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EFFECT OF SEED SOURCE AND SEED SIZE ON THE EARLY GROWTH OF *ANACARDIUM OCCIDENTALE* SEEDLINGS

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ABSTRACT

Seed size and seed origin forms a very important element in the quality of seedlings produced in the nursery. This study investigated the effects of seed size and seed source on early growth of *Anacardium occidentale* seedlings. Seeds collected from mother tree at three sources (Somorin, Funaab and Camp locations) were sorted into Large, Medium and Small sizes. Collected and sorted seeds, raised in 54 poly pots was laid out in 3 x 3 factorial in Completely Randomized Design (CRD). Data was collected fortnightly for 12 weeks and it was subjected to Analysis of Variance (ANOVA) in SAS. Large sized seed had significantly ($p<0.05$) produced higher seedling height (26.39cm), number of leaves (10.82), leaf area (82.27cm^2), collar diameter (5.20mm), total fresh weight (22.72g), total dry weight (6.26g), fresh shoot weight (18.22g) and dry shoot weight (5.09g). Seeds sourced from Funaab had significantly ($p<0.05$) higher effect on seedling height (26.87cm) and fresh root weight (4.87g). There was no significant difference ($p>0.05$) in the effect of source on some morphological parameters, Camp location had the highest effect on leaf area (77.39cm^2) and collar diameter (5.19mm). Seeds sourced from Camp significantly ($p<0.05$) enhanced total dry weight (5.95g), dry shoot weight (4.81g) and absolute growth rate (0.60g/week). There was no significant difference ($p>0.05$) in the combined effect of seed source and seed size on *A. occidentale* seedling growth. To produce quality seedlings for out-planting purpose, it is important to choose large seed from a superior source.

Keywords: Seed source, seed size, *Anacardium occidentale,* seedling growth

INTRODUCTION

Seed size is a significant factor that determines seedling quality which affect its growth and development. Seed size is also a major determining factor in the success of plant propagules, mobility and its survival (Harper, 1997). Further studies showed that Seed size is an important variable, that affects germination, growth and biomass accumulation of the nursery seedlings (Shahi *et al.*, 2015**).** In crop production, the quality of seed sown is directly related to the yield quality (Ambika *et al.*, 2014) and crop growth performance (Adebisi *et al.*, 2011). Different sizes of seeds will have different amount of starch and other energy stashes that is a prominent factor to germination and early growth of young plant (Shahi *et al.*, 2015). Seed size may however affect initial seedling growth but not its final seed yield (Gross & Soule, 1981). Studies have shown the importance of large seed size to seedling survival and growth. Martínez González *et al.* (2021) reported that large seeds give young seedlings the benefit of dealing with environmental stressors. Pandey *et al.* (2017) noted high drought tolerance level in seedlings grown from larger seeds. Bentley *et al.* (1980) concluded that plants grown from smaller seeds with less resources did not grow as much as larger seeds. In a study carried out by Sanderson (2002), seed sizes influenced the germination, emergence and growth rate of Swithgrass. Also, large sized seeds have superior capabilities to persist in a water stress condition (Venable & Brown, 1988).

Seed source can be described as the parental genetic make-up that is available for its seed expressible during any planting program (Mbora *et al.*, 2009). Choice of best seed source of a desired plant specie is very crucial to successful plantation program. This will necessitate seed source testing of these species and selection of the best genetic planting materials for greater productivity in order to meet object of management and future breeding work (Mamo *et al.*, 2006; Bhat & Chauhan, 2002 and Takuathung *et al.*, 2012).

