PRINT ISSN 1119-8362
Electronic ISSN 2659-1502

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 26 (11) 1765-1770 November 2022

Breaking Seed Dormancy of *Prosopis africana* Seeds and its Effects on Seedlings Growth under Two Different Savanna Soils Conditions

***OYEBAMIJI, NA; ADELANI, DO; OJEKUNLE, OO**

*[1]*Department of Forestry and Wildlife Management, Federal University Dutsin-Ma, Nigeria*
[2]*Department of Forestry, Federal College of Forestry Mechanisation, Nigeria*
[3]*Department of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta, Nigeria*

**Corresponding Author Email: noahoye06@gmail.com*
Co-Authors Email: adelani.olusegun@yahoo.com; ojekunleo@funaab.edu.ng

ABSTRACT: Forest trees across the tropics can be effectively domesticated and conserved for afforestation programmes after successful overcoming by breaking the dormancy of their seed coats. The study was conducted at Forest Nursery Unit of Federal University Dutsin-Ma to assess the breaking dormancy of *Prosopis africana* seeds and its effects on seedlings growth under two different savanna soils conditions. A 2x5 factorial in Randomized Complete Block Design was used for this experiment in four replicates. The factors were savannah soils locations; (ZA: Zaria soil and DS: Dutsin-ma soil) and pre-sowing treatments; Seeds soaked in 60% diluted Tetraoxosulphate (VI) acid (H_2SO_4) (A); seeds soaked in hot water at 100^0C (HW); seeds soaked in water for 24 hours (W); mechanical scarification (MS); control (C). The data were analyzed using analysis of variance at (P=.05). Zaria soil had significantly higher values (8.55cm, 12.65cm and 17.65cm, 0.15cm and 0.17cm, and 262.05, and 0.12) on seedling heights (SH) at 4-8 weeks after sowing (WAS), collar diameters (CD) at 4-6 WAS, and leaflet areas (LA) at 4 WAS respectively. Mechanically scarified seeds (MS) had consistent significantly higher values (6.54cm, 13.79cm, 19.90cm, 25.13cm and 29.15cm, 0.15cm, 0.19cm, 0.21cm, 0.25cm and 0.29cm, and 0.14, 0.16, 0.19, 0.20 and 0.23) on SH, CD, and LA at 2-10 WAS respectively. It is concluded that seeds sowed in Zaria soil performed better than Dutsin-ma soil, while, mechanical scarification was the best pre-sowing treatment for improved seedlings growth of *P. africana* seeds.

DOI: **https://dx.doi.org/10.4314/jasem.v26i11.5**

Cite this paper as: OYEBAMIJI, N. A; ADELANI, D. O; OJEKUNLE, O. O (2022). Breaking Seed Dormancy of *Prosopis africana* Seeds and its Effects on Seedlings Growth under Two Different Savanna Soils Conditions. *J. Appl. Sci. Environ. Manage.* 26 (11) 1765-1770

Keywords: Seeds dormancy; pre-sowing techniques; savannah soils; growth parameters

