind for nature, Godalming, UK, Personal communication, 2002), coastal forest in Ghana [8], lowland monson forest in Indonesia & evergreen forest & dry deciduous forest in Africa [4]. *Azadiracta indica* is drought-tolerant species is grown to prevent soil erosion & to help in soil conservation and improvement. It is also important tree for helping to prevent the spread of Sahara Desert [9]. *A. indica* improves soil fertility & water holding capacity and can neutralize acidic soils and therefore it is useful for wasteland reclamation [10]. It grow on saline & alkaline soils with pH of up to 9.8 & with soluble salt content up to 0.45% in the subsoil [11].

Khaya senegalensis is a species of tree in the *meliaceae* family that is a native of Africa. Common name include African mahogany, Gambia mahogany, khaya wood etc. African mahogany is a medium-sized tree can grow up to

15-30 m in height and 1 m in diameter. The bark is dark grey to grey-brown whole the heart wood is brown with a pink-red pigment made up of coarse interlocking grains [12]. The tree is characterized by leaves arranged in a spiral formation clustered of the end of branches. The tree is native to Benin, Burkina faso, Cameroon, Central Africa etc, it is found in riparian forest and higher-rainfall savannah woodlands; in moist region, it is also found on higher ground. The wood is used for a variety of purposes. It is often used conventionally for carpentry, interior trim and construction. Traditionally the wood was used for dugout canoes, household implements & fuel wood [13]. The bitter testify bark is used for a variety of medical purpose; it is taken against fever caused by malaria, stomach complaints & headaches. It is applied externally to cure skin rashes, wounds or any abnormality [14].

Khaya senegalensis has experienced high amounts of exploitation and little regeneration takes place once disturbance occurs. The seeding develops of its genus. It is commonly planted as roadside tree & ornamental shade tree, it is for soil stabilization [15]. Flowers are use in medicines against stomach complaints & syphilis. Seed oil is rubbed in to treat rheumatism and influenza & taken to treat syphilis. The roots & bark is an ingredient of complex arrow poison of which strophanthus roots or seed are the main ingredients. The bark is applied externally as disinfectant in case of inflammations & treats skin disease, rash, scabies wounds, ulcers and boils [16].

Khaya senegalensis occurs in savannah woodland, often in moist localities and along water courses, in area with 650-1300 (1800) mm annual rainfall and dry season of 4-7 month (North Tropical Timber-Khaya fast Growing African mahogany Trees). It occurs up to 1500 (-1800) m altitude. It tolerates flooding, desertification, erosion etc. Tress usually gradually loses their leaves in the dry season, the fallen leaves often immediately being of rainy season. Fruit mature 3-5 months after flowering. Tree start producing seed after 20-25 years dispersal of seed is by wind. But most seed falls close to the parent tree, normally up to 100 m [17].

Gmelina arborea is well adaptable to a wide range of soil and climatic conditions. It is a hardy plant and can be grown in both tropical and subtropical conditions [18]. It grows up very well in red sandy 10 am soil with the PH of 5-8 and a high soil depth. It grows at an elevation of 0-1200 m MSL. It comes up very well humid climate with optimum temperature range from 20-38°C. The annual rainfall requirement is 750-4500 mm. it grows very well in the high sunshine with low slade area. The seed have no dormancy and no pretreatment is required. However, soaking of the seed in cold water for 24-48 hours before sowing is recommended [19].

Gmelina arborea is propagated by both seed and vegetative methods. Seed are showed directly in the root trainer or raised beds can be 0.6 m in height, 1 m in within convenient length. One kg *Gmelina* seed contain about 1500-2000 seeds. The size of the seed varies between the trees. Often the germination will be above 100% as more than the seed will germinate from each stone. The optimal temperature for germination is about 30°C & low temperature will reduce germination [20]. *Gmelina* tree has immense potential for its timber, desertification control, erosion& medicinal values. It is used by farmers, forest department & industries due to the multipurpose utility, rapid growth & maximum economic returns [21].

In Nigeria desertification is a land degradation in which a relative dry land region becomes increasingly arid or fertile land transforming into desert as a result of deforestation, drought or improper/inappropriate agriculture, typically losing its bodies of water as well as vegetation and wildlife. It is caused by a variety of factors such as climate change and human activities. Desertification is a significant global and environmental problem [22]. Dry land occupies approximately 40-41% of earth's land areas and are home to more than 2 billion people [23]. It has been estimated that 10-20% of dry land are already degraded, the total area affected by desertification being between 6 and 12 million square kilometers that about 1-6% of the inhabitants of dry land live in desertified area, and that a billion people are under threat from further desertification, Destruction of vegetation in arid regions often for fuel wood.