Further studies also show that several factors are hinged on seed source which shows effect on seedling growth. Aigbe *et al.* (2016) ascertain that sources with higher longitudes produces higher seedling qualities. Altitudes of seed origin (Holm, 1994) and its climatic factors such as precipitation and temperature during the fruiting stage will affect seed germination and seedling growth (Humara *et al.*, 2000). Also, source microclimate affects characters such as seed morphometric, plant growth, resistance to biotic and abiotic stress of tree species (Das, 2014)

Anacardium occidentale is the family Anacardiaceae, over 70 genera and in wide distribution of more 600 species in tropical, sub-tropical and temperate regions of the world (Zarqa *et al.*, 2021). It originated from the northeast of Brazil It grows up to a height of 15 meters and has a symmetrical spread of up to approximately 25metres (Orwa *et al.*, 2019). It is a tropical evergreen nut-bearing tropical plant (Adeigbe *et al*., 2015) and highly valuable due to its nutritional nuts (Zarqa *et al.*, 2021). It has a wide range of uses such as food, fodder, fuel, fibre, timber, gum or resin, Tannis and dye, Alcohol, poison, medicine (Orwa *et al.*, 2019).

The family is rich in important secondary metabolites with varieties of interesting biological activities (Abu-Reidah *et al.*, 2015). *Anacardium occidentale* has shown inclusion in human health benefits. It has beneficial role in reducing the risk of heart diseases (Dendena & Corsi, 2014; Allen *et al.*, 1977), controls type 2 diabetes (Bes-Rastrollo *et al.*, 2007), rhinitis (Cardoso *et al.*, 2017), obesity (Davis, 2003), protects the eye from UV rays (Zarqa, *et al.*, 2021) and cancer (Fraser, 1994), enhances the skin and protect it from acne and damage (Hu,

2001), used in skin mineralization and in the treatment of premature aging (Layokun *et al,* 1986). Further studies show its importance in protecting the human renal system and controls digestive disorder (Zarqa, *et al.,* 2021), decreases the recurrent attack of headache, lowers the circulatory strains, cardiovascular failures, manages hormonal influences in women during menopause, and lowers the seriousness of Asthma due to the magnesium content in *Anacardium occidentale* (Maia, *et al.,* 2000). *A. occidentale* kernel is rich in unsaturated fat that lowers cholesterol level when consumed (Odunsi, 2002), and serve as a source of vitamins and dietary fats (Oliveira *et al.,* 2015). Obtaining adequate knowledge on the best seed size and site of seed collection suitable for the germination of *Anacardium occidentale* will help to promote optimum growth and productivity.

MATERIALS AND METHOD

Experimental Site

The research experiment was conducted at Forest Nursery of the Federal University of Agriculture Abeokuta, Ogun State latitude 7^0 10'N and 7^0 58' N and longitude 3^0 20' E and 3^0 37'E.

Source of Seed

Mature seeds of *Anacardium occidentale* were collected from mother trees at three locations in Ogun State, Nigeria. They are;

Somorin (Obantoko) latitude 7.1852 N $7^0$11' 6.72684" and longitude 3.424972 E $3^0$25' 29.89956"

Funaab (Alabata) latitude 7.2273 N $7^0$13' 38.298" and longitude 3.43422 E $3^0$26' 3.18444"

Apakila (Camp) latitude 7.18455 N $7^0$11' 4.38756" and longitude 3.43925 E $3^0$26' 21.28776"

Viability Test

Seeds sourced from the three locations were sorted into various sizes of Large, Meduim and Small based on their weights. Sorted seeds were tested to determine their viability. The selected seeds were soaked in normal tap water for 48 hours to soften the seed coat for early germination.

Planting Procedure

Fifty-four (54) polythene bags were acquired and filled with top soil (sandy loam), viable seeds were sown at the rate of 3 seeds per pot. Seeds were watered until germination and thinned down to one seedling per poly pot with 6 replicates in each sample.

Data Collection

Morphological parameters such as seedling height, number of leaves, leaf area and stem collar diameter were taken fortnightly (every two weeks) from three (3) months. At the end of 12 weeks, seedlings physiological variable such as fresh weight, dry weight, fresh shoot weight, fresh root weight, dry shoot weight, dry root weight, root to shoot ratio, Absolute Growth Rate and Relative Growth Rate were determined.