Nigeria savanna soils are low in organic carbon, total nitrogen, available phosphorus, effective cation exchange capacity (CEC) and exchangeable cations plus clay and silt contents. The low fertility status of savanna soils in Nigeria makes crop production fertilizers dependent (Adesoji *et al.*, 2020). *Prosopis africana* also known as iron tree and indigenous to tropical Africa. The tree is mostly growing in the savanna regions of western Africa. It has the height between 4-20 m (Fasidi *et al.*, 2000). *P. africana* has vast social, economic, cultural, medicinal and agricultural values. Its fruits are edible, and highly priced food for condiment or seasoning, rich in protein, fatty acids and other vital nutrients and minerals (Ayanwuyi *et al.*, 2010; Amusa *et al.*, 2010). The rich values of the tree make its value relevant to foresters. Though, its seed coat is hard (exhibiting dormancy), hence, the seeds have to be pre-treated so as to appreciate its germination richness. Seed germination is a crucial process in the plant growth and development (Oyebamiji *et al.*, 2014). Seeds of *P. africana* like most of the leguminous plants possess a hard seed coats, which hamper water imbibition, gaseous exchange and harbors inhibitors to suppress seed germination, which is referred to as dormancy (Mwase and Mvula, 2011). The dormancy in seed could be considered simply as a block to the completion of germination of an intact or viable seed under favourable condition (Finch-Savage and Leubner-Metzger, 2006). Such barriers are commonly eliminated through a number of scarification methods, which include the use of Tetraoxosulphate (VI) acid and steeping in hot water as described by (Azad *et al.*, 2011). The importance of various forest trees suitable for agroforestry cannot be overstressed, but the increase demand of some of these trees has made them not to be accessed easily due to hard seed coats of the seeds that prevent germination (Okwu *et al.*, 2004). Seed germination is a vital stage in plant development and can be considered as a determinant for plant

**Corresponding Author Email: noahoye06@gmail.com*

productivity (Vickery *et al*., 2007). In order to sustain a good seedling development, hence, seed stores a food reserve mainly as proteins, lipids and carbohydrates. Protein and oil bodies are the major reserve in oil seed which represents a source for each of energy, carbon and nitrogen during seedling establishment (Orji *et al*., 2000). As a result of the physiology of reserve mobilization during germination and post-germination events, which are still poorly understood, extensive studies must be performed to know the metabolic mechanisms of reserve food mobilization providing insights into the ability to use such seeds as planting material (Zida *et al*., 2005). Physiological and biochemical changes followed by morphological changes during germination are strongly related to seedling survival rate and vegetative growth which affect yield and quality of the seed (Atiku *et al*., 2013). Some of the methods to overcome physical dormancy of seeds are acid scarification, mechanical scarification and immersion in water (Baskin and Baskin, 2004). Acid scarification and mechanical scarification are costlier and laborious methods as compared to hot or cold water treatments. Different pre-sowing treatments have been used by different researchers to enhance seed germination of different tree species which include; *Faidherbia albida*, *Acacia spp. Terminalia chebula*, *Tetrapleura tetrapetra* and *Adonsania digitata*. However, it is worthy of note to identify the most suitable pre-sowing treatment which will stimulate seed germination and enhance seedling growth of *Prosopis africana* seeds. A dormant seed does not have the capacity to germinate in a specified period of time under any combination of normal physical environmental factors that are otherwise favourable for its germination, that is, after the seed become non-dormant (Baskin and Baskin, 2004). This study aimed at assessing the effectiveness of different soils locations (guinea and derived savanna soils) and to determine best pre-sowing treatment suitable for breaking dormancy of *Prosopis africana* seeds.

MATERIALS AND METHODS

Research area: The experiment was carried out in the nursery unit of the Department of Forestry and Wildlife Management, Federal University Dutsin-Ma, Katsina State, Nigeria. The area lies between latitude 12º28'18.3''N and longitude 07º29'15.4''E with an annual rainfall of 700mm, which is spread from May to September.

The mean annual temperatures range from 29-31ºC; the high temperature normally occurs in April/ May and the lowest in December through February. The vegetation of the area is the Sudan savannah (Tukur and Kan, 2013; Oyebamiji *et al.,* 2018).

Soil sample collections and analysis: Soil sample collections from the depth of 0-30cm which were randomly taken in each location were analyzed as described below. Soil pH was determined in 0.01M $CaCl_2$ by using a soil 2 solution ratio of 1: 2.5 by means of a Philip analogue pH meter. The soil was determined using the pH meter (Black, 1965). The organic carbon content of soil was determined by the wet oxidation method of Walkley-Black as described by Allison (1965). The total nitrogen content of the soil was determined by Micro Kjeldahl procedure Bremner (1965). Available phosphorus (P) was extracted by the Bray 1 method. The P concentration in the extract was determined colorimetrically by using the Spectronic 20 and absorption was read-off as described by Bray and Kurtz (1945) and modified by Murphy and Riley (1962).