Remote measurements of trunk volumes are usually made from a position on the ground where the observer has a clear view of the entire length of the trunk [24]. Measurement may be made using professional surveying equipment such as a total station or an instrument such as Criterion RD 1000, using a combination of a

monocular w/reticle, laser rangefinder and clinometer, using photographic methods combined with a laser rangefinder and clinometer or by using cloud mapping techniques [25]. Electronic surveying instrument such as total station allows the observer of to measure the position of each diameter measurement and the length of trunk section between each measurement with most of the instruments, the diameter is determined by measuring the angle of azimuth between the opposite side of trunk. Laser measured distance to the side of the trunk representing the end of diameter and include angle are used with the law of Cosine to calculate the diameter [26]. The Criterion RD 1000 has a special feature that allows the diameter to be measured through a visible display. These length and diameter values then can be used to determine the volume of the individual section. A monocular w/reticle is a telescope with an internal scale visible through glass, the monocular is mounted on a tripod and the trunk of the tree is sighted through the monocular. The width of the trunk is measured as so many unit of the reticle scale. The height above or distance below, instrument and distance of target point is measured using the laser rangefinder and clinometer. The distance is measured to the center (side) of the tree with the distance known, the diameter of the tree measure expressed as unit of reticle scale, an optical scaling factor for the monocular w/reticle, provided by the diameter of the tree at that point can calculated [27].

2. MATERIALS AND METHODS

This study was carried out in Forestry and Wildlife Nursery Plantation University of Maiduguri, Borno State, lying within latitude 11°C to 15°E and longitude 10° and 25°N. The area is hot and dry for a greater part of the year, with a temperature ranging from 15° -20°C (min) and 37°-50°C (max). The vegetation is typically Sahel Savannah consisting of mainly grasses with few drought resistance trees. The season is divided into two (2), dry and rainy season. The rainy season is normally from June-September with relative humidity of 49%. Rainfall ranges between 500-1000 m annually and evaporation of 203 mm per year. BOSG [28]. Material used were; 1. Ranging pole 2. Diameter Tape 3. Ruler 4. Veneer calliper 5. Field note book.

Volume estimation of the trees was carried out appropriately, in order to determine each volume per each tree species. The tree species in the nursery were arranged in straight line parallel to one another, each species with its own row and column. The volumes were determined by the use of Huber's formula which is the most favourable for the tree volume estimation. Volume measured the height, diameter at the base and diameter at the top were all determine in the practical experiment.

2.1 Sampling Design

Systematic sampling was used throughout the experiment because is the fundamental selection method and the sampling unit are space out at fixed intervals, it provide reliable estimate of the tree mean and spread the sample over the estimate, it is also faster and cheaper to estimate than other type of sampling. The plantation consists of different tree species but the research aimed at considering only three species of trees which include: Neem Khaya and Gmelina. Measurements were taken on tree species whereby 10 species of each (Neem, Khaya and Gmelina) trees were randomly selected out of every 100 species taken for the research. All tree samples are mechanically eliminated from the need of random selection.

The parameters assessed during the experiment were;

2.1.1 Diameter at breast height (m)

This is a point taken on the standing tree at 1.37 m above the ground level, in countries that used metric system of measurement.

2.1.2 Basal area (m^2)

Is the sum of the cross-sections at breast height, per unit of land area. Normally, the section for each tree is calculated from the DBH.

$$Basal\ area\ = \frac{\pi D^2}{4}$$

2.1.3 Total height (m)

This is the vertical distance between the ground level and the tip of the tree.