Root to shoot ratio, relative and absolute growth were calculated using,

$$\text{Root to shoot weight ratio} = \frac{Root\ weight}{shoot\ weight}$$

$$\text{Absolute growth rate} = \frac{W2-W1}{t2-t1}$$

$$\text{Relative growth rate} = \frac{\ln(w2)-\ln(w1)}{t2-t1}$$

Experimental Design and Statistical Analysis

The experiment was laid in a 3 x 3 Factorial in a Completely Randomized Design (CRD). Collected data was subjected to Analysis of Variance (ANOVA) and significant means were separated using Fisher's Least Significant Difference (LSD) in SAS.

RESULTS

Effect of Seed Source on Morphological Parameters of *A. occidentale Seedlings*

The source of seed had significant effect ($p<0.05$) on the height of *A. occidentale* seedlings. Seeds collected from Funaab location had the highest mean height (26.87cm) while the least effect (23.11cm) was recorded in seeds collected from Obantoko. However, seed location had no significant effect ($p>0.05$) no. of leaves, leaf area and collar diameter (Table 1)

Table 1: Effect of Seed Source on the Morphological Parameters of *A. occidentale* Seedlings

Source	Height (cm)	No Of Leaves	Leaf Area (cm^2)	Collar Diameter (mm)
S1	26.87 [a]	9.89 [a]	74.91 [a]	4.92 [a]
S2	25.72 [a]	9.41 [a]	77.39 [a]	5.19 [a]
S3	23.11 [b]	10.24 [a]	68.36 [a]	4.86 [a]

Means values with the same subscripts in each column are not significantly different ($p>0.05$).
S1: Funaab seed source; S2: Camp seed source; S3: Obantoko seed source

Effect of Seed Source On Physiological Parameters of *A. occidentale Seedlings*

The effect of seed source on of *A. occidentale* was significantly ($p<0.05$) different on the physiological variables measured. Seeds sourced from Camp had the highest significant effect ($p<0.05$) on Total Dry weight (5.95g), Dry Shoot Weight (4.81g), Absolute Growth Rate (0.60g). Fresh Root Weight (4.87g) recorded the highest effect in seeds sourced from Funaab. Least significant effect in seedlings Total Dry weight (4.28g), Dry Shoot Weight (3.40g), Absolute Growth Rate (0.39g) and Fresh Root Weight (16.43g) were observed in seeds sourced from Obantoko (Table 2)

Table 2: Effect of Seed Source on the Physiological Parameters of *A. occidentale* Seedlings

Source	Total Fresh Weight	Total Dry Weight	Fresh Shoot Weight	Fresh Root Weight	Dry Shoot Weight	Dry Root Weight	Root to Shoot Ration	Absolute Growth rate	Relative Growth rate
S1	21.27[a]	5.63[a]	16.40[a]	4.87[a]	4.73[a]	0.90[a]	0.19[a]	0.53[a]	0.18[a]
S2	18.38[a]	5.95[a]	14.73[a]	3.65[b]	4.81[a]	1.14[a]	0.27[a]	0.60[a]	0.20[a]
S3	16.43[a]	4.28[b]	13.25[a]	3.18[b]	3.40[b]	0.88[a]	0.29[a]	0.39[b]	0.16[a]

Means values with the same subscripts in each column are not significantly different (p>0.05).
S1: Funaab seed source; S2: Camp seed source; S3: Obantoko seed source

Effect of Seed Size on Morphological Parameters of *A. occidentale Seedlings*

The size of seeds had significant effect of the morphological parameters of *A. occidentale* seedlings. Large and medium sized seeds had the highest mean seedling height of 26.39cm and 25.91cm respectively. Seedling leafiness (10.82), leaf area (82.27cm^2) and collar diameter (5.20mm) were highest in large sized seeds. Seedlings raised from small seeds had the least significant effect on seedling height (23.40cm), number of leaves (9.28), leaf area (66.60 cm^2) and collar diameter (4.80mm) (Table 3).

