African Research Review

An International *Multidisciplinary Journal, Ethiopia*
Vol. 5 (6), Serial No. 23, November, 2011
ISSN 1994-9057 (Print) ISSN 2070--0083 (Online)

DOI: http://dx.doi.org/10.4314/afrrev.v5i6.33

Effects of Seed Size on Germination and Early Morphorlogical and Physiological Characteristics of *Gmelina Arborea*, Roxb

(Pp. 422-433)

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Abstract

A research was carried out to determine the effects of seed size on germination and early growth rate of Gmelina arborea. Mature seeds of Gmelina arborea were collected from the mother trees in Uyo Local Government Area, Akwa Ibom State. They were grouped into 3 categories as large seed size (LSS), medium seed size (MSS) and small seed size (SSS), using a predetermined weight method. A total of six hundred depulped seeds from each size class were selected and weighed and had the following *values: 0.94g, 0.57g and 0.38g respectively. The seeds were sown in germination boxes measuring (28cm x 14cm x 14cm) and germination was observed for two weeks. Germination percentages were calculated by dividing the number of germinated seeds against the number of seeds sown. At two-leaf stage, seedlings were transplanted into polythene pots and laid out in a Randomized Complete Block Design (RCBD), replicated 3 times. Seedling height (cm), number of leaves, collar diameter (cm), leaf area (cm^2) were assessed fortnightly while shoot dry weight (g/m) and root dry weight (g/m) were assessed monthly. Data collected were arc-sine transformed before being subjected to a two-way Analysis of Variance (ANOVA). Least Significant Difference (LSD) at 5% probability level was used to compare the significantly different treatment means. Biomass data were used to calculate Relative Growth Rate (RGR), Average Growth Rate (AGR) and Shoot Root Ratio (S/R) of the species. In all the parameters assessed, LSS had the best performance which was significantly different from other seed sizes. Thus, LSS are recommended to silviculturists and tree planters for best germination and seedling vigour.*

Key words: Effects, seed size, germination, morphology, physiology, *Gmelina arborea.*

Introduction

A prerequisite in any planting programme is an assured supply of seeds (FAO, 1955). Seed is such a key element in plant production that it exercises a profound influence on the success or failure of both artificial and natural regeneration and it is of fundamental importance since both artificial and natural regeneration start with it (Nwoboshi, 1982). Several attempts made to achieve effective afforestation have been inadequately rewarding because of the lack of or insufficient quantity/quality seed. Seed size is a parameter for predicting germination and seedlings growth rates, both in the nursery and for a brief period following plantation establishment (Oni and Bada, 1992). Seed also forms a very important element in the quality of seedlings produced in the nursery, since the quality of the seedlings is determined by the genotype of the seed from which it originates. Hence, to produce high quality trees, one has to sow high quality seeds.

The rate of germination of some seeds due to their sizes may be attributed to the hard seed coat which is an inherited factor of dormancy of such seed and the duration of storage of the seeds and wrong time of seed collection (Nwoboshi, 1982). As a result of these factors, it may be necessary to consider the seed sizes of some tree species before sowing in the field. This is to reduce the excessive loss of seeds during germination and growth periods. In general, as the population of Nigeria continues to increase rapidly, so also the demand for forest products and services, because man's activities become more pronounced. The increase in the cost of imported wood products explains the need for intensification of the establishment of some exotic species into plantations to produce raw materials for our pulp and paper industries in the country.

Presently, forests are being depleted of their goods and services, which would have been derivable from them because of anthropogenic factors. Even though seed is a renewable natural resource, once it is exhausted, it may take a long time to regenerate. Ogigirigi, (1989) revealed that the original vegetation, especially in savannah zones has been modified by human activities over the years; this has made the vegetation lose its original form. To correct this situation, plantations of economic and exotic species must be established to regain the lost glory.

A successful plantation cannot be established unless health nursery seedlings or stocks are produced. This also may depend on the viabilities and seed sizes (Kadambi, 1972). Within the last two to three decades, the need for seed has considerably increased in the tropics with the unprecedented expansion of afforestation and reforestation programmes (Troupe, 1921). Therefore, the effect of seed sizes in early morphological and physiological characteristics of *Gmelina arborea* has become necessary to be considered and determined. This could be known or determined by the percentage of the germination of each class of the sizes of the seed. The objectives of this study are to investigate the effects of seed sizes on early growth rate of *Gmelina arborea*.