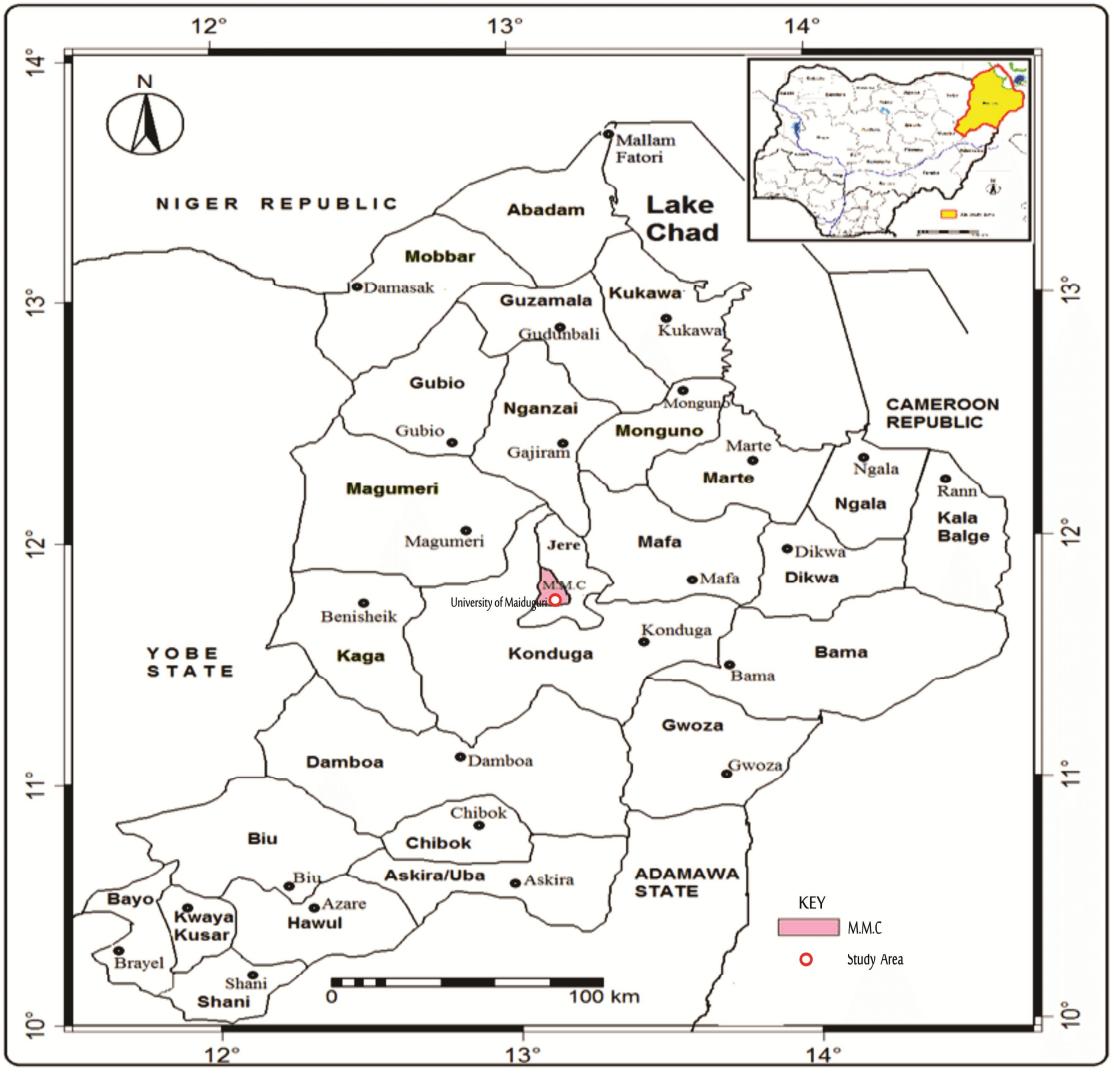

Fig. 1. Map of borno state showing local governments and the study area
Source: Nigeria Administrative Boundaries, [29]

2.1.4 Merchantable height (m)

This is the distance along the tree stem between the top of the stump and the terminal position of the last useable portion of a tree stem.

2.1.5 Bole height (m)

This is the distance between the ground level and the Crown Point.

2.1.6 Crown depth (m)

This is the distance between the Crown Point and the tip of the tree, which is usually determined with a direct or indirect measuring height instrument.

2.1.7 Volume (m^3)

This is taken by using Huber's formula $V=h(A_m)$.

3. RESULTS AND DISCUSSION

Results from Table 1 shows that Gmelina tree species has the highest values in terms of the measurements taken which include; Diameter at breast height(m), Basal Area(m^2) $\pi D_m^2/4$, Total height(m), Merchantable height(m), Bole height(m), Crown depth(m) followed by Neem and Khaya tree species.

Table 1. Measurement of tree species

S/N	Name of species	Dbh(m)	Basal area(m^2) $\pi D_m^2/4$	T.ht(m)	M.ht(m)	B.ht(m)	C.depth (m)
1	Neem	22.5	397.7	9.5	1.6	1.8	7.7
2	Neem	21.2	353.0	8.5	1.4	1.6	6.9
3	Neem	22.8	408.3	9.4	1.5	1.7	7.7
4	Neem	23.4	430.1	10.2	1.7	1.9	8.3
5	Neem	25.2	498.8	10.5	1.9	2.2	8.3
6	Neem	20.1	317.3	7.8	1.4	1.3	6.5
7	Neem	21.6	366.5	7.9	1.4	1.4	6.5
8	Neem	22.4	394.1	9.0	1.6	1.7	7.3
9	Neem	18.8	277.6	10.0	1.9	2.0	8.0
10	Neem	16.2	206.2	9.6	1.6	1.8	7.8
11	Khaya	6.3	31.2	4.7	1.6	2.1	2.8
12	Khaya	6.2	30.2	4.6	1.5	2.0	2.6
13	Khaya	6.4	32.2	4.8	1.7	2.1	2.7
14	Khaya	6.8	36.3	5.0	2.0	2.2	2.8
15	Khaya	6.5	33.2	4.9	1.8	2.1	2.8
16	Khaya	6.6	34.2	5.1	1.9	2.3	2.8
17	Khaya	6.9	37.7	5.3	1.9	2.4	2.9
18	Khaya	7.0	38.5	5.4	2.2	2.5	3.2
19	Khaya	7.0	38.5	5.5	2.3	2.5	3.0
20	Khaya	7.2	40.7	5.5	2.2	2.4	3.1
21	Gmelina	28.8	651.5	11.5	1.8	2.3	9.2
22	Gmelina	28.6	642.5	11.6	1.8	2.4	9.2
23	Gmelina	28.3	629.1	11.7	1.8	2.6	9.1
24	Gmelina	28.1	620.2	11.3	1.9	2.7	8.6
25	Gmelina	27.8	607.1	11.2	1.3	2.2	9.0
26	Gmelina	26.5	551.6	10.9	1.3	2.1	8.8
27	Gmelina	24.8	483.1	9.8	1.3	2.2	7.6
28	Gmelina	29.3	674.3	9.0	1.6	2.4	6.6
29	Gmelina	29.1	665.2	11.2	2.1	2.6	9.1
30	Gmelina	24.5	471.5	11.1	2.0	2.5	8.6