Table 3: Effect of Seed Size on the Morphological Parameters of *A. occidentale* Seedlings

Size	Height (cm)	No Of Leaves	Leaf Area (cm^2)	Collar Diameter (mm)
F1	25.91[a]	10.82[a]	82.27[a]	5.20[a]
F2	26.39[a]	9.44[b]	71.78[b]	4.98 ab
F3	23.40[b]	9.28[b]	66.60[b]	4.80[b]

Means values with the same subscripts in each column are not significantly different (p>0.05).
F1: Large seed size; F2: Medium seed size; F3: Small seed size

Effect of Seed Size on Physiological Parameters of *A. Occidentale* Seedlings

Large size seed has the highest significant effect (p<0.05) on some physiological variables. Seedling fresh weight (22.72g), dry weight (6.26g), fresh shoot weight (18.22g), dry shoot weight (5.09g), while medium sized seeds produced the highest root to shoot ratio (0.28). Small sized seeds had the least significant effect on fresh weight (15.52g), dry weight (4.76g), fresh shoot weight (12.21g), dry shoot weight (3.92g) (Table 4).

Table 4: Effect of Seed Size on the Physiological Parameters of *A. occidentale* Seedlings

Size	Total Fresh Weight	Total Dry Weight	Fresh Shoot Weight	Fresh Root Weight	Dry Shoot Weight	Dry Root Weight	Root to Shoot Ration	Absolute Growth rate	Relative Growth rate
F1	22.72[a]	6.26[a]	18.22[a]	4.50[a]	5.09[a]	1.16[a]	0.23[a]	0.60[a]	0.18[a]
F2	17.84[b]	4.85[b]	13.95[b]	3.89[a]	3.93[b]	0.92[a]	0.28[a]	0.47[a]	0.19[a]
F3	15.52[b]	4.76[b]	12.21[b]	3.31[a]	3.92[b]	0.84[a]	0.24[a]	0.45[a]	0.17[a]

Means values with the same subscripts in each column are not significantly different (p>0.05).
F1: Large seed size; F2: Medium seed size; F3: Small seed size

Interaction of Seed Size and Source on the Morphological Parameters of *A. Occidentale* Seedlings

The study showed that there was no significant difference (p>0.05) in the combined effect of seed size and source on the morphological parameters *A. occidentale*. Result indicates that S1F2 and S2F1 had the highest mean height (27.76cm and 27.30cm) respectively. S2F1 and S3F1 had the highest mean number of leaves (10.80 and 11.22 respectively). S2F1 had the highest mean leaf area (91.05cm^2) and collar diameter (5.43mm) compared to other size source interacted seeds (Table 5).

Table 5: Interaction of Seed Size and Source on the Morphological Parameters of *A. occidentale* Seedlings

Size* Source	Height (cm)	No Of Leaves	Leaf Area (cm^2)	Collar Diameter (mm)
S1F1	26.53[a]	10.44[a]	80.64[a]	5.24[a]
S1F2	27.76[a]	9.16[a]	74.17[a]	4.84[a]
S1F3	26.32[a]	10.08[a]	69.91[a]	4.70[a]
S2F1	27.30[a]	10.80[a]	91.05[a]	5.43[a]
S2F2	26.45[a]	8.97[a]	72.75[a]	5.17[a]
S2F3	23.40[a]	8.47[a]	68.36[a]	4.98[a]
S3F1	23.9[a]	11.22[a]	75.11[a]	4.94[a]
S3F2	24.95[a]	10.19[a]	68.42[a]	4.93[a]
S3F3	20.50[a]	9.30[a]	61.54[a]	4.72[a]

Means values with the same subscripts in each column are not significantly different (p>0.05).
S1F1: Funaab large seed; S1F2: Funaab medium seed; S1F3: Funaab small seed;
S2F1: Camp large seed; S2F2: Camp medium seed; S2F3: Camp small seed;
S3F1: Obantoko large seed; S3F2: Obantoko medium sized seed; S3F3: Obantoko small seed

Interaction of Seed Size and Source on the Physiological Parameters of *A. occidentale* Seedlings

The study shows that there was no significant difference (p>0.05) in the combined effect of seed size and seed source on the physiological parameters of *A. occidentale* seedlings. Yet, S2F1 had the highest effect on seedling fresh weight (26.62g), dry weight (7.05g), fresh shoot weight (21.85g), dry shoot weight (5.56g), dry root weight (1.48g), absolute growth rate(0.70g/week) and relative growth rate (0.20g/g/week) (Table 6).

