



## NEEM (*AZADIRACHTA INDICA* A. JUSS) FRUIT YIELD DETERMINATION IN MAKURDI, BENUE STATE, NIGERIA

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### ABSTRACT

*This study determined fruit yield of Neem (*Azadirachta indica* A. Juss) in the guinea savanna of Nigeria at Makurdi. Fifteen mature neem trees which had no overlapping canopies and had not been previously pruned were purposively selected out of 207 stands growing at the study site. All ripped fruits felling from the selected trees were collected at 7 days intervals for six weeks and weighed to obtain the weekly fruit yield. Girth size was measured using a 30 meter steel tape, while crown cover was estimated by taking a perpendicular to the spreading branches and leaves round the base of the tree. Descriptive statistics were calculated on yield, girth size and crown cover. The results showed that all fruits felled within a period of 6weeks from the onset of first fruit fall. Total fruit yield per tree ranged from 31.5 to 47.7Kg, while the average was 40.5Kg. Girth size, ranged from 130cm to 275cm with a mean of 215 cm. Crown diameter ranged from 1,280cm to 1,760cm, with a mean of 1,281.3cm. Fruit yield was positively and significantly correlated with the girth size  $r=569^*$  ( $p<0.05$ ). Crown diameter and girth size were positively correlated ( $r = 0.383$ ) but not statistically significant ( $p>0.05$ ). Fruit yield and crown diameter were also positively correlated ( $r=0.259$ ) but not statistically significant ( $p>0.05$ ). The Linear Regression model, suggest that girth size was a better predictor of fruit yield than crown diameter. However, other variables, when employed may likely explain better, neem fruit yield variations in the study area.*

**Key words:** Neem, Fruit yield, Guinea savanna, Makurdi.

### INTRODUCTION

Neem (*Azadirachata indica* A. Juss) is a fast growing, drought resistant tree species of the family: Meliaceae and the sub-family: Melioideae. It is native to tropical South East Asia (HDRA 1998). Neem is now well established in not less than 72 countries

outside its original territory. It was introduced to Africa in the early 19<sup>th</sup> Century. Presently it is found in almost all the countries in West African sub-region and some in the East, North and Southern Africa (Ogbuewu *et.al*; 2011). Neem is said

to have been introduced in Nigeria from Ghana by the colonial authorities at about the year 1928 (Okrikata and Oruonye 2013). Its agronomic characteristics include appearance of first flowers between 2-3 years after planting and production of first fruits when the tree is between 3-5 years old. The tree matures in 10 years and produces between 30-100Kg of fruits every year, depending on rainfall, insolation, soil type and ecotype. Mature trees reach the height of about 30 meters and a girth size of 2.5 meters. Their spreading branches form crowns with a diameter as much as 20 meters (Neem foundation 2016). Life span of the tree is 150- 200 years. Mature fruits are oval shaped measuring 2cm in length and 1.5cm in diameter. Temperature requirements are between 4°C-44°C, (HDRA 1998).

Neem has been used extensively for pharmaceuticals (Ogbuewu *et.al.*, 2011, Ruchi *et. al.*, 2014), livestock feeds (Odunsi *et.al.*, 2009, Aruwayo and Maigandi, 2013), insecticides (Okrikata and Oruonye 2013),

Aerosols, fungicides and traditional medicine (Ogbuewu *et.al.*, 2011). It is also widely established in plantations to check desertification in Kano, Katsina and Jigawa States of Nigeria, and to create a raw material base for industrial development (Newton, 2012). Neem also provides shade for animals and man in the hot, arid areas of northern Nigeria. In Makurdi metropolis and its suburbs, Neem is planted along major streets, and these shield pedestrians from the scorching sun in the late dry season period of the year. Propagation of neem is by seeds. At its fruiting season, many fruits are found littered under the neem trees which can be collected and planted in nurseries in preparation for plantation establishment. In view of the growing importance of neem, investigation of factors responsible for its fruit yield is paramount. Maximum yields reported from northern Nigeria (Samaru) amounted to 169 m<sup>3</sup> of fuel wood per hectare after a rotation of 8 years. Yields in Ghana were recorded between 108 and 137 m<sup>3</sup> of fuel wood per hectare within the same

time (Neem foundation 2016). The fruit yield production potentials of neem in the southern guinea savanna of Nigeria is however sparingly documented. This research was therefore designed to investigate some factors that determine the fruits yield of Neem trees in Makurdi.