Source: Field Survey, [30]

Table 2. Mean values of Neem tree species

S/N	Name of species	Dbh(m)	Basal area(m^2) $\pi D_m^2/4$	T.ht(m)	M.ht(m)	B.ht(m)	C.depth (m)
1	Neem	22.5	397.7	9.5	1.6	1.8	7.7
2	Neem	21.2	353.0	8.5	1.4	1.6	6.9
3	Neem	22.8	408.3	9.4	1.5	1.7	7.7
4	Neem	23.4	430.1	10.2	1.7	1.9	8.3
5	Neem	25.2	498.8	10.5	1.9	2.2	8.3
6	Neem	20.1	317.3	7.8	1.4	1.3	6.5
7	Neem	21.6	366.5	7.9	1.4	1.4	6.5
8	Neem	22.4	394.1	9.0	1.6	1.7	7.3
9	Neem	18.8	277.6	10.0	1.9	2.0	8.0
10	Neem	16.2	206.2	9.6	1.6	1.8	7.8
MEAN VALUVES		21.42	404.73	9.24	1.71	1.74	7.5

Source: Field Survey, [30]

Table 3. Mean values of Khaya tree species

S/N	Name of species	Dbh(m)	Basal area(m^2) $\pi D_m^2/4$	T.ht(m)	M.ht(m)	B.ht(m)	C.depth (m)
11	Khaya	6.3	31.2	4.7	1.6	2.1	2.8
12	Khaya	6.2	30.2	4.6	1.5	2.0	2.6
13	Khaya	6.4	32.2	4.8	1.7	2.1	2.7
14	Khaya	6.8	36.3	5.0	2.0	2.2	2.8
15	Khaya	6.5	33.2	4.9	1.8	2.1	2.8
16	Khaya	6.6	34.2	5.1	1.9	2.3	2.8
17	Khaya	6.9	37.7	5.3	1.9	2.4	2.9
18	Khaya	7.0	38.5	5.4	2.2	2.5	3.2
19	Khaya	7.0	38.5	5.5	2.3	2.5	3.0
20	Khaya	7.2	40.7	5.5	2.2	2.4	3.1
MEAN VALUES		6.69	35.27	4.53	1.91	2.69	2.87

Source: Field Survey, [30]

Table 4. Mean values of Gmelina tree species

S/N	Name of species	Dbh(m)	Basal area(m^2) $\pi D_m^2/4$	T.ht(m)	M.ht(m)	B.ht(m)	C.depth (m)
21	Gmelina	28.8	651.5	11.5	1.8	2.3	9.2
22	Gmelina	28.6	642.5	11.6	1.8	2.4	9.2
23	Gmelina	28.3	629.1	11.7	1.8	2.6	9.1
24	Gmelina	28.1	620.2	11.3	1.9	2.7	8.6
25	Gmelina	27.8	607.1	11.2	1.3	2.2	9.0
26	Gmelina	26.5	551.6	10.9	1.3	2.1	8.8
27	Gmelina	24.8	483.1	9.8	1.3	2.2	7.6
28	Gmelina	29.3	674.3	9.0	1.6	2.4	6.6
29	Gmelina	29.1	665.2	11.2	2.1	2.6	9.1
30	Gmelina	24.5	471.5	11.1	2.0	2.5	8.6
MEAN VALUES		27.58	599.61	10.93	1.69	2.40	8.58

Source: Field Survey, [30]

Calculation of volume using Huber's formula:

$V=h\ (A_m)$

Where

V= volume
H= height of tree
Am= Cross sectional area of tree at the middle

Table 5. Volumes of Neem tree species

S/N	Name of Specie	Am(m)	T.ht(m)	Volume (m^3)
1	Neem	0.225	9.5	2.14
2	Neem	0.213	8.5	1.81
3	Neem	0.228	9.4	2.14
4	Neem	0.234	10.2	2.39
5	Neem	0.252	10.5	2.65
6	Neem	0.201	7.8	1.57
7	Neem	0.216	7.9	1.71
8	Neem	0.224	9.0	2.02
9	Neem	0.188	10.0	1.88
10	Neem	0.162	9.6	1.56
GRAND TOTAL OF VOLUME				19.87

Source: Field Survey, [30]

Table 6. Volumes of *Khaya senegalensis* tree species

S/N	Name of Specie	Am(m)	T.ht(m)	Volume (m^3)
1	Khaya	0.63	4.7	2.96
2	Khaya	0.62	4.6	2.85
3	Khaya	0.64	4.8	3.07
4	Khaya	0.68	5.0	3.40
5	Khaya	0.65	4.9	3.19
6	Khaya	0.66	5.1	3.37
7	Khaya	0.69	5.3	3.66
8	Khaya	0.70	5.4	3.78
9	Khaya	0.70	5.5	3.85
10	Khaya	0.74	5.5	4.07
GRAND TOTAL OF VOLUME				34.20

