ASSESSMENT OF GERMINATION AND EARLY GROWTH TRIAL OF *Gmelina arborea* (ROXB.)

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ABSTRACT

*The Gmelina arborea is a multi-purpose tree used daily by the forest industries for pulping, light constructions, furnitures and rural communities as fuel wood. A field experiment was carried out to investigate the provenance germination and early growth trial of Gmelina seedlings. One thousand eight hundred seeds were sourced from 3 different locations namely Akwanga, Nasarawa Eggon and Lafia for germination test, while 270 seedlings were examined for growth performance. The study was laid in a 3 x 3 factorial experiment in a completely randomized design. Analysis of variance was performed to show the comparative performance of each treatment. Duncan's Multiple Range Test (DMRT) was applied to locate where the significant difference occur among the locations and treatments in the measured variables. The result of germination with respect to locations revealed that Akwanga recorded the highest germination percentage of 70.09±25.70%, Nasarawa Eggon 66.95±25.24% and Lafia 64.04±22.20%. Also with respect to treatment, it revealed that (T2-Sundried for 72hrs and soaked in water for 72hrs) recorded the highest germination with a mean value 69.33±23.65%, (T1-Sundried for 72hrs) 66.61±22.33% and (T3-Control) 65.14±27.24%. The result of growth variables revealed that, the average plant height of Gmelina arborea seedlings after 12 weeks was 62.04±38.50cm, collar girth 2.20±1.18cm, leaf count 14.80±7.13 and leaf area 210.06 ±142.84cm^2. However, analysis of variance showed a significant difference in early growth variables assessed at p<0.05. The result of Correlation analysis revealed that there was a significant correlation (r) between leaf area and plant height (0.916**). The result of the regression analysis on the effects of growth variables on tree plant height had coefficient of (R^2 = 0.957) meaning that the assessed growth variables had about 95.7% effects on plant height. Seed from different sources has different viability, as it was observed that seed obtained from Akwanga were more viable than the other two locations, therefore when raising Gmelina arborea seedlings for plantation establishment, care should be taken to locate appropriate seed source and needed pre-treatment method.*

Keywords: Gmelina arborea, germination, growth, seedlings, pre-treatment

INTRODUCTION

Gmelina arborea is a deciduous tree of the family of Verbenaceae. It is a medium to large tree that reaches about 35m in height and more than 3m in diameter in natural stands in the tropical and subtropical regions of Asia (Dvorak, 2003). It lives up to 40 years (Wikipedia, 2013). *Gmelina arborea* is a native of Pakistan, South of Srilanka and East of Myanmar, Thailand and South China. It is extensively planted in many countries and large scale plantations are also found in Senegal, Ghana and Nigeria (Adegbehin *et al*., 1998). *Gmelina arborea* grows best within the temperature range of 18°C and 35°C (Oduwaiye, 1996). It grows well in areas with distinct dry season and annual rainfall range of 1,776mm and 2,280mm with atmospheric humidity of 40% (Oduwaiye, 1996).

The tree is sunlight demanding, drought resistant and it has a fairly good fire tolerance. As a result, the rapid increase in the demand of Gmelina based wood products and its other uses such as a raw material for pulp and paper production, climate amelioration, soil management, and erosion control has greatly affected the total hectarage of Gmelina plantations in Nigeria. Hence, there is need to urgently establish plantations of Gmelina which thrives well on moist, fertile, sandy-loam, well drained soils (NAFRI and DANIDA, 2000). Gmelina seeds ripen about January to March. Thus, seeds are preferably best collected at this period. Seed fertility of Gmelina may be

confirmed by throwing a small quantity into burning charcoal (without flame) and fertile ones will sputter or explode which is an indication of fertile seeds or the seeds are soaked for 24 - 28 hours in water till signs of sprouting are detected in the seed. The seeds are sown in beds and they germinate within 2 - 5 weeks (Adegbehin *et al*., 1998). Gmelina seedlings are raised in pots or polythene bags until when the first pair of leaves has emerged. Polythene bags of 3.5 x 7 inches are suitable to raise *Gmelina arborea* seedlings (Adegbehin *et al.,* 1998).