## **MATERIALS AND METHODS**

### ***Study Area:***

The experiment was carried out at the Lower Benue River Basin Development Authority (LBRBDA) Head office and Staff Quarters, Makurdi. River Basin Development Authority (RBDA) is a Federal Government project which was established in 1976 by Decree No. 25. The Makurdi head office was established at Kilometer 10, Makurdi Otukpo road (Latitude 7°37'56"N and Longitude 8°32'26"E). The area falls within the southern guinea savanna zone with a characteristic mean annual rainfall of 400mm and mean annual temperature of 33.5°C (Kalu, 2004). The location is endowed with fertile tropical ferruginous soil which has encouraged the production of

arable and tree crops. The layout of the Authority is well designed and properly configured to contain an office complex, a workshop and Staff Quarters. The lawns are decorated with hedges and border line trees which are planted along the road network at irregular interval of 5 to 10 meters apart to improve the environment on the estate. The tree species used include: Neem (*Azadirachta indica*), Christmas tree (*Casuarina glauca*), Flamboyant tree (*Delonix regia*) and Albizia tree (*Eucalyptus sideroxylon*). Other trees and shrubs planted in no definite pattern on the estate by tenants living in the Staff Quarters include: Mango (*Mangifera indica*), Moringa shrub (*Moringa oleifera*), Pawpaw (*Carica papaya*), Coconut tree (*Cocus nusifera*) Gmelina tree (*Gmelina arborea*), Banana (*Musa spiantum*), Newbouldia (*Newbouldia leavis*) and Cashew tree (*Anacardium occidentale*). Orange and oil palm plantations are also found on the estate. The predominant hedge plant on the estate is Ixora (*Ixora coccinea*). Neem trees which

were planted in 1988 were 26 years old at the time of this research. Branches of some Neem trees were occasionally pruned by the residents in order to check interference of the trees with their buildings.

***Sampling design and data collection:***

Fifteen (15) Neem trees within the Staff Quarters of LBRBA were purposively selected for data collection. Care was taken to ensure that the selected trees did not have overlapping canopies. Trees with some pruned branches were not selected. The girth size of trees at breast height was taken using a 30 Metre steel tape. The canopy cover was determined by taking a perpendicular projection from the extent of spread of the branches to the ground where a spot was marked. This was repeated at four points equally spaced round the base of the tree. The arcs were joined to produce a circumference round the base of the tree. Diameter of the circumference (canopy) was measured using a steel tape. The circumference of the canopy was determined using the relation;  $Cir = \pi D$ , where  $\pi = \frac{22}{7}$ ,

and  $D =$  diameter). Fruit collection started at the beginning of fruit fall and lasted until the last fruits that fell were collected. Before commencement of fruits collection, bases of all trees were cleared of debris. At interval of 7 days, all fruits that had fallen under the trees were picked and placed into plastic buckets properly identified with the tree number. The base of each tree was swept clean and ready for another collection. The fruits in the baskets were taken to Forestry Laboratory of the University of Agriculture Makurdi and weighed separately. The data gathering exercise lasted for six weeks and covered the period from 23<sup>rd</sup> August, 2014 to 11<sup>th</sup> October, 2014 which was the duration of fruit fall. ***Data Analysis:***

Data collected were analysed using descriptive statistics namely mean, standard deviation, median, minimum and maximum of the tree variables. Data on fruit yield was used to plot histogram and line graph of cumulative fruit production level on weekly basis within the production period of 6 weeks. Pearson's correlation coefficients

and Simple linear regression analysis were calculated on the fruit yield, girth size and crown diameter using MINITAB 14 Software.

The straight line Regression Equation of the model,  $Y = a + bx_1 + bx_2$ , was used to estimate the explanatory power of the independent variables on the dependent variable. The variables are defined as follows:

$Y$  = Fruit yield of Neem trees (Kg), which is a dependent variable

$a$  = Intercept

$b$  = regression coefficient

$x_1$  = Girth size of Neem trees (cm); an independent or explanatory variable

$x_2$  = Crown diameter of Neem trees (cm); another independent or explanatory variable.