Materials and methods

The study was carried out in Department of Forestry's Teaching and Research Farm, University of Uyo, Uyo, in Akwa Ibom State, Nigeria. Uyo, the capital of Akwa Ibom State lies between latitude 4°58' and 5°05' N and longitude 7°54' and 8°00'E of the Equator. It comprises 21 villages and a total land area of 15,750 hectares (Akpabio *et al*., 2004). The relief of Uyo urban is that of relatively gentle sloping to plain land. Rainfall ranges from 1800 – 3200mm per annum. The rain begins in March and continues till October with peaks in June and September (Akpabio *et al*., 2004). The dry seasons starts from November and lasts till February, while the annual temperature varies between 22.49°C and 30.13°C. The mean relative humidity is 76.25%

and the mean relative sunshine is 8.31°C. There is abundant Sunlight and long growth periods to sustain luxuriant vegetation all year round (Etukudo, 2001).

Seed collection and processing: Mature fruits of *Gmelina arborea*, were collected from the mother trees in Uyo Local Government Area, Akwa Ibom State. The seeds were depulped, washed and sun-dried for 24 hours to enhance germination.

Seed sizes determination: The seeds were randomly selected and grouped into three size classes namely, large seed size (LSS) (Fig. 3), medium seed size (MSS) (Fig. 2) and small seed size (SSS) (Fig 1), based on the seed fresh weight (Offiong. 2008). Seeds of 0.94g were considered large while seeds of 0.57g and 0.38g were considered medium and small respectively. These size classes constituted the 3 treatments. A total of six hundred seeds with no visible sign of injury were selected from the three size classes.

Fig 1: Small seed size (SSS)

Fig 2: Medium seed size (MSS)

Fig 3: Large seed size (MSS)

Sowing medium and germination: The selected seeds were sown in 30 germination boxes (28cm x 14cm x 14cm), filled with washed and sterilized river sand. The boxes were arranged in a Randomized Complete Block Design (RCBD) replicated three times. Watering was done twice daily. Germination count was done daily for two weeks. Germination percentage of each treatment was calculated by dividing the number of germinated seedlings against the number of seeds sown and multiplied by one hundred. Data collected from the germination parameters were arcsine and transformed before they were subjected to a two-way analysis of variance (ANOVA). All the significant differences obtained among the treatments were tested at $p \leq 0.05$, using the Least Significant Difference (LSD) to compare the significantly different means (Akindele, 1996).

Growth assessment

After the determination of germination, at two-leaf stage, a total of one hundred and eighty (180) fairly uniform seedlings from each treatment were selected and transplanted into polythene pots (26cm x 16cm x 9cm), filled with topsoil and laid on the field in a Randomized Complete Block Design (RCBD) replicated three times. Two weeks after transplanting the seedlings, the following growth parameters were measured fortnightly for three months; height, stem collar diameter, number of leaves, leaf area, and shoot and root dry weight. Plant height was determined by measuring the height of the plants using a ruler calibrated in centimeter (cm), stem collar diameter was determined by measuring the diameter of the plants using vernier caliper, calibrated in centimeter (cm); numbers of leaves were determined by visual counting, while leaf area (cm^2) was determined using graphical methods (Oni and Bada, 1992).

Data analysis: Data collected from growth parameters were subjected to a two-way analysis of variance at 5% probability level and the least significant differences (LSD) were used to compare the significantly different means (Akindele, 1996).

Biomas production assessment

Biomass production was assessed at monthly internal. On each occasion, five (5) seedlings were randomly selected from each treatment. The seedlings were uprooted carefully from the soil to avoid damage to the roots; the roots were carefully washed in water. Subsequently, the seedlings were separated into shoot and root components for biomass determination. These components were dried at 80°C for 24 hours (Surgi-field-SM9023A Laboratory Oven). The dry weights were determined by weighing them on an electronic weighing balance, calibrated in grams (g). These data were used to calculate the following physiological growth parameters; Relative Growth Rate (RGR); Average Growth Rate (AGR) and Shoot/root Ratios (Offiong, 2008).