Gmelina arborea is faced with many problems including annual bush burning, over exploitation, poor seed viability and dormancy (Beet, 1989). The tree species faces the danger of extinction; hence, there is need for continuous attention to solve the above named problems (Agboola and Etejere, 1991; Agboola, 1995). Gmelina is a source of fodder, food, tannin, furniture making and gum apart from helping nutrient recycling (Etejere *et al*., 1982; Beet, 1989). Gmelina seeds like any other tree seeds are difficult to germinate. However, the work done by (Agboola, 1995) established that Gmelina seeds soaked in water produced high quality seedlings and promote rapid germination of *Gmelina arborea* seedlings but recommended further studies involving using sun-drying and soaking in water and other methods. Thus, there is need to intensify on his work and to find out other methods for rapid multiplication of Gmelina seedlings for plantation establishment particularly to examine the effect of the different location of seed sources and examine the effect of different pretreatment on the seedlings germination and growth rate.

Gmelina arborea plantation establishment in Nigeria

Gmelina arborea is a pioneer tree native to Asia. It was introduced to tropical Africa from South-East Asia (Ogbonnaya *et al*., 1992). *Gmelina arborea* was introduced to Enugu Nigeria in 1921; an international provenance trial was established for *Gmelina arborea* and *Gmelina leicharadtii* in Enugu. The trials were assessed on the provenance during the civil war when some of the trees were harvested for war purpose. The result of the provenance trials show that *Gmelina leicharadtii* was not suited to Nigeria conditions. *Gmelina arborea*, on the other hand, showed high adaptability and vigour. Plantations of *Gmelina arborea* has since then being spreading to other parts of the country. Presently, plantations of *Gmelina arborea* mainly for timber, poles, pulp and paper production exists in many parts of the country. In Nigeria, the high cost of newsprint and other papers sparked a search for suitable pulpwood to support the pulp and paper mills. *Gmelina arborea* was exhaustively studied and recognized as suitable for pulp and paper production (Kpi Kpi, 1989). This species is now the most important pulpwood species in Nigeria (Chow and Lucas, 1998). Its timber is also suitable for many purposes including plywood, matches splints and boxes (Omoyiola, 1974). The leaves are harvested for fodders for animals and silkworm; the bitter sweet fruits were once consumed by human. Over 65% of the world population depends on wood for cooking and heating (Harker *et al*., 1982) and over 80% of wood consumed annually in developing countries is used for fuel (Akachuku, 1980; Harker *et al*., 1982).

Climatic and Topographic Requirement for Gmelina

Gmelina arborea grows best within the temperature range of 18°C and 35^0C (Oduwaiye, 1996). It does well in areas with distinct dry season and of rainfall range of 1,776mm and 2,280mm per annum with atmosphere humidity of 40% (Oduwaiye, 1996). The fast growth of the species, its tolerance to a wide range of sites and ease of establishment makes Gmelina highly acceptable for plantation forestry (Nwoboshi, 1985). Gmelina performs better in valleys and deep alluvium than core steep. This is because valleys and deep alluvium have better moisture retaining capacity than steep slopes. Soil requirement for Gmelina indicated that it grows well on deep loamy, clay loams, calcareous and moist soils (Tewari, 1995; Lauridsen *et al*., 2002; Wijoyo, 2000; Espinoza, 2003). In addition, Hossain (1999) said that the species needs soil acidity between pH 5.0 and 8.0. Lamb, 1988 reported that the most suitable soil for *Gmelina arborea* is deep fertile, light textured and moderately acidic soils.