Source: Field Survey, [30]

Table 7. Volumes of gmelina tree species

S/N	Name of specie	Am(m)	T.ht(m)	Volume (m^3)
1	Gmelina	0.288	11.5	3.31
2	Gmelina	0.286	11.6	3.32
3	Gmelina	0.283	11.7	3.20
4	Gmelina	0.281	11.3	3.15
5	Gmelina	0.278	11.2	3.11
6	Gmelina	0.265	10.9	2.89
7	Gmelina	0.248	9.8	2.43
8	Gmelina	0.293	9.0	2.64
9	Gmelina	0.291	11.2	3.26
10	Gmelina	0.245	11.1	2.72
GRAND TOTAL OF VOLUME				30.03

Source: Field Survey, [30]

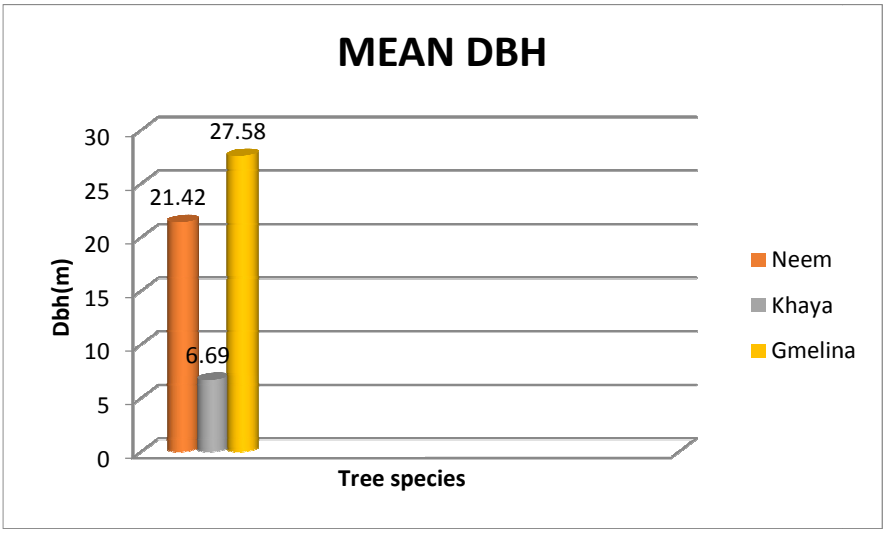

Fig. 2. Bar chart of Mean DBH of Neem, Khaya and Gmelina

Source: Field Survey, [30]

GTVTS= ∑VN + ∑VK+ ∑VG

19.87+ 34.20+ 30.03 = 84.1m^3

Where:

GTVTS = Grand Total of Volume of All the Tree Species
VN= Volume of Neem
VK= Volume of Khaya
VG= Volume of Gmelina

Bar chart Fig. 2 shows the mean of tree species measured in the Nursery plantation where by their mean include (Neem: 21.42 m, Khaya: 6.69 m and Gmelina: 27.58 m). The result shows that Gmelina tree species has larger DBH followed by Neem and then Khaya.

Bar chart Fig. 3 shows the mean Basal Area of in which the mean include (Neem: 404.73 m^2, Khaya: 35.27 m^2 and Gmelina: 599,61 m^2) and are presented above where by Gmelina has larger basal area as shown on the graph by the colours followed by Neem and Khaya.

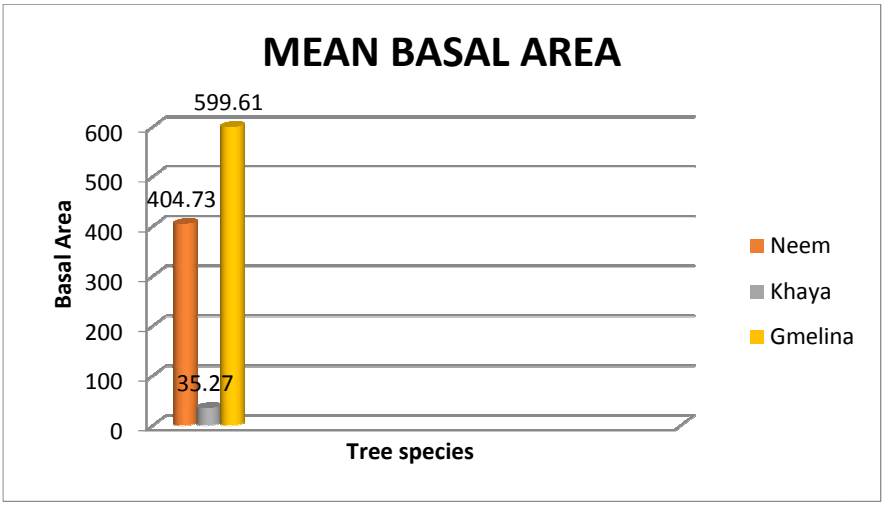

Fig. 3. Bar chart of the mean basal area of Neem, Khaya and Gmelina
Source: Field Survey, [30]