Experimentation and design: The experimental materials include: agricultural top soils, acid of 60% diluted Tetraoxosulphate (VI) acid (H_2SO_4) solution, soaking in water at room temperature for 24 hours, hot water at 100°C boiling point, watering can, germination polythene tubes (32cm x 40cm), sand paper (emery cloth), thermometer, seeds, watering etc. The soil was collected and a total of eighty (80) polythene tubes were filled with the top soil. Seeds of *P. africana* were procured from Federal College of Forestry and Mechanization, Afaka, Kaduna State. The viability test was carried out before experimentation using simple floating method following the procedure of Agbogidi *et al.* (2007). The seeds were dropped in a beaker containing water. The seeds that floated indicated that they were not viable. Such seeds were removed and replaced. A total of 40 viable seeds were used in each of the treatments to make the total of 160 seeds. Experiment was then laid out as 2x5 factorial in a Randomized Completely Block Design (RCBD) in four replicates with soil locations and pre-sowing treatments as factors (Table1).

Data collection: The data were taken at interval of two (2) weeks after sowing (WAS) to assess different parameters which include the following; seedling heights, collar diameters, total number of leaves and leaflet area and were accordingly measured.

The seedling heights (SH) from each pot were measured from the root collar to the tip of the terminal shoot using ruler in (cm).

The collar diameters (CD) from each pot were measured at 2cm above the root collar using a digital vernier caliper (6'-150mm) in (cm).

Leaflet areas (LA) was obtained by linear measurement of leaflet length (L) and leaflet width (W) as described by Clifton-Brown and Lewandowski (2000).

$$LA = 0.74 \times L \times W$$

Table 1: Dormant seeds of *Prosopis africana* subjected to pre-sowing treatments and sown in different soil locations

Treatments	Description
DS	Dutsin-ma soil (Sudan savanna soil)
ZS	Zaria soil (Guinea savanna soil)
A	Seeds soaked in 60% diluted Tetraoxosulphate (VI) acid (H_2SO_4) for 5 minutes
HW	Seeds soaked in hot water at 100º C boiling point
S	Seeds soaked in water at room temperature for 24 hours
MS	Seeds mechanically scarified at the micropyle
C	No seeds treatment (Control)

Statistical analysis: The data were analysed using analysis of variance (ANOVA) Analysis of Variance with the Statistical Analysis System (SAS, 2015) computer package at 5% level of significant to determine difference in the treatments effect, while, the means of differences among the treatments were separated using Fisher's Least Significant Difference (F-LSD; $P \leq 0.05$).

RESULTS AND DISCUSSION

The soil physical and chemical properties of Zaria and Dutsin-ma soils before the experiment: Zaria soil had physical and chemical properties which were analyzed and had particle size 620g/kg sand, 260g/kg silt and 120g/kg clay belonging to the textural class sandy loam. The soil had 6.47 pH in water (H_2O), 5.30 pH in salt (0.01M $CaCl_2$), 5.20g/kg organic carbon, and 0.70g/kg total nitrogen and 4.15mg/kg available phosphorus.

Table 2: Soil physical and chemical properties of the study areas

Soil properties	Zaria soil	Dutsin-ma soil
Particle Size (g/kg)		
Sand	620	660
Silt	260	240
Clay	120	100
Textural class	Sandy loam	Sandy loam
Chemical Properties		
pH in water (H_2O)	6.47	7.10
pH in salt ($CaCl_2$)	5.30	6.20
Organic carbon (g/kg)	5.20	2.80
Total nitrogen (g/kg)	0.70	0.42
Available phosphorus (mg/kg)	4.15	1.85

K: Potassium, Ca: Calcium, Mg: Magnesium, Na: Sodium

However, Dutsin-ma soil had particle size 660g/kg sand, 240g/kg silt and 100g/kg clay belonging to the textural class sandy loam. The soil had 7.10 pH in water (H_2O), 6.20 pH in salt (0.01M $CaCl_2$), 2.80g/kg organic carbon, 0.42g/kg total nitrogen and 1.85mg/kg, available phosphorus. The soils belong to the textural class sandy loam and alkaline with pH, the soil in Zaria location experienced higher content of organic carbon and available phosphorus in comparison as observed by Oyebamiji *et al.* (2017) (Table 2).