Seed Production, Dispersal and Collection

Improved seeds of *Gmelina arborea* could be obtained in Nigeria from seed stands created at various locations such as Ukpam Bende in lmo State, Okhuesan in Delta State, Olomu in Kwara State and Manu in Anambra State (Oduwaiye and Akoun, 1990). Large quantities of fruits are normally produced during the seed year. A single tree can produce thousands of seeds. The seed sizes range from small to medium, and large. The large seeds are the most common. Gmelina seed is dispersed by birds and bats that lives on the trees, animals like cattle which feed on the fruits, water and wind. Fruits can be collected from the floor in Septembers. *Gmelina arborea* should be collected twice a week because not all the fruits are shed at the same time. Gmelina fruits should be depulped. The fleshly cover is rubbed off the stone seeds by hand to remove the remaining dry pulp from the stones. They are rubbed with sand

and water. Removal can also be done with sand in a cement mixer. The stone need further washing and then dry in the sun.

Propagation of Gmelina

Gmelina arborea (Roxb) is normally propagated through seed. Freshly collected seeds yield best in germination results. The seed per kilogram (kg) is between 700 - 1400 (Evans, 1999). It can also be propagated or reproduced through micro propagation and tissue culture (Purse, 1989). NonnaIly, seeds of *Gmelina arborea* are selected from the ground, depulped and the stones are dried. Pretreatment might not be necessary. For quick germination, the seeds should be soaked for 48 hours. The seeds germinate within 18-35 days. Ideal conditions, the average rate for healthy seed lot is 60%. Trees can be raised easily by transplanting, which is carried out in the rainy season, or by direct sowing in lines; the latter has proved to be more successful in some instances. Large cuttings planted during the rainy season do well (Katende *et al*., 1995; Mbuya *et al*., 1994).

Nursery Techniques

Stones are sown in open sowing beds in September or October covered lightly with straw. They need full sunlight for germination. Gmelina can also be planted directly in containers with one stone per container. Polythene bags of 3.5 x 7 inches are suitable to raise Gmelina seedlings (NAFRI and DANIDA, 2000). Soil mixture for the sowing bed and potting usually contains one part sand and two parts topsoil from the forest, up to 10% rice husk can also be used in the potting soil (NAFRI and DANIDA, 2000).When Gmelina arborea seedlings have the first parts of leaves after 30 days, they are transplanted into containers (NAFRI and DANIDA, 2000).

Economic importance of Gmelina

Gmelina arborea is reasonably strong for its weight. It is used for a great variety of purposes including furniture and light constructions. It is also used for veneers and plywood, particle board matches and as a major source of raw material for pulp and paper making, carriages, sports, musical instrument and artificial limbs. Once seasoned, it becomes a very steady timber and moderate resistant to decay and also ranges from very resistant to moderately resistant to termites. The leaves are considered good as fodders for cattle (Crude of about 11.9%). Its root and bark are to improve appetite; useful in hallucination, fever and abdominal pains (Duke, 1983). The leaf paste when apply, relieve headache and its juice is used to cure ulcer. Its flowers are sweet, cooling and bitter; they are useful in curing leprosy and blood disease. The plant is recommended in combination with other drugs for the treatment of snakebites and scorpion stings. In snakes, a concoction of the root and bark is given internally (Wikipedia, 2013).

Seed Quality of Gmelina

Seed quality is a multiple concept comprising several components but they are not all of equal value nor are their order of relative importance the same in all circumstances. Of the ten qualities of seed; seed germination (viability) and vigour are the most important. Seed viability and vigour are measured to provide indication of the future performance of a seed lot. This performance relates to the ability of seeds to germinate and produce a seedling that will emerge from the soil and develop into a healthy vigorous plant (Copeland, 1976).

Seed Viability and Germination

Germination is a component of seed quality. It therefore, occurs when a viable seed takes up water to induce respiration, protein synthesis and other metabolic activities that lead to the emergence of radicle from the testa. A viable or live seed is one which is able to germinate under favorable conditions provided there is no dormancy. Germination period of seeds in nursery beds in various parts of the world varies from 0.96% in periods varying from 10 days to 3 months. However, *Gmelina arborea* germinates within 2–4 weeks of planting after breaking its dormancy (Adegbehin *et al*., 1998). Seed vigour has been defined as "that condition of active good health and natural robustness in seed which permits germination to proceed rapidly, under a wide range of experimental conditions. The factors affecting seed and seedling vigour are: seed coats, environment and nutrition of the mother plant, stage of maturity at harvest, seed size, senescence, pathogens and genetic characters. The speed of germination is an important aspect of vigour and it provides a reasonably good index of vigor of any seed lot (Copeland, 1976).