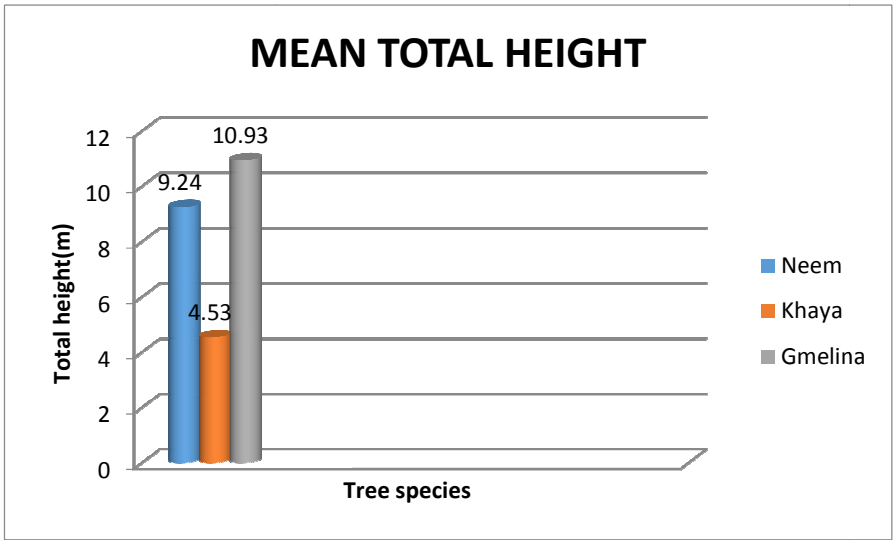

Fig. 4. Bar of the mean total height of Neem, Khaya and Gmelina
Source: Field Survey, [30]

Bar chart Fig. 4 shows that the result obtained from the mean of tree species which include (Neem: 9.24 m, Khaya: 4.53 m and Gmelina: 10.93 m). Gmelina performed highest in the total height followed by Neem and Khaya.

Bar chart Fig. 5 shows the result of the mean merchantable height of tree species which include (Neem: 1.74 m, Khaya: 1.91 m and Gmelina: 1.69 m). Khaya has the highest merchantable height followed by Neem and Gmelina.

Bar chart Fig. 6 the result obtained indicate the mean bole height of tree species which are (Neem: 1.74 m, Khaya: 2.69 m and Gmelina: 2.4 m). Khaya tree species have the highest bole height followed by Gmelina and Neem.

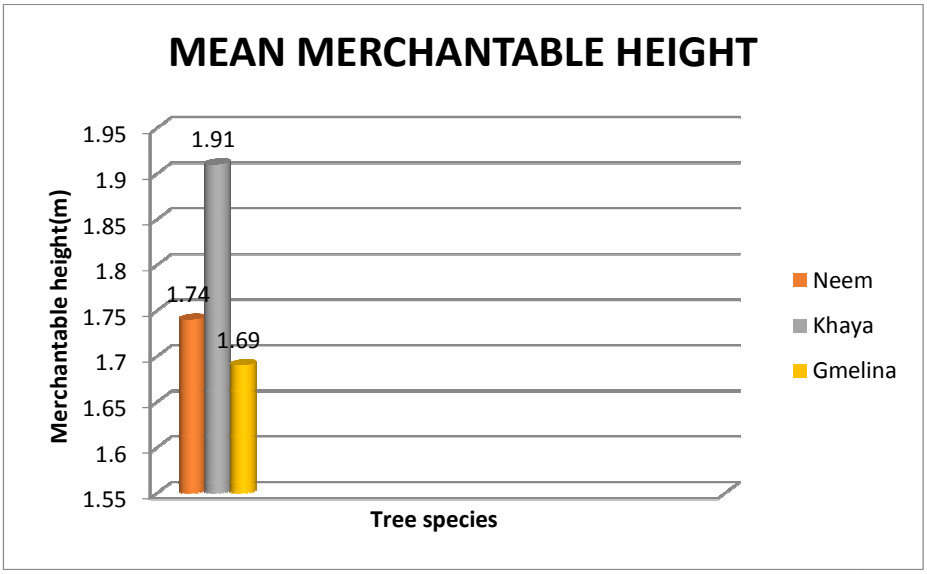

Fig. 5. Bar chart of the mean merchantable height of Neem, Khaya and Gmelina
Source: Field Survey, [30]