Table 6: Interaction of Seed Size and Source on the Physiological Parameters of *A. occidentale* Seedlings

Size* Source	Fresh Weight	Dry Weight	Fresh Shoot Weight	Fresh Root Weight	Dry Shoot Weight	Dry Root Weight	Root to Shoot Ration	Absolute Growth rate	Relative Growth rate
S1F1	24.29[a]	6.36 [a]	19.15 [a]	5.13 [a]	5.32 [a]	1.04 [a]	0.19 [a]	0.59 [a]	0.16 [a]
S1F2	21.33 [a]	4.99 [a]	15.81 [a]	5.51 [a]	4.07 [a]	0.92 [a]	0.24 [a]	0.47 [a]	0.19 [a]
S1F3	18.19 [a]	5.549 [a]	14.22[a]	3.96 [a]	4.81 [a]	0.73 [a]	0.15 [a]	0.54 [a]	0.19 [a]
S2F1	26.62 [a]	7.051 [a]	21.85 [a]	4.77 [a]	5.56 [a]	1.48 [a]	0.30 [a]	0.70 [a]	0.20 [a]
S2F2	14.44 [a]	5.60 [a]	11.49 [a]	2.95 [a]	4.76 [a]	0.83 [a]	0.17 [a]	0.58 [a]	0.23 [a]
S2F3	14.07 [a]	5.22 [a]	10.84 [a]	3.23 [a]	4.10 [a]	1.12 [a]	0.34 [a]	0.51 [a]	0.17 [a]
S3F1	17.25 [a]	5.36 [a]	13.64 [a]	3.60 [a]	4.38 [a]	0.97 [a]	0.22 [a]	0.52 [a]	0.18 [a]
S3F2	17.75 [a]	3.97 [a]	14.54 [a]	3.20 [a]	2.96 [a]	1.00 [a]	0.42 [a]	0.36 [a]	0.15 [a]
S3F3	17.75 [a]	3.53 [a]	11.56 [a]	2.74 [a]	2.86 [a]	0.67 [a]	0.24 [a]	0.31 [a]	0.15 [a]

Means values with the same subscripts in each column are not significantly different (p>0.05).
S1F1: Funaab large seed; S1F2: Funaab medium seed; S1F3: Funaab small seed;
S2F1: Camp large seed; S2F2: Camp medium seed; S2F3: Camp small seed;
S3F1: Obantoko large seed; S3F2: Obantoko medium sized seed; S3F3: Obantoko small seed

DISCUSSION

The study showed the importance of seed size on the morphological growth and Biomass production of *A. occidentale* seedlings. Large seeds influenced the seedling height, foliage, leaf area and stem collar diameter. This observation correlates with the findings of Aderounmu *et al.* (2019), Fredrick *et al.* (2020) and Aderounmu *et al.* (2020) who reported the direct association between seed sizes and growth rate of *Afzelia africana, Dennettia tripetala* and *Anacardium occidentale* respectively. Singh *et al.* (2021) also reported that larger seeds enhanced more growth in shoot length, collar diameter and root length in some forest tree species. Furthermore, Owoh *et al.,* (2011) and Mtambalika *et al.,* (2014) observed highest growth rate in large seeds compared to medium and small seed sizes in *Terminalia irvorensis, Gmelina arborea* and *Afzelia quanzensis* respectively. Uniyal *et al.* (2007) observed similar growth trend in the growth of shoot and root length of *Azadirachta indica* seedlings. Significant increase in height, number of leaves, leaf area and collar diameter observed in large seed size could be attributed to the availability of more food reserves in large seeds (Owoh *et al.,* 2011).