MATERIALS AND METHODS

This experiment was carried out at the Faculty of Agriculture, Lafia, (08^0 35'^{N}, 08^0 33'^{E}), located in the Guinea Savannah zone of North Central Nigeria at an altitude of about 177m above sea level. The mean monthly maximum temperature range is between 35.06^{0C} to 36.40^{0C} and 20.16^{0C} to 20.50^{0C} respectively while the mean monthly relative humidity and rainfall are 74.67% and 168.90mm respectively. One thousand eight hundred (1800) polythene pots were purchased from the Ministry of Environment Lafia and the pots were perforated at the base to allow movement of water and aeration. Soil is a medium for plant growths; it serves as nutrient for plant

uptake and maintenance of physiological function. For this study, top soil, river sand and poultry manure were collected and mixed properly in the ratio 2:1:1 respectively, it was then used to fill the polythene pots of size (6 x 9) inches, which serves as plant medium for raising the *Gmelina arborea* seedlings (Plate 1). The *Gmelina arborea* seeds were collected from three (3) different locations namely: College of Education, Akwanga; Nasarawa Eggon and Lafia.

(a) (b)

Plate 1: Layout of the experimental site about $60m^2$

Seed Collection and Processing

The seeds were picked from plus trees (trees with desirable characteristics) of *Gmelina arborea*. A total of number 1800 seeds were collected, 600 from each of the various location. The seeds were collected on April 27, 2014. Seed were soaked in water for three (3) days so as to ease de-pulping of the seeds. Seeds were extracted manually by removing the pulp covering the seeds and after that, the seeds were subjected to different treatment.

Seed Pretreatment

Seeds were subjected to three different pretreatment during the experimental research, they include:

I. Treatment One (Sundried for 72hrs)

Six hundred (600) seeds were sundried for 72hrs, so as to break or reduce its dormancy. The sun drying lasted for two days, 6 hours per day that is from 10am to 4pm daily.

II. **Treatment Two (Sundried 72hrs and Soaking in water 72hrs)**

Six hundred (600) seeds were sundried for 72 hrs and then soaked in water for 72hrs in order to break its dormancy and improved its germination rate. According to literatures, sun-drying and soaking in water has been found beneficial for rapid germination of *Gmelina arborea* seeds.

III. Treatment Three (Control)

Six hundred (600) seeds were selected without any treatment to the seeds and kept in open air container. This is serves as control and it is used to check the performance of the other treatments.

Six hundred (600) seeds per treatment were sown on the nine 3m x 3m germination beds with 3 beds per treatment before the seedlings were transplanted into the polypots (Plate 1). Watering was done in the morning and evening at (2) two days interval to enable the soil to dissolve properly before the seeds were sown. Watering continues after planting was done for another two weeks and thereafter, watering was done only in the evening. Hoeing and hand weeding was carried out in the site so as to reduce competition with the Gmelina seedlings for water, sunlight and nutrients. Germination test was carried out on the seeds to determine its viability. The germination test was carried out by sowing the seed in a germination bed. One thousand eight hundred 1800 seeds were sown on the germination bed, germination rate was observed for about eight weeks and estimated thus:

$$\% \text{ Germination test} = \frac{\text{Number of germinated seeds}}{\text{Number of seed sown}} \times 100 \ldots\ldots\ldots\ldots 1$$

The young seedlings transplanted into polythene pots with 600 seedlings selected from each location. Two hundred and seventy (270) seedlings of good vigour were tagged and transplanted in polypots, that is, 90 seedlings from each treatment were measured to determine the growth variables namely: plant height, leaf count, leaf area and stem collar girth. Measurement was carried out fortnightly for a period of 3 months. The fresh weight and dry matter of seedlings were determined at the end of the experiment. Six (6) samples were selected from each treatment, oven dried at 75^oC. At the end, the initial moisture content was subtracted from the final oven dried to determine the moisture content.