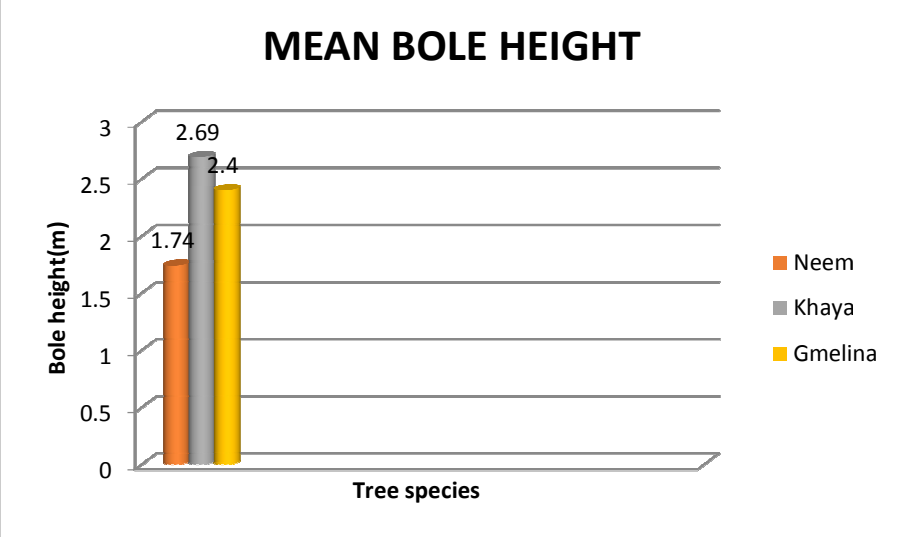

Fig. 6. Bar chart of the mean bole height of Neem, Khaya and Gmelina
Source: Field Survey, [30]

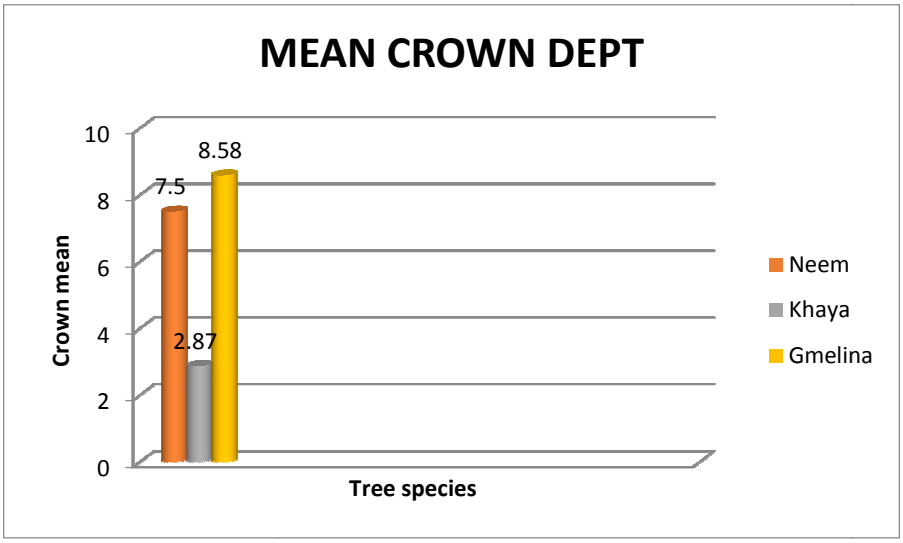

Fig. 7. Bar chart of the mean crown dept of Neem, Khaya and Gmelina
Source: Field Survey, [30].

Bar chart Fig. 7 shows the mean crown dept obtained from tree species which include (Neem: 7.5 m, Khaya: 2.87 m and Gmelina: 8.58 m). Gmelina is the highest followed by Neem and Khaya.

3.1 Discussion

This study shows that tree species (Neem, khaya and Gmelina) have different measurement and different volume within the nursery plantation which is planted within same year i.e 5 yrs back and grow very well within the location. Tree mean Diameter at breast height where determined and the result include (Neem: 21.42 m, Khaya: 6.69 m and Gmelina: 27.58 m), from the results obtained Gmelina tree has larger Dbh and as shown from Fig. 2 followed by Neem and Khaya. The mean Basal area of tree was also obtained and the result where stated in Fig. 3 which include (Neem: 404.73 m^2, Khaya: 35.27 m^2 and Gmelina: 599,61 m^2), from the result Gmelina has large basal area followed by Neem and Khaya. Results from the Total height of tree mean obtained which are presented graphically in Fig. 4 (Neem: 9.24 m, Khaya: 4.53 m and Gmelina: 10.93 m), Gmelina performed the highest followed by Neem and Khaya. Merchantable height was obtained from the mean of tree graphically determined and presented in Fig. 5 which include (Neem: 1.74 m, Khaya: 1.91 m and Gmelina: 1.69 m), Khaya tree species grow at the highest level above the others followed by Neem and Gmelina. Results from Bole height obtained are presented in Fig. 6 (Neem: 1.74 m, Khaya: 2.69 m and Gmelina: 2.4 m), as presented Khaya has the highest in terms of tree mean Bole height followed by Gmelina and Neem. Mean Crown depth was determined from measurement of different species which is graphically presented in Fig. 7 (Neem: 7.5 m, Khaya: 2.87 m and Gmelina: 8.58 m), Gmelina is the highest followed by Neem and Khaya.