Results from this study revealed that there were significant differences in biomass accumulation (fresh weight, dry weight, fresh shoot weight, and dry root weight) among seed sizes with large sized seed accumulating the highest biomass. Similar to the findings of Owoh *et al*. (2011), significantly higher differences were observed in biomass production in large seed size compared with medium seeds and small seeds. According to He *et al.* (2007) and Cicek and Tilki (2007), larger seeds accounted for a significant increase in biomass production of *Ligularia virgaurea* and *Saraca asoca* respectively. This significant difference is higher in larger seeds than in medium and small size seeds. (Mirgal *et al*., 2016) and Zareian *et al*., (2013) concluded higher seedling dry weight observed in larger seeds sizes are related to more seed food storages in their endosperms. The availability of these food reserves will give younger seedlings a vigorous start in early growth and development due to the availability of sufficient nutrients.

Seed source significantly influenced the early growth of *A. occidentale*. Seeds sourced from Funaab and Camp produced the highest seedling height compared seeds sourced from Obantoko. However, source effect was not significantly different from each other. There is similarity with observed growth rate in *Heinsia crinita* with no significant variation in the effect of source on collar diameter and number of leaves, and root weight of (Aigbe *et al*., 2016). The variation of the effects could be due to soil, slope, environmental factor, genotype of the parent tree or longitude of the seed source.

Seed source significantly affected the biomass of *A. occidentale* seedlings. Seedlings Dry weight, Fresh root weight, Dry shoot weight and Absolute growth rate were significantly increased in seeds obtained from Funaab. The variation in biomass from this study may be due to microclimate differences among the seed sources (Das, 2014). The variability between sources of seeds could be as a result genetic variation (Bischoff *et al.,* 2010). These genetic variations may contribute to the superior performance (Gallagher & Wagenius, 2015) of the seeds sourced from Funaab. Further buttress by Gallagher and Wagenius (2015) showed that some variation in seedling performance seed provenances may also be inferred to non-genetic effects resulting from differences in parental environmental conditions.

The result showed that there was no significant influence of the combined effect of seed size and source on all growth parameters measured. This may infer that the growth and development of *A. occidentale* would be affected irrespective of the size or source of collection.

CONCLUSION

The study showed that seed size and source is a crucial seed quality trait which influences growth, development and early maturity of *Anacardium occidentale* seedlings.

REFERENCES

Abu-Reidah, I.M., Ali-Shtayeh, M.S., Jamous, R.M., Arraez-Roman, D. and SeguraCarretero, A., 2015. Screening of Bioactive Components from *Rhus coriaria* L. (Sumac) Fruits. *Food Chem*. 166:179-191.

Adebisi, M.A., Kehinde, T.O., Ajala, M.O., Olowu, E.F and Rasaki, S. (2011). Assessment of seed quality and potential longevity in elite tropical soybean (*Glycine max* L.) Merrill grown in Southwestern Nigeria. *Niger. Agric. J*. 42:94-103.

Adeigbe, O.O., Olasupo, F.O.., Adewale B.D. and Muyiwa, A. A. (2015). A review on cashew research and production in Nigeria in the last four decades. *Scientific Research and Essays* Vol. 10(5): 196-209

Aderounmu, A.F., Asinwa, I.O., Adetunji, A. O., (2019). Effects of Seed Weights and Sowing Media on Germination and Early Growth of *Afzelia africana* Smith ex Pers. *Journal of Agriculture and Ecology Research International*, 19(3):1-11

Aderounmu, A.F., Ogidan, O.A., Adams, B.A., Adeniran, T. (2020). Silvicultural Implications of Seed Size On Germination and Early Growth of Cashew (*Anacardium Occidentale* L.). *Ethiopian Journal of Environmental Studies and Management* 13(2): 253 – 260

Aigbe, H.I., Fredrick, C., Omokhua, G.E. (2016). Effect of Seed Source on Germination and Early Seedling Growth of *Heinsia crinita* (Afzel.) *Applied Tropical Agriculture* Volume 21, No. 3, 180-185.

Allen, K. G., Klevay, L.M. and Springer, H.L. (1977). The zinc and copper content of seeds and nuts. *Nutr Rep Int*. 16:227-230

Ambika, S., Manonmani, V. and Somasundaram, G. (2014). Effect of Seed Size Vigour and Seed Yield. *Research Journal of Seed Science* 7(2):31-38

Bentley, S., J. B. Whittacker, and Malloch, A. J. C. (1980). Field experiments on the effects of grazing by a chrysomelid beetle (*Gastrophysa Viridula*) on seed production and quality in *Rumex obtusifolius* and *Rumex crispus. Journal of Ecology* 68: 671-674.