Data Analysis

The study was laid out in a 3 x 3 factorial experiment in a completely randomized design (CRD), resulting to 9 treatment combinations replicated 30 times as described by (Akindele 2004: Adesoye, 2004). Analysis of variance was carried out to show the comparative performance of each treatment. Duncan's Multiple Range Test (DMRT) was applied to locate where the significant difference occur among the location and treatment in the measured variables. Correlation analysis was used to access the magnitude and the degree of relationship between the selected variable while the plant height of *Gmelina arborea* was predicted using linear regression analysis as described thus:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \ldots + b_nx_n + \mu \quad \ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where Y = (dependent variable) the plant height, a = intercept, b_1--b_n, = regression parameters, x_1 ---x_n = independent variables

The coefficient of determination (R^2) and standard error of estimate (mean square error) were determined to know the proportion of variation explain by the regression equation.

RESULTS

The result of the mean values of seed germination on the basis of seed source and treatment

The average germination of the seeds sourced from the three (3) locations was 67.03 ± 24.16%. It also showed that the seeds collected from Akwanga (L1) have the highest germination with a mean value of 70.09%, followed by Nasarawa Eggon (L2) with mean value of 66.95%, while Lafia (L3) has the least with a mean value of 64.04%. On the basis of treatment, (Sundried for 6hrs and soaked for 24hrs) treatment (T2) recorded the highest mean value of 69.33%, followed by (Sundried for 12hrs) treatment (T1) with a mean value of 66.61%, while Control treatment (T3) recorded the least germination with a mean value of 65.14% (Table 1). The result of the ANOVA for germination test shows that there is no significant difference in the seed sources while there was no significant difference in seed germination. Finally, there was no significant interaction among seed sources and seed treatments on seed germination at $p<0.05$ (Table 2).

The result of the mean values of growth parameters measured on the basis of seed source and seed treatment.

The mean values of growth parameters measured on the basis of seed source showed that, Akwanga (L1) recorded the highest mean collar girth of 2.39cm, plant height 66.92cm, leaf count 15.38 and leaf area 223.14cm^2 . This was followed by Nasarawa eggon (L2) with mean collar girth of 2.18cm, height 61.66cm, leaf count 14.52 and leaf area of 211.08cm^2 while seed collected from Lafia recorded the least mean collar girth 2.03cm, height 57.55cm, leaf count 14.48 and leaf area of 195.96cm^2. Based on the treatment, (Sundried for 72hrs and soaked in water for 72hrs) (T2) recorded

Table 1: Mean value and Duncan mean separation value for Germination test on the basis of Seed source, Treatment and Duration

S/N	Source of Variations	Sample size	Mean (%)	% Coefficient of Variation
1.	**Seed source**			
	Akwanga	600	70.09 ± 25.70^a	36
	Nasarawa eggon	600	66.95 ± 25.24^a	37
	Lafia	600	64.04 ± 22.20^a	34
2.	**Treatment**			
	Sundried (72hrs)	600	66.61 ± 22.33^a	33
	Sundried72hrs & Soak72hrs	600	69.33 ± 23.65^a	34
	Control	600	65.14 ± 27.24^a	41
3.	**Duration**			
	2 weeks	1800	18.00 ± 4.66^a	25
	3 weeks	1800	47.22 ± 7.42^b	15
	4 weeks	1800	72.11 ± 5.62^c	7
	5 weeks	1800	82.55 ± 5.02^{cd}	6
	6 weeks	1800	83.11 ± 4.91^{cd}	5
	7 weeks	1800	83.11 ± 4.91^{cd}	5
	8 weeks	1800	83.11 ± 4.91^{cd}	5
	General mean	1800	**67.03 ± 24.16%**	

Figures with the same alphabet in the same column are not significantly different, ns = not significant

Table 2: Result of Analysis of Variance for germination of Gmelina seedlings

Source of Variation	Type III Sum of Squares	df	Mean Square	F	Sig.	R^2
Location	384.222	2	192.111	0.293	0.747^{ns}	
Treatment	189.746	2	94.873	0.145	0.865^{ns}	
Locat*treat	262.540	4	65.635	0.100	0.982^{ns}	
Error	35363.429	54	654.878			
Total	**36199.937**	**62**				**0.023**

Note: ** = highly significant at 1% probability level, * = significant at p<0.05, ns = not significant

Table 3: Mean value and Duncan mean separation value for growth variables on the basis of seed source, Treatment and Duration.

