Original Research Article

Effects of Seed Weights and Sowing Media on Germination and Early Growth of *Afzelia africana.* Smith ex pers.

ABSTRACT

Seed weight is one of the most important seed quality traits, while sowing medium has significant role in seed germination. This study therefore assessed effect of seed weights and sowing media on germination of *Afzelia africana* seeds to enhancing sustainable production of the species.

Seeds of different sizes were collected, measured with sensitive weighing balance and grouped into small (120), medium (120) and large (120) seeds. Each seed group was sown in three sowing media (washed river sand, decomposed sawdust, and forest top soil) replicated 4 times and arranged in Completely Randomized Design. The growth assessment comprised of 3 treatments which included seedlings from small, medium and large seeds planted in 1kg polythene pots filled with top soil and replicated 4 times. Plant height, leaf production and stem diameter were assessed fortnightly for twelve weeks. Biomass assessment was carried out twice (second week and twelfth week). Mean Daily Germination (MDG), Germination Percentage (GP), Germination Energy (GE), Peak Value (PV), Germination value (GV), Net Assimilation Rate (NAR) and Relative Growth Rate (RGR) were estimated. Data were subjected to analysis of variance (ANOVA)

The MDG showed that large seeds sown in river sand large seed size sown in saw dust (T_4 and T_7) had highest value of 3.47 and 3.29 respectively with GV of 12.83.

There was significant difference ($p < 0.05$) in the effects of different sowing media and seed weights on the germination of *Afzelia africana.* Saw dust gave the highest mean value with 52.777±0.28 while mean value of large sized seeds was highest (57.539±0.6). There was significant difference ($p<0.05$) in the effects of different seed weight on the height, collar diameter and leaf production.

Germination percentage of *A. africana* improved significantly with the sowing media and seed weight especially sawdust, river sand, and large seed size. It therefore suggested that *Afzelia africana* seedling should be raised at nursery stage with Sawdust and Large seed size in order to increase the growth of plant and have more vigorous seedlings for plantation establishment.

Keywords: Sowing media, Biomass, Net Assimilation Rate, Relative Growth Rate

INTRODUCTION

Afzelia africana also called African mahogany belongs to the family Ceasalpiniaceae. It is a multipurpose tropical African tree suitable for use in Agroforestry systems mostly recognized as vulnerable in some parts of Africa while it is categorized as endangered in Nigeria because of its high-grade timber for various wood constructions and furniture works (Bonou *et al*., 2009; Hutchings *et al*., 1996). It is one of the commercial timbers in Africa, leaves, fruits and seeds are good potential livestock fodders; flowers and oil from seeds are used for cooking and also makes good firewood and charcoal (Ejikeme and Chukwuma 2011). *A. africana* is easily recognized by its broad rather open crown with many branches and blackish fruit. It is a N-fixing tree, thus improves soil fertility through N and mineral –rich fallen leaves which mulch and provide nutrient and soil cover which protects the soil from erosion. In Nigeria, the seeds of the species are processed for soup in the eastern part of the country, while the leaves are used for feeding grazing animals like cow, goats, and sheep. The root infusion provides a remedy for billorzia and certain eye complaints. The roots are used to treat gonorrhea, chest pains, kidney problems and snake bites (Hutchings *et al*., 1996).

The regeneration or multiplication of many plants depends on seed and characteristic features. A seed is defined as an embryo, which is an immature diploid sporophyte developing from the zygote, surrounded by nutritive tissue and enveloped by a seed coat (Cendán *et al*., 2013). The embryo generally consists of an immature root called the radicle, a shoot apical meristem called the epicotyls, and one or more young seed leaves called the cotyledons. All these are developed under favourable condition before vigorous seedlings can be achieved (Cendán *et al*., 2013).

Viable seeds are living entities. They must contain living, healthy embryonic tissue in order to germinate. A fully developed seed contains an embryo and, in most plant species, a store of food reserves, wrapped in a seed coat. Seeds generally germinate when soil moisture and temperature conditions are intact for them to grow (Miles and Brown, 2007).

Germination is a critical stage in the life cycle of plants and often controls population dynamics (Boyko *et al.,* 2010). In angiosperms, there is increasing evidence that environmental maternal effects affect both germination percentage and germination phenology (Li *et al*., 2005; Lacey, 1996; Donohue, 2009; Figueroa *et al*., 2010; Tielbörger and Petrü, 2010; Cendán *et al.,* 2013) .