Bes-Rastrollo, M., Sabaté, J., Gomez-Gracia, E., Alonso, A., Martinez, J.A. and Martinez-Gonzalez, M.A. (2007). Nut consumption and weight gain in a Mediterranean cohort: the SUN study. *Obesity* 15(1): 107-107.

Cardoso, B. R., Duarte, G. B. S., Reis, B. Z. and Cozzolino, S. M. F. (2017). Brazil nuts: Nutritional composition, health benefits and safety aspects. *Food Research International* 100(2): 9-18.

Cicek, E and Tilki, F. (2007). Seed size effects on germination, survival and seedling growth of *Castanea sativa* Mill. *Journal of Biological Sciences*. 7: 438-441.

Das, N. (2014). The Effect of Seed Sources Variation and Presowing Treatments on the Seed germination of Acacia catechu Elaeocarpus floribundus Species in Bangladesh. *International Journal of Forestry Research* Volume 2014, Article ID 984194, 8 pages. http://dx.doi.org/10.1155/2014/984194

Davis, C. D. (2003). Low dietary copper increases fecal free radical production, fecal water alkaline phosphatase activity and cytotoxicity in healthy men. *The Journal of nutrition* 133(2): 522-527.

Dendena, B. and Corsi, S. (2014). Cashew, from seed to market: a review. *Agronomy for sustainable development* 34(4): 753-772.

Fraser, G. E. (1994). Diet and coronary heart disease: beyond dietary fats and low density-lipoprotein cholesterol. *The American journal of clinical nutrition* 59(5): 1117S-1123S.

Fredrick Charity, Chima, U.D., Jimmy, A.O., (2021). Effect of Seed Size on Germination and Early Seedling Growth of *Dennettia tripetala* (G. Baker). *PAT* 16. 94-103.

Gallagher, M.K. and Wagenius, S. (2015). Seed source impacts germination and early establishment of dominant grasses in prairie restoration. *Journal of Applied Ecology* Vol. 53(1): 251-263

Gross, K.L. and Soule, J.D. (1981). Differences in biomass allocation to reproductive and vegetative structures of male and female plants of a dioecious perenial herb, Silene alba. *American Journal of Botany* 68: 801 - 807.

Harper, J.L., (1997). The Population Biology of Plants. Academic Press, London.

He,Y.,Wang, M.,Wen,S.,Zhang, Y., Ma, T and Du, G.(2007). Seed size effect on seedling growth under different light conditions in the clonal herb *Ligularia virgaurea* in Qinghai Tibet Plateau.*Acta Ecologica Sinica*. 27(8): 3091-3108.

Holm, S.O. (1994). Reproductive patterns of *Betula pendula* and *B. pubescens* coll. along a regional altitudinal gradient in northern Sweden. *Ecography*, 17: 60-72.

Hu, F. B., Manson, J. E. and Willet, W.C. (2001). Types of dietary fat and risk of coronary heart disease: a critical review. *Journal of the American college of Nutrition* 20(1): 5-19.

Humara, J.M., Lopez, M., Csares, A. and Majada, J. (2000). Temperature and provenance as two factors affecting *Eucalyptus nitens* seed germination. *Forestry*, **73**: 87-90.

Layokun, S.K., Obawole, A.B., Fatile, I.A. and Bamidele, S. (2006). Investigation of cashew apple juice as a substrate for single cell protein production. *Journal of Food science* 51(1): 237-238.

Maia, J.G.S., Andrade, E.H.A. and Zoghbi, M.D.G.B. (2000). Volatile constituents of the leaves, fruits and flowers of cashew (Anacardium occidentale L.). *Journal of food composition and analysis* 13(3): 227-232

Martínez González, I., Sanchez-Velazquez, L.R., Ruiz-Guerra, B., del Rosario Pineda-Lopez, M. and Velazquez-Rosas, N. (2021). The role of seed size in the emergence and survival of seedlings in contrasting environments: The case of *Ceiba aesculifolia*. *New Forests* 52: 493–507.