S/N	Source of Variation	Collar girth (cm)	Height (cm)	Leaf count	Leaf area (cm^2)
	Location				
1.	Akwanga	2.39 ± 1.30^a	66.92 ± 40.24^a	15.38 ± 7.19^b	223.14 ± 142.9^a
2.	Nas. Eggon	2.18 ± 1.15^b	61.66 ± 39.33^b	14.52 ± 7.19^a	211.08 ± 151.19^b
3.	Lafia	2.03 ± 1.06^c	57.55 ± 35.39^c	14.48 ± 7.02^a	195.96 ± 133.33^c
	Treatment				
1.	Sundry(72hrs)	1.90 ± 0.94^a	57.22 ± 33.07^a	13.98 ± 6.54^a	187.18 ± 131.63^a
2.	Sundry 72hrs & Soak 72hrs)	2.60 ± 1.43^b	65.29 ± 42.29^b	15.76 ± 7.72^b	241.09 ± 159.72^b
3.	Control	2.10 ± 1.01^c	63.62 ± 39.30^c	14.64 ± 7.02^c	201.91 ± 130.56^c
	Duration				
1.	4 weeks	0.98 ± 0.18^a	23.05 ± 2.37^a	6.68 ± 0.95^a	48.34 ± 9.04^a
2.	8 weeks	2.08 ± 0.52^b	50.70 ± 8.06^b	14.04 ± 1.36^b	213.24 ± 59.47^b
3.	12 weeks	3.54 ± 0.79^c	112.37 ± 13.73^c	23.66 ± 2.20^c	368.59 ± 79.03^c
	General mean	**2.20 ± 1.18**	**62.04 ± 38.50**	**14.80 ± 7.13**	**210.06 ± 142.84**

Note: figures with the same alphabet in the same column are not significantly different, ns = not significant

Table 4: Analysis of Variance for growth parameter assessed

		Collar girth		Height		Leaf count		Leaf area	
Sources of Variation	**df**	**F**	**sig.**	**F**	**sig.**	**F**	**sig.**	**F**	**sig.**
location	2	49.28	0.00**	202.75	0.00**	39.26	0.00**	21.04	0.00**
treatment	2	193.10	0.00**	166.81	0.00**	121.87	0.00**	88.02	0.00**
week	2	2405.0	0.00**	19200	0.00**	10930	0.00**	2908	0.00**
locat*treat	4	32.26	0.00**	115.53	0.00**	35.06	0.00**	27.54	0.00**
locat*week	4	6.44	0.00**	34.00	0.00**	1.16	0.00**	18.09	0.00**
treat*week	4	44.02	0.00**	91.86	0.00**	29.55	0.00**	24.36	0.00**
locat*treat*week	8	4.56	0.00**	18.86	0.00**	5.76	0.00**	12.65	0.00**
Error	513								
Total	**539**								
R^2			**0.917**		**0.987**		**0.978**		**0.926**

Note: ** = highly significant at 1% probability level, * = significant at p<0.05, ns = not significant.