4. CONCLUSION

In conclusion, knowledge of measurement and volume determination of trees both in theoretical and practical aspect and as well how to make calculations, estimates and chart of the required data taken. The study confirmed that *Azadiracta indica* species grow very well in the region with an annual rainfall below 400mm, but in such case it depends largely on ground water level and also both *Khaya senegalensis* and *Gmelina arborea* are used as anti-desertification control properties and possible as a good carbon – dioxide sink. Tree planting (afforestation) reduce the high rate of desertification, erosion etc in arid and Semi-arid regions.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Skovsgaard JP, Vanclay JK. Forest site productivity: A review of the evolution of

dendrometric concepts for even-age stands. Forest (London). 2008;81(1):13-31.

2. Van Pelt, Robert. Forest giants of the pacific coast. University of Washington Press. 2002;200.
3. Antonio N, Tome M, Tome J, Soares P, Fontes. Effect of tree, stand and site variables on the allometry of Eucalytus globules tree biomass. Can. J. For. Res. 2007;37(5):895-906.
4. World Agroforestry Centre. Agroforestree Database. Nairobi, Kenya: ICRAF; 2002.
5. Muellner AN, Samuel R, Chase MW, Pannell CM, Greger H. Aglaia (meliaceae): An evaluation of taxonic concept based on DNA data and secondary metabolites. American Journal of Botany. 2005;95(3):534-543.
6. Lemmens RHMJ, Soerianjeral Wong WC, Eds. Plants resources of South– East Asia No. 5(2). Timber trees: Minor commercial timbers. Prosea Foundation, Bogor, Indonesia, Lei den: Backhuys Publishers. 1995;655.
7. Champion HG, Seth SK, Khattak GM. Manual of silviculture for Pakistan. Pesheawar, Pakistan: Pakistan Forest Institute; 1965
8. Chamberlain L. Framework for monitoring invasive tree species Ghana. Oxford, UK: Centre for Natural Resource and Development, Green Collage; 2000.
9. Vietmeyer ND (Director). Neem is a tree for solving global problems. Report of an ADHOC panel of the Board on science Technology for international Development, National Research Cannal: ix+ 141; 1992.
10. Webb DB, Wood PJ, Smith JP, Henman GS. A guide to species selection for tropical and sub-tropical plantation. Tropical Forestry Papers, No. 15 Oxford. UK: Common Wealth Forestry Institute, University of Oxford; 1984.
11. Singh SP. Wasteland development. New Delhi, India: Agricole; 1989.
12. Arbonnier M. Trees, shrubs and lianas of West Africa dry zone. CIRAD, Margrat Publishers Gmbh, MNHN, Paris, France. 2004;573.
13. Arnold R. *Khaya senegalensis*: Current use for it natural range and its potential in Sri Lanka and elsewhere in Asia. 19-21 October, Mareeba; 2004.
14. World Agroforestry Centre, Undated. Agroforestree Database. (Internet) world Agroforestry Center (ICRAF), Nairobi, Kenya; 2008.
15. Burkill KM. The useful plants of West Tropical Africa. 2nd Edition. Families M-R. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 1997;4969.
16. World Conservation Monitoring Centre. *Khaya senegalensis*. 2006 IUCN Red list of Threatened species; 1998.
    (Downloaded on 22 August 2007)
17. *Khaya senegalensis* at the way back machine (Archieved 2012-1028) at Agroforestry Tree Database; 2012.
18. Hossain MK. *Gmelina arborea*: A population plantation species in the tropics. FACT 99-05. Forest Farm and Community Network, Winrock International. Morrilton AR, United Staff. 1999;3.
19. Lamb AFA. *Gmelina arborea*. Fast growing timber trees of lowland tropics No 1. Common Wealth Forest Institute, Oxford, United Kingdom. 1970;31.
20. Adegbehin JO, Abayomi JO, Nwaigbo LB. *Gmelina arborea* in Nigeria. Common Wealth Forestry Review. 1998;67(2):159-166.
21. Naik D, Vartak V, Bhargava S. Provenance and subculture-dependent variation during micro propagation of *Gmelina arborea*. Plant Cell, Tissue & Organ Culture. 2003;73(2):189-195.
22. Encarta; 2009.
23. Mayell, Hillary. Shrinking African Lake Offers Lesson on Finite Resources. Natural Geographic News; 2001.
24. McRobert RE, Westfall JA. Effects of uncertainty in model prediction of individual tree volume on large area volume estimates. Forest Sci. 2013;60(1):34-42.
25. Blozan, Will. The tree measuring guidelines of the Eastern Native Tree Society; 2004.
    Available:http://www.nativetreesociety.org/Tree-measuring-guidlines-revised1.pdf
    (Accessed March 4, 2013)
26. Lost Monarch; 2013.
    Available:http://en.wikipedia.org/wiki/lostMonarch
    (Accessed 14, 2013)

27. Larsen, David. Tree Volume Estimation; 2000.
Available:http://oak.Snr.missouri.edu/nr3110/pdf/volume.pdf
(Accessed March 25, 2013)

28. Borno State Government (BOSG); 2008.

29. Nigerian Administrative Boundaries. North Tropical Timber-Khaya Fast Growing African Mahogany Trees; 2013.

30. Field Survey; 2013.

© 2020 Umar; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/58509