Seedling heights (cm): There was significant effect of soil locations and pre-sowing treatments on seedling heights of *P. africana* at 2-10 WAS. Zaria soil had significantly higher values (8.55cm, 12.65cm and 17.65cm) on seedling heights at 4-8 WAS. However, there was no significant effect of soil locations on seedling heights at 2 and 10 WAS. Meanwhile, mechanically scarified seeds had consistent significantly higher values (6.54cm, 13.79cm, 19.90cm, 25.13cm and 29.15cm) on seedling heights across the period of the experiment (2-10 WAS) (Table 3). The significant effect observed in Zaria soil location on seedling heights was as a result of high organic carbon, total nitrogen and available phosphorus contents than Dutsin-ma soil as noted by Oyebamiji *et al.* (2017). The brilliant effect of mechanically scarification of seeds for successful seedlings growth is in line with the report of Tomlinson *et al.* (2000) who said seed dormancy resulting from an impermeable seed coat may be overcome by peeling off the seed coat through mechanical scarification technique. According to Azad *et al.* (2010), the use of sand paper (emery cloth) is known to break physical dormancy of seeds with hard coats which inhibits water uptake and gases. Missanjo *et al.* (2014) also noted that the use of sand paper for seeds scarification made the seeds experienced easy entry of water and exchange of gases that can result to enzymatic hydrolysis and thus transforming the embryo to transform into seedlings. However, Luna *et al.* (2009) in their report noted that the conditions necessary to allow seeds break dormancy and easily germinate should be critically under studied. Other pre-sowing treatments (hot water, water at room temperature and acid) assessed in this study performed lower in their growth parameters (this means that, these pre-sowing treatments has tendencies to hamper seed embryo, and also detrimental to the seed cotyledon for successful germination of seeds into healthy seedlings) than mechanical scarification treatment.

Collar Diameters (cm): Zaria soil was noted to have significantly higher values (0.15cm and 0.17cm) on collar diameters of *P. africana* at 4-6 WAS. Meanwhile, there was no significant difference between the two soils locations at 2, 8-10 WAS. However, mechanically scarified seeds had consistent significantly higher values (0.15cm, 0.19cm, 0.21cm, 0.25cm and 0.29cm) on collar diameters across the period of the experiment among other treatments (Table 4). The significant effect observed in Zaria soil location on seedlings collar diameters was as a result of high organic carbon, total nitrogen and available phosphorus contents than Dutsin-ma soil as noted by Oyebamiji *et al.* (2017). According to Azad *et al.* (2010), the use of sand paper (emery cloth) is known to break physical dormancy of seeds with hard coats which inhibits water uptake and gases. Missanjo *et al.*

(2014) also noted that the use of sand paper for seeds scarification made the seeds experienced easy entry of water and exchange of gases that can result to enzymatic hydrolysis and thus transforming the embryo to transform into seedlings. Missanjo *et al.* (2014) said fast growth of *Acacia polyacantha* seedlings just like *P. africana* occurred as a result of seeds scarified using sand paper which had an advantage of absorbing much water and also started the photosynthetic activity much faster than others. However, Wang *et al.* (2011) suggested that care has to be taken when using sand paper because it has the tendency to add drawback of wearing out seeds rapidly. Although, seeds soaked hot water, water at room temperature and acid can also give better performance in terms of growth and development based on the nature of species of seeds under investigation. It is however noted that other pre-sowing treatments performed low in comparison with mechanical scarification.