Table 5: Correlation analysis for parameters assessed

S/N	Source of variation	Collar girth	Leaves count	Germination	Leaf area	Height
1	**Collar girth**	1				
2	**Leaf count**	0.931**	1			
3	**Germination**	0.434**	0.262*	1		
4	**Leaf area**	0.923**	0.934**	0.003	1	
5	**Height**	0.923**	0.976**	-0.181	0.916**	1

**= correlation is significant at 1% level p< 0.01, *= correlation is significant at 5% level p<0.05

Table 6: Multiple Linear Regression analysis of Variables assessed

Variables	Model	Un-standardized Coefficient B	Std. Error	Standard Coefficient Beta	t B	Sig	S.E.E	R^2
	(Constant)	-16.086	1.705		-9.434	0.000		
	Location	-2.232	0.442	-0.047	-5.045	0.000**		
	Treatment	1.498	0.432	0.032	3.468	0.001**		
	Week	1.303	0.501	0.111	2.600	0.010**		
	Collar girth	3.482	0.957	0.107	3.639	0.000**		
	Leaf count	4.256	0.284	0.789	14.996	0.000**		
	Leaf area	-0.007	0.008	-0.026	-0.910	0.363^{ns}	8.070	0.957

Note: ** = highly significant at 1% probability level, * = significant at p<0.05, ns = not significant, Dependent Variable: Height, S.E.E = Standard Error Estimate

Table 7: Mean and Duncan mean separation value for biomass variables on the basis of seed source and treatments.

S/N	Source of Variation	Wet weight (g)	Dry weight (g) (biomas)	Moisture content	% Moisture Content
	Location				
1.	Akwanga	89.86 ± 58.29^a	19.87 ± 12.40^a	69.99 ± 46.05^a	346.90 ± 44.37^b
2.	Nas. Eggon	55.39 ± 32.89^a	16.57 ± 11.07^b	38.82 ± 22.17^b	252.68 ± 68.78^a
3.	Lafia	64.66 ± 60.61^a	15.54 ± 14.82^b	49.11 ± 45.93^c	320.56 ± 72.14^b
	Treatment				
1.	Sundried (72hrs)	59.13 ± 60.97^a	15.89 ± 14.45^b	43.23 ± 46.75^a	264.99 ± 73.42^a
2.	Sundried 72hrs & soaked 726hrs)	78.84 ± 57.85^a	18.01 ± 11.82^a	60.83 ± 46.15^b	330.38 ± 45.70^a
3.	Control	71.93 ± 40.14^a	18.07 ± 12.49^a	53.86 ± 28.69^c	324.78 ± 83.31^a
	General mean	**69.97 ± 51.21**	**17.32 ± 12.23**	**52.64 ± 39.58**	**306.71 ± 71.89**

Note: figures with the same alphabet in the same column are not significantly different, ns = not signif

Table 8: Analysis of Variance for biomass variables of Gmelina seedlings

	Dry weight (biomas)			% M. C		
Sources of Variation	**df**	Mean Square	**F**	**sig.**	Mean Square	**F**	**sig.**
Location	2	1909.11	0.74	0.50^{ns}	14179.42	3.40	0.07^{ns}
Treatment	2	600.11	0.23	0.79^{ns}	7881.45	1.89	0.20^{ns}
locat*treat	4	4150.79	1.62	0.25^{ns}	1564.87	0.37	0.82^{ns}
Error	9	2551.83			4166.49		
Total	**17**						
R^2				**0.485**			**0.573**

Note: ** = highly significant at 1% probability level, * = significant at p<0.05, ns = not significant

the highest mean collar girth 2.60cm, height 65.29cm, leaf count r 15.76 and leaf area 241.09cm^2 then followed by Control (T3) with mean collar girth 2.10cm, height 63.62cm, leaf count 14.64 and leaf area 201.91cm^2 while (Sundried for 72hrs) (T1) recorded the least mean collar girth 1.90cm, height 57.22cm, leaf count 13.98 and leaf area 187.18cm^2 (Table 3). However, the growth variables among seed sources were significantly different except for Nasarawa Eggon and Lafia which has no significant difference with respect to leaf count at p<0.05 (Table 4). There was significant difference in leaf area among seed sources, treatments and interaction between seed sources and treatments. Similarly, there was also significant interaction among seed sources and treatments at p<0.05 probability level (Table 4).

The result of Correlation analysis revealed that there was a significant correlation between leaf area and plant height (0.916**), between the collar girth and leaf count (0.931**), collar girth and leaf area (0.923**), collar girth and plant height (0.923**) (Table 5). The result of the regression analysis on the effects of growth variables on tree plant height had coefficient of (R^2 = 0.957) (Table 6) meaning that the assessed growth variables had about 95.7% effects on plant height of *Gmelina arborea* seed collected from different locations in Nasarawa State.