Environmental factors that affect the mother plant, such as photoperiod and temperature, during seed maturation have also been found to influence seed germination of many species (Boyko *et al.,* 2010; Figueroa *et al.,* 2010). These factors may also influence the size of the seeds, which in turn may influence germination timing and success (Castro, 2006) and within species, seed mass is often associated with probability or time of germination (Hendrix, 1984). This is important because it has been shown that larger seeds have an advantage over smaller ones as a higher proportion of larger seeds will germinate and give rise to more vigorous seedlings (Baskin and Baskin 1998). However, there is little information on how environmental factor and seed weight affect the germination of seed.

Seed characteristics affect germination, seedling growth and canopy development (Dutta, 1995). Seeds of higher plants have various sizes and this is attributable to the size of the endosperm within the seed and it has been found to influence germination and consequently productivity of species (Dutta, 1995) Thus, according to Houssard and Escarre (1991), early germination means early opportunity for growth. Seed size is one of the most important seed quality trait, which affect the performance of seedlings (Adebisi *et al.,* 2013). The nutrient content of seed depends on seed size and varies in species to species (Arunachalam *et al.,* 2003).

A growing medium can be defined as a solid substrate that replaces the natural soil on which roots grow regularly by extracting water and nutrients for plant development (Douglass *et al*., 2009). Several materials can aspire to be used for growing media preparation; however, the final choice depends on the whole of their intrinsic characteristics that may be correlated to agronomical functions, such as the ability to sustain plant growth (Parente *et al*., 2000). This study therefore assessed effect of seed weights and sowing media on germination of *A. africana* seeds in enhancing sustainable production of the species.

MATERIAL AND METHODS

Study area

The experiment was carried out at Silviculture Nursery of Forestry Research Institute of Nigeria (FRIN) situated at Jericho Hill in Ibadan Nigeria which lies between latitude $7^{0}23^{'}$N and longitude $3^{0}51^{'}$ E. The climatic condition of the area is tropically dominated by rainfall pattern from 1400mm-1500mm with average temperature of about 31.2^{0}C. The area experiences two distinct seasons dry and rainy seasons; the former starting from April to October and the latter commencing from November to March, (FRIN Meteorological Station, 2017).

Seeds of *Afzelia africana* were collected from scattered mother trees at Olokemeji Forest Reserve in Ogun State, Nigeria and the seedlot processed. Based on weights measured with sensitive weighing balance, seeds were grouped into small (120) medium (120) and large (120) classes. Ten (10) seeds per treatment and replicated four (4) times were sown into three different germination media namely: washed river sand, decomposed sawdust, and forest top soil. Altogether, three hundred and sixty 360 seeds were used. Thirty-six (36) germination trays were filled with three different media and arranged in Completely Randomized Design in the screen house. Watering was done once daily and germination counts were taken daily for 28 days.

For the assessment of early growth of the species, resulting uniform germinant from the three seed weights were pricked and transplanted into polythene pots filled with 1kg top soil. The physiochemical properties of the experimental top soil was analysed at Soil Laboratory of Bioscience Department in Forestry Research institute of Nigeria (FRIN). The growth assessment comprised of three treatments which included seedlings from small medium and large seeds. Four (4) seedlings were made up of a treatment and replicated 4 times making a total of forty-eight seedlings. Watering of the seedlings was done daily and plant height, leaf production and stem diameter were assessed fortnightly for twelve weeks. Heights were measured from the root collar to apical bud using a graduated ruler while the numbers of leaves were counted and stem diameter was measured at about 2cm above the root collar with the use of digital caliper.

Biomass assessment was done twice; the first assessment was carried out at the end of the first two weeks after transplanting and the second biomass determination was at the end of the experiment (twelfth week). The same selected seedlings whose growths were assessed were subjected to destructive experiment.