## RESULTS

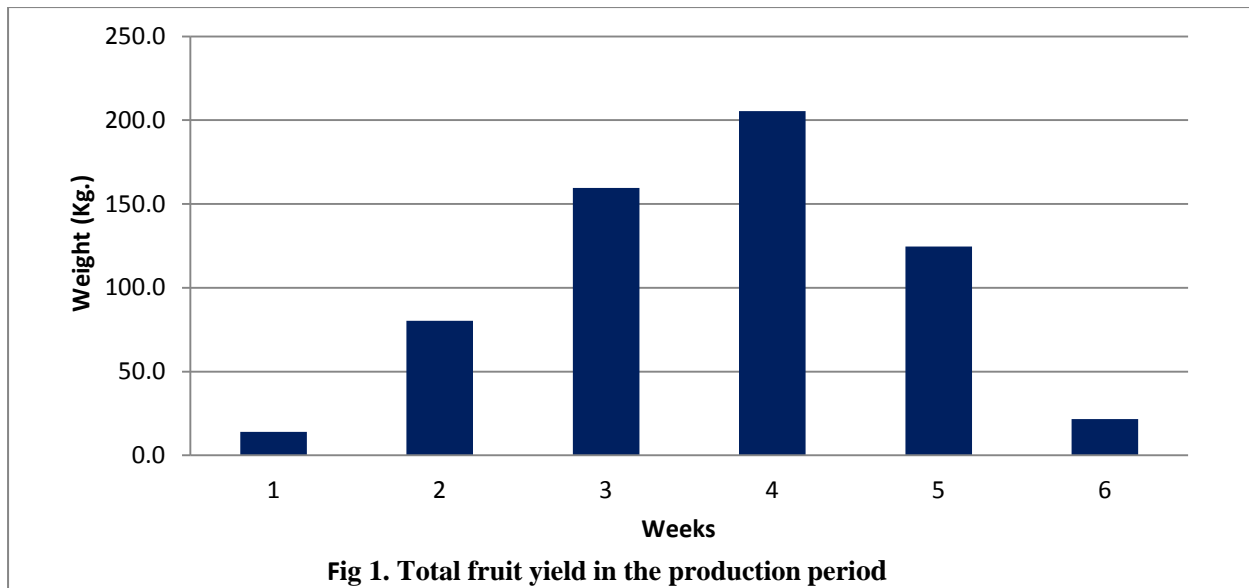
The descriptive statistics of Neem trees in this study are presented in Table 1. Out of 15 trees sampled, total fruit yield ranged from 31.50Kg to 47.70Kg, the median was 40.50Kg while the mean yield was 40.38Kg. Girth size distribution ranged from 130.00cm to 275.00cm, the median was 215.00cm, while the mean was 217.00cm. The crown diameter ranged from 820.00cm to 1760.00cm. The mean crown diameter was 1281.30cm while the Median was 1280.00cm.

**Table 1:** Descriptive Statistics of Sampled Neem trees

Variable	N	Mean StDev	Minimum	Median	Maximum
Fruit Yield (Kg)	15	40.38 ± 3.92	31.40	40.50	47.70
Girth Size (cm)	15	217.00± 34.73	130.00	215.00	275.00
Crown diameter (cm)	15	1,281.30±315.00	820.00	1,280.00	1,760.00