Result of mean values of biomass variables on the basis of seed source and treatment.

The average values of biomass weight of the seedlings produced from sourced seeds from the three

(3) locations was 17.32 ± 12.23g. The mean of biomass weight on the basis of seed sources revealed that, the seedlings produced from sourced seeds from Akwanga (L1) recorded the highest mean biomas weight of 19.87 ± 12.40g, followed by Nasarawa Eggon (L2) with mean 16.57 ± 11.07g while Lafia (L3) recorded the least mean biomas weight of 15.54 ± 14.82g. Based on the treatment, the Control Treatment (T2) recorded the highest mean biomas weight of 18.07 ± 12.49g,, then followed by (Sundried for 72hrs and soaked in water for 72hrs) (T2) with mean values of 18.01 ± 11.82g while (Sundried for 72hrs) (T1) had the least mean biomas weight of 15.89 ± 14.45g (Table 7). However, the result of ANOVA showed that there was no significant difference in the biomas weight of the seedlings produced from sourced seeds from the 3 different locations whereas, there was a significant difference among the treatment at $p > 0.05$ (Table 8).

DISCUSSION

Effect of pretreatment and location on seed germination and seedling growth

The variation in the growth variables could be attributed to the fact that the seeds gotten from different locations has different viability due to its inherent climatic traits from the mother plant, while the significant effect of seeds sources on virtually all the variables measured could be attributed to the fact that the seeds might have inherent climatic traits helped by the poultry manure which contains macro and micro nutrients needed for plant growth development. The result of the study showed that sun-drying and soaking in water treatment has the highest percentage germination of 69.33%, this could be attributed to the fact that treatment two (sun-drying 72hrs and soaking in water 72hrs) was able to break the seed dormancy more rapidly than the other (Agboola and Etejere, 1991). This finding is in conformity with the finding of Agboola and Etejere, 1991 who reported that "drying and soaking is the most suitable treatment for releasing dormancy in *Gmelina arborea* seeds." However, there was no significant difference in the germination. The result of the experiment also show that there is a significant increase due to the drying and soaking the seed on the growth parameters on the *Gmelina arborea* seedlings with mean values of height 65.29cm, collar girth 2.60cm, leaf number 15.76 and leaf area 241.09cm^2, the response of these characters to the drying and soaking treatment could be attributed to the fact that sun-drying and soaking in water break the dormancy readily (Agboola and Adedire, 1998), that lead to rapid germination and establishment of the seed, therefore the seedlings started receiving sunlight and absorbing nutrients first that lead to the significant difference in the growth parameters (Agboola and Etejere, 1991). On the other hand, the control (non-treated) followed the (sun-drying and soaking in water) while (sun-drying 72hrs) recorded the least mean values on growth parameters.

CONCLUSION AND RECOMMENDATION

Seeds from different source has different viability, as it was observed that seeds obtained from Akwanga were more viable than the other two locations, therefore when raising *Gmelina arborea* seedlings for plantation establishment, the seed source should be considered as a factor. There is little dormancy present in *Gmelina arborea* seeds and therefore it required little pretreatment. Seeds treated with sun-drying and soaking in water recorded the highest germination percentage, even though there was no significant difference among the treatments. Sun-drying and soaking in water contributed to rapid germination of the seeds which could be responsible for significant difference on all the growth variables such as height, collar girth, leaf count and leaf area.

From the result of the study, it is recommended that the treatment with sundried for 72hrs and soaked in water for 72hrs performed better than the other treatments. Therefore, it should be adopted in raising *Gmelina arborea* seedlings in the nursery. However, further research activities on pretreatment of seed of *Gmelina arborea* should be carried out when raising the species for plantation establishment. Also, care should be taken to locate appropriate seed source, pre-treatment method. This will go a long way to increase the production of *Gmelina arborea* trees and guarantee its sustainable supply to the forest industry.

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