The combined weight of the leaves, stems and roots of each specie accounted for the total weight. Leaves, stem and root of the experimental samples were excised with a sharp razor blade to separate the leaves, stems and roots. Fresh weights were determined using a Sensitive Weighing Balance and then oven dried to constant weight for twenty-four hours at 70^{o}C. The net assimilation rate (NAR) and relative growth rate (RGR) were calculated using formula:

$$NAR = \frac{(W2-W1)(Loge\ L2 - Loge\ L1)}{(T2-T1)(L2-L1)}$$

$$RGR = \frac{(Loge\ W2 - Loge\ W1)}{(T2-T1)}$$

Where: W_1 = Initial weight of the seedlings.
W_2 = Final weight of the seedlings.
T_1 = Initial time.
T_2 = Final time.
L_1 = Initial leaf numbers.
L_2 = Final leaf numbers.
Log_e = Exponent of logarithms.

Data Analysis

Germination Percentage (GP), Germination Energy (GE), Mean Daily Germination (MDG), Peak Value (PV) and Germination value (GV) were determined with the use of the following equations according to Schelin *et al*., (2003):

1. Germination Percentage (%) = $\frac{total\ seeds\ germinated}{Total\ sseds\ sown}$ …….. (Eqn. 1.)
2. Germination Energy (GE) is the percentage total of highest germination counts from the day it begins till when it starts diminishing divided by total seed sown.

GE = $\frac{\ldots\ldots x+y+z}{Total\ sseds\ sown}$ X 100………………………………. (Eqn. 2.)

Where: x = the first highest germination count, y = higher germination count, z = high germination count

3. Mean Daily Germination percentage (MDG): This is cumulative total percentage of germinated seeds divided by exact germination day.

MDG(%)= $\frac{Cumulative\ Total\ Percentage\ of\ seed\ sown}{X}$…………. (Eqn. 3.)

Where: x = Exact germination day

4. Peak Value (PV) is the highest value calculated as MDG
5. Germination Value (GV) is the product of the last day MDG and PV

GV = Last *day MDG X PV*………………………………. (Eqn. 4)

Data were subjected to analysis of variance (ANOVA) and where there were significant differences, post-hoc analysis was carried out with Duncan Multiple Range Test (DMRT) in order to separate the means. The experimental was a 3 x 3 factorial with three (3) sowing media and three (3) seed weights. There were 9 treatment combinations replicated 4 times.

A1B1 = T_1, A1B2 = T_2, A1B3 = T_3, A2B1 = T_4, A2B2 = T_5, A2B3 = T_6, A3B1 = T_7, A3B2 = T_8, A3B3 = T_9

Where,

A– Sowing media: A1 –Top soil, A2 – River sand, A3 – Saw dust

B – Seed weights: B1 – Large, B2 – Medium, B3 – Small

RESULTS AND DISCUSSION

Germination Percentage (%), Germination Energy, Peak Values, Mean Daily Germination and Germination values of *Afzelia africana* seeds

Table 1 shows the result of the effects of seed weights on germination of *Afzelia africana* seeds. The Mean daily germination (MDG) shows that the treatment with saw dust and large seed weight and river sand and large seed weight (T_7 and T_4) had highest value of 3.29 and 3.47 with the same Germination Value (GV) of 12.83 and 12.28. This was closely followed by Medium seed weight and Saw dust (T_8) with the MDG of 2.95 and GV of 12.27 respectively. The treatment with top soil and small weight (T_3) had the least value with MDG of 2.61 and GV of 7.07 (Table 1).

Table 1: Germination values of *Afzelia africana* seeds under different sowing media treatments.

TREATMENT	GERMINATION %	GERMINATION ENERGY	PEAK VALUE	MDG FINAL	GERMINATION VALUE
T_1	46.88	28	2.88	2.6	7.49
T_2	40.6	25	2.9	2.9	8.41
T_3	46.9	25	2.71	2.61	7.07

T_4	62.5	31.25	3.54	3.47	12.28
T_5	50	41	3.65	2.79	10.15
T_6	37.5	37.5	3.13	3.13	9.8
T_7	62.5	37.5	3.9	3.29	12.83
T_8	53.13	34	4.16	2.95	12.27
T_9	43.75	28	2.87	2.43	6.97

Effects of sowing media and seed weights on the germination of *Afzelia africana* seeds

There was significant difference ($p < 0.05$) in the effects of different sowing media and seed weights on the germination of *Afzelia africana* (Table 2). However, mean value showed that seeds sown in saw dust gave the highest mean value with 52.777±0.28 while the seeds sown in top soil gave the lowest mean value with 42.399±0.24 (Table 3). Mean value of different sown seed weights were highest in large weight (57.539±0.6) while small seeds gave the lowest value 39.521±0.09 (Table 4).