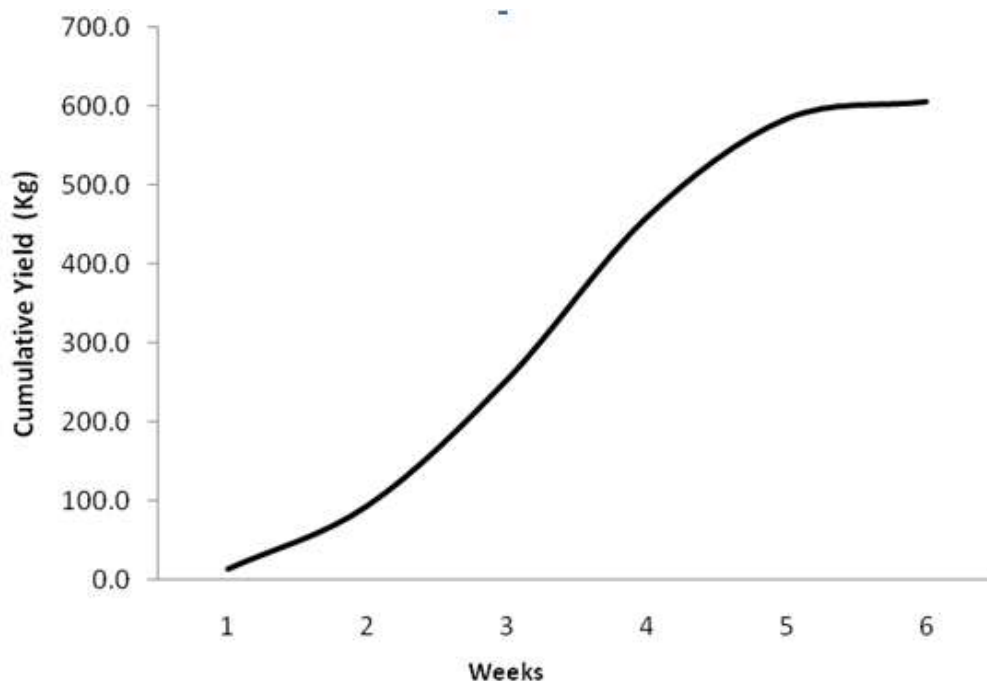
The total fruit yield of Neem in a production period of 6 weeks is presented in Figure 1. Total yield increased steadily from 14.0Kg in

week 1, to a peak of 200.5Kg in week 4, then sharply declined in week 5 (124.4Kg). Fruit fall ended in week 6 with a yield of 21.7Kg.



Cumulative average fruit yield (Kg) is shown on the line graph in Figure 2. Initial yield was 14.0Kg. in week 1, and

increased sharply through week 4, and tapered in week 5, then ended in week 6, with a total of 605.7Kg.



Correlation coefficients between fruit yield, crown diameter and girth size are shown on Table 2. Girth size correlated positively with Crown diameter ( $r = 0.383$ ) and

fruit yield ( $r = 0.569$ ). Crown diameter also correlated positively with fruit yield ( $r = 0.259$ ). However, only the correlation coefficient between girth size and yield was statistically significant ( $p < 0.05$ ).

**Table 2.** Correlation Coefficient ( $r$ ) between Girth size Crown diameter and Fruit yield

Girth size (cm)	Girth size	Crown diameter	Yield
Girth size (cm)	1	0.383 <sup>ns</sup>	0.569*
Crown diameter (cm)	-	1	0.259 <sup>ns</sup>
Yield (Kg)	-	-	1

\*= statistically significant at  $p < 0.05$ , and ns= not statistically significant at ( $p > 0.05$ ),  
Substituting for the coefficients in the Regression equation,  
Fruit Yield (Kg) =  $26.1 + 0.0620 X_1 + 0.00060 X_2$

## DISCUSSION

Average fruit yield/tree of neem in this study (40.38Kg) for one fruiting season holds a great production potential of neem fruits and seeds in the Guinea savanna zone of Nigeria. This production level falls within the 30-100Kg/tree per annum earlier reported by Ramesh (2000) in India. Given the spacing and density of 1,200 trees per hectare in Kebbi, Sokoto and Zamfara States of Nigeria in the afforestation project, approximately

48.456 metric tons/hectare/year of neem fruits production is possible. Besides, mature neem trees fruit more than once in a year. Fruiting period was observed in May-July in Ogbomosho-Nigeria (Odunsi *et.al.*, 2009), while period of production in Makurdi observed in this study was from August-October. This suggests that neem fruiting period is not strictly synchronized in Nigeria but may be dependent on environmental factors.