(i) RGR (g/months) = $$\frac{LnTDM_2 - LnTDm_1}{t_2 - t_1}$$

(ii) AGR (g/month) = $$\frac{TDM_2 - TDM_1}{t_2 - t_1}$$

(iii) Shoot/root ratio = $$\frac{\text{Dry weight of shoot}}{\text{Dry weight of root}}$$

Where;

TDM_1 = Initial total dry weight

TDM_2 = Final total dry weight

t_1 = Initial time (in months)

t_2 = Final time (in months)

RGR = Relative growth rate

AGR = Average growth rate

LN = Natural logarithm

Results

Germination assessment: There was no significant ($p<0.05$) effect among the seed sizes on seed germination (Table 1). First germination was observed eleven (11) days after sowing in the large seed size (LSS) and medium seed size (MSS). This was followed by the small seed size (SSS) on the 13th day. Two weeks after the first germination, further germination was discarded. LSS had the highest mean germination value of 80.25%, while MSS and SSS recorded 56.50% and 35.50% mean values of germination (Table 2).

Growth assessment

Seedling height (cm): Result of this study showed that seed size had significant ($p > 0.05$) effect on seedling height (Table 3). Seedlings of large seed size recorded the tallest (11.42cm) plant among the seed sizes. Medium seed size had the seedlings with the mean value of 8.84cm. The shortest seedling (8.76cm) was obtained from small seed size (Table 4).

Number of leaves: Number of leaves were significantly ($p>0.05$) affected by the seed size (Table 3). The result showed that LSS produced seedlings with mean number of leaves of 10.36 while the MSS and SSS produced seedlings with the mean values of 8.54 and 8.26, respectively (Table 4).

Stem diameter (cm): The result showed that seed size had significant ($p>0.05$) effect on collar diameter (Table 3). Large seed size recorded significantly biggest collar diameter with the mean value of 0.18cm. Seedlings produced by the medium seed size had the collar diameter with the mean value of 0.13cm, while SSS recorded the least (0.12cm) collar diameter (Table 4).

Leaf area (cm^2): Leaf area was significantly ($p>0.05$) affected by seed sizes (Table 3). The largest leaf area (15.40cm^2) was obtained from the seedling produced by the large seed size. Seeds of the medium size recorded the mean leaf area of 11.73cm^2 while the smallest leaf area of 7.87cm^2 was obtained from the small seed size (Table 4).

Shoot dry weight (g/m): Seed size had significant ($p>0.05$) effect on shoot dry weight (Table 3). Among the seed sizes, LSS produced seedling with the mean value of 0.87g/m. The least shoot dry weight of 0.56g/m was obtained from the SSS while seedlings produced by the MSS recorded the mean value of 0.63g/m (Table 4).

Root dry weight (g/m): Seed sizes significantly ($p > 0.05$) affected root dry weight of *Gmelina arborea* seedlings (Table 3). LSD results showed that large seed size had the highest (0.34g/m) while the least of 0.22g/m root dry weight was obtained from seedlings produced by the medium seed size. Seeds of the small size produced seedlings with the mean value dry weight of 0.24g/m (Table 4).

Physiological growth

Relative growth rate (RGR): Large seed size (LSS) produced seedlings with the highest mean relative growth rate of 0.69, while medium seed size (MSS) and small seed size (SSS) produced seedlings with the mean relative growth rate of 0.57 and 0.52, respectively (Table 5).

Average growth rate (AGR): The result indicated that among the seed sizes, SSS recorded the least (1.57) average growth rate, while the mean values of 1.84 and 2.66 were obtained from MSS and LSS in that order (Table 5).

Shoot root ratio (S/R): As presented in Table 5**,** the results large seed size (LSS) produced seedlings with the least shoot root ratio (2:3). The seedling of medium seed size (MSS) produced seedlings with mean shoot root (S/R) ratio of 2:9 while small seed size (SSS) produced seedlings with mean shoot ratio of 2:8 (Table 5).

Discussion

Seed sizes significantly affected both germination and early growth rate of *Gmelina arborea* seedlings. The superior germination exhibited by the large seed size could be attributed to availability of more food reserves in large seeds. This enhanced their viability, hence earliest and highest germination percentage of the large seeds. Similar observation has been made by Offiong (2008), who reported that seeds with large dimensions are likely to have large embryo which enhances good germinability.