Table 2: Analysis of variance for the influence of sowing media and seed weights on the germination of *Afzelia africana* seeds

SV	Df	SS	MS	F-cal	P-Value
Sowing Media	2	511.693	255.847	234.684	.000*
Seed weight	2	1463.849	731.925	671.381	.000*
Sowing Media* Seed weight	4	131.094	32.773	30.063	.000*
Error	18	19.623	1.090		
Total	26	2126.260			

Table 3: Post- hoc Test for the influence of sowing media on the germination of *Afzelia africana* seeds

Treatments	Mean
Top Soil	$42.399±0.24^{a}$
River Sand	$49.711±0.30^{b}$
Saw dust	$52.777±0.28^{c}$

Means with the same superscript are not significantly different (p> 0.05)

Table 4: Post- hoc Test for the influence of seed weights on the germination of *Afzelia africana* seeds

Treatments	Mean
Small weight	$39.521±0.09^{a}$
Medium weight	$47.827±0.29^{b}$
Large seedweight	$57.539±0.16^{c}$

Means with the same superscript are not significantly different (p> 0.05)

Effects of different seed weights on the mean height growth of *Afzelia africana* seedlings

The result of Analysis of Variance (ANOVA) revealed that there was significant difference ($p<0.05$) in the effects of different seed weight on the height of *Afzelia africana* seedlings (Table 5). Mean value shows that T_3 had the highest growth height of 71.438±0.61 cm while T_1 gave the least growth height of 35.218±0.45 cm (Table 6 and Fig.1)

Table 5: Analysis of Variance (ANOVA) for Shoot Height (cm), Collar Diameter (mm) and Leaf Production of different Seed weights of *Afzelia africana* within 12 weeks

Parameters	SV	Df	SS	MS	F-cal	P-Value
	Treatments	2	11108.97	5554.49	46.600	.000*
	Errors	45	5363.78	119.20		
Shoot Height	Total	47	16472.75			
	Treatments	2	3.746	1.873	3.351	.044*
	Errors	45	25.149	.559		
Collar Diameter	Total	47	28.896			
	Treatments	2	66.292	33.146	12.011	.000*
Leaf Production	Errors	45	124.188	2.760		
	Total	47	190.479			

***=**significant at $P<0.05$

Table 6: Post- hoc Test for Shoot Height (cm) of different Seed weights of *Afzelia africana* within 12 weeks

Treatments	Mean
T_1	35.218±0.45 [a]
T_2	45.738±0.52 [b]
T_3	71.438±0.61 [c]

Means with the same superscript are not significantly different ($p> 0.05$)

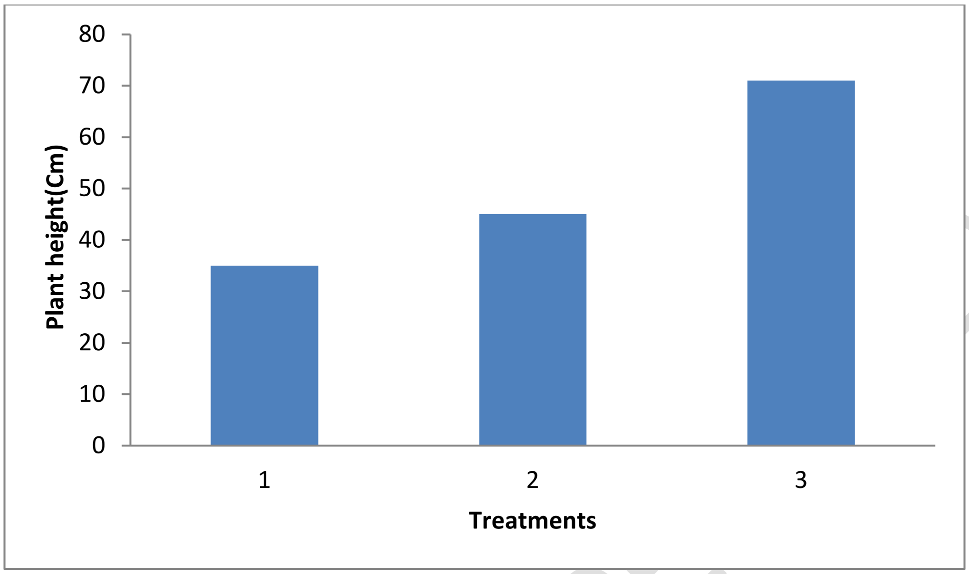

Fig 1: Growth pattern showing the mean height (cm) of *Afzelia africana* within 12 weeks