This study showed that if neem fruits are allowed to fall freely as done in this study, the maximum period of the fruit fall is six weeks. The pattern of fruit fall which showed a gradual increase from week 1 to a maximum at week 4 and a sharp decline to the end in week 6 suggests that during flowering, fruit formation and maturation are not instantaneous but gradual. However processes of abscission that sets in are at their maximum levels when most of the fruits on the tree are ripped. This result into a heavy fruit fall in week 4 and a sharp ending, in week 6. Abscission which is the separation of a leaf, flower, or fruit from a plant as a result of natural structural and chemical changes helps to conserve water loss through transpiration. Neem is a deciduous plant which has to shed its leaves and fruits in order to get ready for another flowering and fruit production period.

Cumulative fruit yield curve of neem in this study is characteristic of the typical sigmoid shape observed in the production

system. The abrupt end of the curve in week 6 is due to the sudden end in the fall of fruits which was determined by the natural biological phenomenon of abscission.

Most of the current studies on Neem focus on, processing of the seeds to oil for various industrial uses (Usman *et. el.*, 2014) including but not limited to medicinal, (Ogbuewu *et. al.*, 2010, Ruchi *et.al.*; 2014), agricultural, for control of insect pests (Okrikata and Oruonye 2013, Amtul *et.al.*, 2016, Ojiako *et.al.*, 2016) and processing of the seed into cake for Livestock feed as a source of protein (Odunsi *et.al.*, 2009, Aruwayo and Maigandi, 2013) among others. In view of the enormous potentials for industrial and environmental uses of neem, its production on a large scale to satisfy the demand is envisaged. However, it is established that neem propagation is almost exclusively by seed. Average fruit production capacity of Neem tree is therefore a useful indicator for estimating the number of seedling that



can be raised from a number of fruiting trees for plantation establishment. Fruit yield potential of neem seeds can also be used to estimate production capacity and turnover of its industrial products.

The strong positive correlation coefficient ( $r=0.569$ ) between the Girth size and fruit yield ( $p=0.027$ ) suggests that as neem trees mature and increase in Girth size, their fruit yield also increase. Trees in this study were about 26years old. Bearing in mind the 150-200 year lifespan of neem (Neem foundation 2006), and the onset of fruit production from 3-5 years of age, these trees may have been in the first phase of the normal production curve when yield is proportional to age and size of the trees. The non-significant ( $p>0.05$ ) positive correlation coefficient between Girth size vs Crown diameter ( $r=0.383$ ) and Crown diameter vs fruit yield ( $r=0.259$ ) is supported by the regression equation which shows that, Girth size is a better predictor of fruit yield than Crown diameter.

The coefficient of determination R-squared is 32.5%, and the regression coefficients are both positive. This means, as girth size and canopy cover increases, fruit yields also increases.

The girth size is responsible for 32.3% of the coefficient of determination at the significant level,  $P=0.027$  while canopy cover is responsible for 0.002% at significant level,  $P=0.094$  indicating that girth size has more explanatory power over canopy cover.

It was observed during the study that axial formation of branches in neem produced a crown that was tall rather than wide. When the crown was heavy with fruits, branches spread under the weight of the fruits, but retracted to the tall posture when the branches shed off the fruits. However, size of the crown can be influenced greatly by spacing. While recommending the spacing of 5m X 5m for fuel wood plantation, Neem Foundation (2006) suggested a wider spacing if fruit yield is the purpose of the plantation. Comparing the mean

crown diameter of 12.81meters and mean girth size of 2.17metres respectively with the 20meters and 2.5meters reported by Neem Foundation (2006), the trees used in this research may be relatively younger.

## **CONCLUSION AND**

### **RECOMMENDATIONS**

Neem production has great potential in Makurdi area of the Guinea savanna in Nigeria, and girth size is a better predictor of fruit yield than crown diameter. However, the low coefficient of determination value suggests that girth size and crown diameter did not explain sufficiently fruit yield variation in neem trees. Other variables, when employed may likely explain better fruit yield variation in neem trees in the study area. Planting material can be sourced easily in the locality owing to the promising high fruit production capacity of neem trees.

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Under large scale production, there should be adequate preparation for harvesting the seeds when ripped, failure of which waste may result. If not planned well, it can cause labour challenge in gathering the fruits for further processing.

More research is required on the variables that are the best predictors of fruit yield in order to fully understand the production pattern of neem in Nigeria.

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