Mirgal, A.B., Gunago, R.P and Salunkhe, C.B. (2016). Seed size and its influence on germination, seedling growth and biomass in *Saraca asoca* Roxb. De Wilde, critically endangered tree species of Western ghats, India. *Journal of Applied and Natural Science*. 8 (3):1599-1602.

Mtam Mtambalika, K., Munthali C., Gondwe, D. and Missanjo E. (2014). Effect of seed size of a*fzelia quanzensis* on germination and seedling growth. *International Journal of Forestry Research*. 2014 Vol (2014) http://dx.doi.org/10.1155/2014/384565.

Odunsi, A. (2002). Effect of feeding reject cashew kernel meal on pre and early-laying performance of pullet."*Archivos de Zootecnia* 51(196): 423-429.

Oliveira, N. F., Leal, R.S. and Dantas, T.N.C. (2015). The importance of the cashew nut (*Anacardium occidentale* L.) coat: a review. *American International Journal of Contemporary Scientific Research* 2(8): 09-41.

Orwa C, A Mutua, Kindt R , Jamnadass R, S Anthony. (2009) Agroforestree Database: a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp)

Owoh, P. W., Offiong, M. O., Udofia, S. I. and Ekanem, V. U. (2011). Effects of Seed Size on Germination and Early Morphorlogical and Physiological Characteristics of G*melina Arborea*, Roxb. International *Multidisciplinary Journal* Vo. 5(6): *422-433*

Pandey, R., Bagali, K. and Bargali, S. S. (2017) Does seed size affect water stress tolerance in Quercus leucotrichophora A. Camus at germination and early seedling growth stage*? Biodiver. Int. J.* 1: 24–30.

Sanderson, M.A., Skinner, R.H. and Elwinger, G.F. (2002). Seedling Development and Field Performance of Prairie grass, Grazing Brome grass, and Orchard grass. *Crop Science* 42: 224-230.

Shahi, C., Vibhuti, Bargali, K. and Bargali, S.S. (2015). How Seed Size and Water Stress Effect the Seed Germination and Seedling Growth in Wheat Varieties? *Current Agriculture Research Journal* Vol. 3(1):60-68.

Singh. M.K., Singh, F., Meharchand and Kumar, N. (2021): Effect of Seed Size on Germination and Seedlings Growth of Some Forest Tree Species. *International Journal of Current Microbiology and Applied Sciences Vol. 10(01): 2184-2189*

Takuathing C. N. Pipatwattanakul D., Behumibhamon S. (2012). Provenance variation in seed Morphomeric Traits and Growth performance of *Senna siamea* (Lam) Erwin Etbarreby at Lad. Kasetsart *Journal of Nat. science*, 46: 394-407.

Uniyal, A.K., Singh, B and Todaria, N.P (2007). Effects of seed size, sowing orientation and depth on germination and seedling growth in Neem, *Azadirachta indica*. *Seed Technology*.29: 68-75.

Venable, D.L. and Brown, J.S. (1988). The selective interactions of dispersal, dormancy and seed size as adaptations for reducing risk in variable environments. *American Naturalist*.130:370-398.

Zareian, A., Hamidi, A., Sadeghi, H. and Jazaeri, M.R. (2013). Effect of Seed Size on Some Germination Characteristics, Seedling Emergence Percentage and Yield of Three Wheat (*Triticum aestivum* L.) Cultivars in Laboratory and Field. *Middle-East Journal of Scientific Research*, 13(8): 1126-1131

Zarqa, I., Muhammad, A., Muhammad, M. S., Marium, A., Muhammad, D., Aamir, S., Muhammad, T. K., Hina, A., Fahad, S. and Muhammad, R. (2021). Medicinal Uses of Cashew (*Anacardium occidentale*): Review. *Journal of Science Technology and Research* Vol.2(1): 1-9