Effects of different seed weights on the Mean Collar Diameter of *Afzelia africana* seedlings

There was significant difference ($p< 0.05$) in the effects of different seed weights on the collar diameter of *Afzelia africana* seedlings within the period of study. **(**Table5). The mean separation test shows that T_3 had the highest collar diameter of the seedlings 5.963±0.22 mm while T_1 had the least collar diameter of 5.363±0.13mm (Table 7 and Fig. 2)

Table 7: Post- hoc Test for Collar Diameter (mm) of different Seed weights of *Afzelia africana* within 12 months of study

Treatments	Mean
T_1	5.363±0.13[a]
T_2	5.377±0.11[a]
T_3	5.963±0.22[b]

Means with the same superscript are not significantly different ($p> 0.05$)

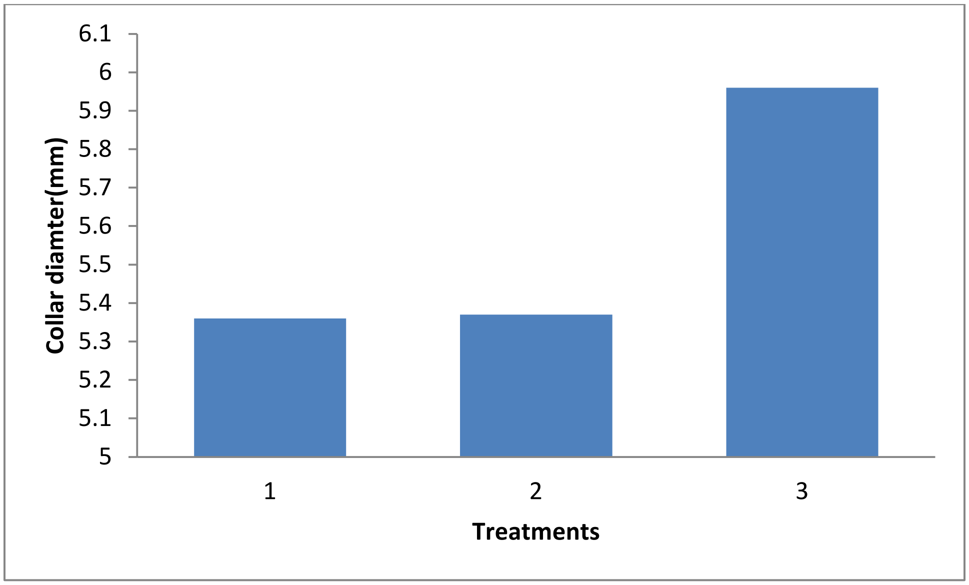

Fig 2: Growth pattern showing the mean stem diameter (mm) of *Afzelia africana* within 12 week of study

Effects of different seed weights on leaf production of *Afzelia africana* seedlings

The result of ANOVA indicated that there was significant difference ($p < 0.05$) in the effect of different seed weights on the mean leaf production of *Afzelia africana* seedlings (Table 8). Post- hoc test shows that T_3 had the highest mean leaf production of 8 leaves while T_1 gave the least mean leaf production (Table 9 and Fig. 3).

Table 9: Post- hoc Test for Leaf Production of different Seed weight of *Afzelia africana* within 12 weeks

Treatments	Mean
T_1	5.375 ± 0.14^a
T_2	6.688 ± 0.17^b
T_3	8.025 ± 0.11^c

Means with the same superscript are not significantly different ($p > 0.05$)