On the other hand, the lower germination obtained from small sized seeds could be attributed to relatively lower food reserve in the small sized seeds, the stage of maturity, size of the cotyledon and genetics factors. This finding agrees with the observations of Faluyi (1986), who reported better growth in cashew (*Anacadium accidentale*) from large nuts than small nuts. Oni and Bada (1992) also reported that seed from large nuts showed better germination and growth than seeds from small nuts. Oni and Bada (1992) further reported that seed size can be used as a parameter for predicting germination and seedling growth rate both in the nursery and a brief period following establishment. Similarly, Simmone *et al*., (2000) reported that size of seed has a strong influence on germination as well as growth and biomass increment of a plant. The results of this study agree with these previous studies as the largest seed had the best germination while the smallest sized seeds recorded the lowest germination percentage.

The initial superior growth that was observed in large size seeds could be attributed to the larger food reserves in those seeds. This might have accounted for the early comparative growth advantage in the seedlings. This finding had earlier been observed by Simmone *et al*., (2000), who stated that seed size has a stronger influence on growth and biomass allocation patterns than light. These authors further added that stem length and plant mass are positively related with seed mass.

Gonzalez (1993) stated that seed size affect plant vigour as seeds with greater mass-produced vigorous plants. Seeds in the large seed size had the highest values of seedling height, collar diameter and number of leaves. Similar result had earlier been reported by Boot (1996), who found that bigger seeds usually produce bigger seedlings with larger area of green leaves capable of conducting photosynthesis. However, the different sizes of seeds did not, significantly affect in biomass production.

Conclusion and **recommendations**

This study indicated that large sized seeds gave best germination at a shorter period of time than the medium seed size and small seed size. It was shown that the large and medium seed sizes of *Gmelina arborea* germinated faster than the small sizes. The study also revealed a significant effect among the different seed size categories at the initial stages of growth, followed by no significant effect at the later stages of growth. Large seed size had the highest mean height of 11.42cm, compared to the medium and small seed sizes. The best seed sizes to use by tree planters and other stakeholders were the large sized seeds because of their fast germination. Large seed sizes are recommended as they will promote early maturity of *Gmelina arborea* for sundry purposes such as pulp for paper production, timber, fuel wood, etc.

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Table 1: Analysis of variance for germination of *Gmelina arborea* seed as affected by seed size

Source of variance	Degree of freedom	Sum of square	Mean of square	f-cal	f-tab
Treatment	2	60.67	30.335	3.715 NS	6.94
Block	2	112.67	56.335	6.899 NS	6.94
Error	4	32.66	8.166		
Total	8	206	25.76		

Ns – Not significant at 5% probability level ($p < 0.05$).

Table 2: Mean value of germination percentage as affected by seed size.

Treatments	Mean germination percentage (%)
Large (LSS)	80.25
Medium (MSS)	56.50
Small (SSS)	35.50
LSD (0.05)	NS

Table 3: Summary of analysis of variance for seedlings growth as affected by seed size

Variables	Degree of freedom MS	Height (cm) MS	No. of leaves MS	Diameter (cm) MS	Leaf Area (cm^2) MS	Shoot Dry weight (g/m) MS	Root Dry Weight (g/m) MS
Treatment	2	19.15335*	9.78837*	0.00833*	80.16667*	0.154873^{NS}	0.05636*
Block	2	4.99104*	5.38291*	0.00139*	5.83333*	0.149805*	0.05389^{NS}
Error	10	2.34461	3.28399	0.01104	2.23333	0.13646	0.03691
Total	14	5.12392	4.51263	0.00878	13.87667	0.140995	0.04417

*Significant at 0.05 probability level (p> 0.05)

Table 4**:** Summary of mean values of growth parameters of seedlings of *Gmelina arborea* as affected by seed size

Treatments (Seeds sizes)	Height (cm)	No. of leaves	Diameter (cm)	Leaf area (cm^2)	Shoot dry weight (g/m)	Root dry weight (g/m)
Large (LSS)	11.42	10.36	0.18	15.4	0.87	0.34
Medium (MSS)	8.84	8.54	0.13	11.73	0.63	0.22
Small (SSS)	8.76	8.26	0.12	7.87	0.56	0.24
LSD (0.05)	2.73	0.81	0.042	3.67	0.144	0.108

(g/m) = gram per month.

Table 5: Mean of Relative Growth Rate (RGR), average growth rate (AGR) and shoot to root (S/R) ratio of *Gmelina arborea* as affected by seed size

Treatments	RGR (g/m)	AGR (g/m)	S/R
Large (LSS)	0.69	2.66	2:3
Medium (MSS)	0.57	1.84	2:9
Small (SSS)	0.52	1.57	2:8

g/m = gram per month