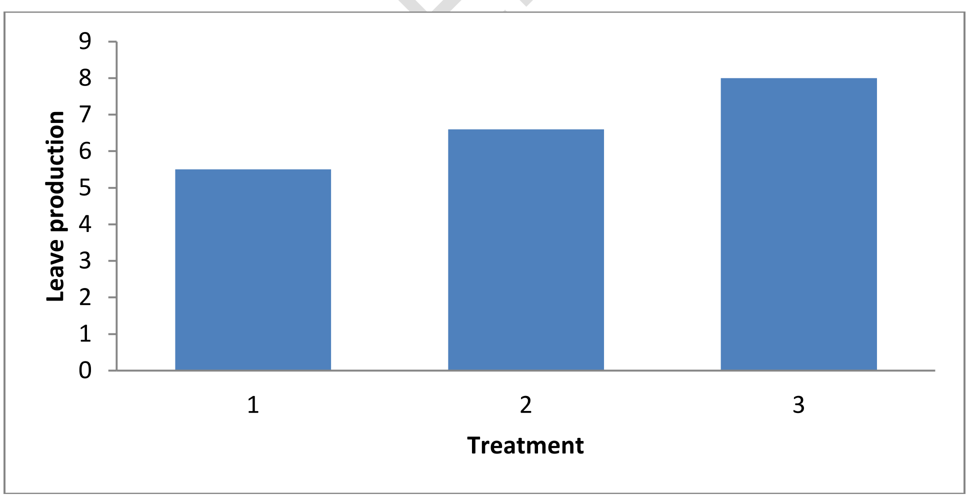

Fig 3: Growth pattern showing the mean leaf production of *Afzelia africana* within 12 week of study

Biomass accumulation of *Afzelia africana* at 2nd and 12th week of study

The result of biomass accumulation at 2nd and 12th week of study as influenced by seed weights is shown in tables 10 and 11. At both 2nd and 12th week, the large seed weight (T_3) had the highest biomass accumulation of 5.83g and 18.59g respectively while the least biomass accumulation were recorded for small seed weight (T_1) at 2nd week (1.94g) and 12th week (6.13g) . Considering root, leaves and stem ratio, biomass accumulation of leaves were highest at 2nd week (3.25g) and at 12th week (8.45g) (Table 11 and 12). The biomass accumulation of stem at both 2nd and 12th week were the least (0.4g) and (1.47g) respectively (Table 11 and 12).

Table 10: Biomass Accumulation of *Afzelia africana* at 2nd week

Treatments	Root (g)	Leaves (g)	Stem (g)	Total (g)
T_1	0.55	0.99	0.4	1.94
T_2	0.79	1.99	0.44	3.22
T_3	1.06	3.25	1.52	5.83

Table 11: Biomass Accumulation of *Afzelia africana* at 12th week

Treatments	Root (g)	Leaves (g)	Stem (g)	Total (g)
T_1	1.92	3.72	1.47	6.13
T_2	2.49	6.15	2.73	11.37
T_3	3.54	8.45	6.6	18.59

Net Assimilation Rate (NAR) and Relative Growth Rate (RGR) for *Afzelia Africana*

Table 12 shows effects of seed weights on NAR and RGR of *Afzelia africana* seedlings within 12 weeks of study. Large seed weight (T_3) had highest NAR (0.12 g/wk) and RGR (0.99 g/wk) while T_1 had the least of NAR (0.08 g/wk) and RGR (0.18 g/wk).

Table 12: Net Assimilation Rate (NAR) and Relative Growth Rate (RGR) for *Afzelia africana*

	Treatments	Root (g/wk)	Leaves (g/wk)	Stem (g/wk)	Total (g/wk)
NAR	T_1	0.036	0.008	0.036	0.08
	T_2	0.036	0.01	0.058	0.10
	T_3	0.039	0.014	0.066	0.12
RGR	T_1	0.077	0.028	0.071	0.18
	T_2	0.078	0.41	0.12	0.61
	T_3	0.082	0.78	0.13	0.99

Discussion

Seed weights and sowing media significantly affected the germination potentials of the seed of *Afzelia africana* within the period of study. The highest values for large seeds on MDG, GP, GV and GE over medium and small seed weights depicts the importance of seed size on germination of the seeds. According to Adebisi, (2004) and Adebisi *et al.,* (2011), seed size is one of the components of seed quality which affects the germination ability of plant seeds. Gunaga *et al.*, (2011) expressed that seed weight and/or seed size is a widely accepted measure of seed quality and large seeds have high germinability, survival, seedling growth and establishment. They further identified wide array of different effects of seed size as been reported for seed germination, emergence and related agronomical aspects in many plant species. The highest germination values of large seed size which could be ascribed to stored energy in the cotyledons of the seeds agreed with the finding of (Hojjat, 2011) who reported that the germination parameters were significantly related by seed weight and large seeds germinated early and showed better germination than small seeds of lentil genotypes, in *Mammea suriga,* larger sized seeds recorded quick and highest seed germination (79.2 %), followed by medium (59.0 %) and small (22.0 %). Kazeem, (2019) reported that large seed size of *Caesalpinia bonduc* as influenced by sowing media performed significantly better than the medium and small seed size in terms of seedling emergence, mean daily germination, germination percentage and germination value. Higher and quicker germination in larger sized seeds could also be attributed to the presence of higher amount of carbohydrates and other nutrients than in medium and small sized seeds

(Gunaga *et al.*, 2011). Generally, larger seeds germinate quicker and would take lesser duration when compare to that of smaller ones (Gunaga *et al.,* 2007).

Different seeds of indigenous tree species require various techniques and several factors for successful germination. One of important prerequisites is sowing media. After appropriate seed procurement, handling and processing for sowing, optimum germination of such seeds will be the function of suitable sowing media (Asinwa *et al*., 2019).

The influence of sowing media was significant in the germination of *Afzelia africana* with more germination potentials obtained from large seed size sown in sawdust when compared to other sowing media. The highest PV which is the function of MDG recorded for large seed size in river sand and saw dust could be attributed to aeration and absorption capability of the two media. According to Arunachalam *et al*., (2003) moisture and aeration play key roles in germination of seed as they enhance metabolic activities in the seed.. The high germination percentage in river sand also agrees with the finding of (Dickens, 2011), who reported high germination percentage from seeds of *Irvingia wombolu* sown in river sand. The least germination potentials obtained from top soil in this study contrasted sharply with the findings of Okunomo (2000; 2004) who obtained a higher germination percentage in topsoil with *Dacryodes edulis and Persia americana* respectively. The least impact of top soil on the germination of different seed size disagrees with the findings of Okunomo, (2010) who observed higher germination percentage in topsoil with *Parkia bicolor*. It also contradicts Agboola and Adedire (2001) who reported highest germination percentage of *Terminalia ivorensis*; a tropical tree species in topsoil. This thereby implies that *A. africana* requires relatively more aeration and water percolation as evident in saw dust and river sand in comparison to top soil.

Plant growth and development are characterized by high degree of co-ordination and phasing. The growth of one part is closely related with the growth or activities in other part of the plant. Such basic or systematic activities going on inside the plant pre-suppose that there must be some form of functional co-ordination between different plant parts within the plant. Such internal co-ordination system is enhanced and maintained by amount of reserved food which is mostly dependent on seed size (Bawa and Krugma, 1991).

The result obtained on height, diameter and leaf production of *Afzelia africana* from different seed weight agreed with work of (Nagaraju, 2001) that observed highest shoot height, leaf production and collar diameter from large sized seeds followed by medium compared to small seeds in sun flower seedlings. Plants continue to grow throughout their lives like other multicellular organism. They grow through a combination of cell growth and cell division under favourable environmental conditions which entails water, soil nutrients, air, light and temperature (Agboola and Adedire, 2001). The varying in growth parameters of seedlings raised from different sizes therefore implies that initial stored food in the seeds play crucial roles in growth and development of the plant.

The increase in plant dry mass per unit leaf area within period of study depicts biomass accumulation, NAR and RGR is influenced by efficiency of food production between plants of different sizes. It could be inferred that seed size constitute life history trait relevant for germination and growth of seedlings in *Afzelia africana*. Moreover, Seedlings from large sized seeds with highest growth parameters and highest biomass in term of root, stem and leaves conforms to the general assertion that the amount of reserves contained in the cotyledon (a correlate of seed size) is positively related with plant's growth potentials (Harper, 1977; Hall *et al*., 2003).

CONCLUSION AND RECOMMENDATION

The study has shown that the germination percentage of *A. africana* improved significantly with the sowing media and seed weight especially sawdust, river sand, and large seed weight.

The increase in all parameters assessed within twelve weeks of study indicated that quantitative changes had occurred. This was also confirmed by the biomass yield assessment. *Afzelia africana* performed well in large seed weight compared to small seed weight in height growth, leaf production, stem diameter and dry matter yield.

It is therefore recommended that *Afzelia africana* seedling should be raised at nursery stage on sawdust medium using large weighted seed for vigorous seedlings with rapid growth for plantation establishment.

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