Table 3: Effect of soil locations and pre-sowing treatments on seedling heights at 2-10 WAS

	Seedling heights				
	Weeks after sowing (WAS)				
Treatment	**2**	**4**	**6**	**8**	**10**
Soil Locations					
Zaria	4.27	8.55[a]	12.67[a]	17.65[a]	21.36
Dutsin-ma	4.03	7.57[b]	11.65[b]	16.39[b]	21.35
SE±	1.399	3.300	4.858	5.366	5.606
Pre-Sowing Treatments					
A	4.10[b]	8.46[b]	14.54[b]	19.69[b]	25.15[b]
HW	3.65[b]	7.01[c]	10.53[c]	16.23[c]	20.66[c]
W	3.57[b]	6.44[c]	8.23[c]	13.02[d]	17.34[d]
MS	6.54[a]	13.79[a]	19.90[a]	25.13[a]	29.15[a]
Control	2.91[c]	4.61[d]	7.59[d]	10.97[e]	14.46[e]
SE±	0.568	1.038	1.347	1.635	1.527

*Means followed by the same letters within the same column and treatment are not significantly different at 5 % level of probability using Least Significant Difference (LSD). **SE±**: Standard Error, **A**: Acid, **MS:** Mechanical scarification, **HW:** Hot water, **W:** Water at room temperature.*

Table 4: Effect of soil locations and pre-sowing treatments on collar diameters at 2-10 WAS

	Collar diameters				
	Weeks after sowing (WAS)				
Treatment	**2**	**4**	**6**	**8**	**10**
Soil Locations					
Zaria	0.15	0.15[a]	0.17[a]	0.18	0.22
Dutsin-ma	0.12	0.13[b]	0.15[b]	0.17	0.20
SE±	0.104	0.036	0.040	0.046	0.065
Pre-Sowing Treatments					
A	0.13[ab]	0.17[b]	0.20[a]	0.21[b]	0.24[b]
HW	0.10[ab]	0.14[c]	0.17[b]	0.19[c]	0.20[c]
W	0.11[ab]	0.13[c]	0.15[c]	0.16[d]	0.18[c]
MS	0.15[a]	0.19[a]	0.21[a]	0.25[a]	0.29[a]
Control	0.06[c]	0.10[d]	0.11[d]	0.12[e]	0.13[d]
SE±	0.017	0.019	0.020	0.022	0.028

*Means followed by the same letters within the same column and treatment are not significantly different at 5 % level of probability using Least Significant Difference (LSD). **SE±**: Standard Error, **A**: Acid, **MS:** Mechanical scarification, **HW:** Hot water, **W:** Water at room temperature.*

Leaflet areas: There was significant effect of soil locations and pre-sowing treatments on leaflet areas of *P. africana* at 2-10 WAS. Zaria soil had significantly higher value (0.12) on leaflet areas at 4 WAS. While, there was no significant difference between the two soil locations on leaflet areas at 2 WAS and 6-10 WAS.

However, mechanically scarified seeds had consistent significantly higher values (0.14, 0.16, 0.19, 0.20 and 0.22) on leaflet areas across the period of the experiment other than other treatments (Table 5).

The significant effect observed in Zaria soil location on seedlings leaflet areas was as a result of high organic carbon, total nitrogen and available phosphorus contents than Dutsin-ma soil as noted by Oyebamiji *et al.* (2017). Mwase and Mvula (2011) also revealed that soaking seeds in hot water make the seed coats permeable to water, imbibe and swell as the seeds absorb water. Meanwhile, seeds that stayed in acid for a long time may likely have its embryo destroyed and thereby prevent germination to occur as confirmed by Ariana *et al.* (2011).

The lowest seedlings growth observed in hot water is an indication that hot water treatment is detrimental to the growth of *P. africana* seedlings. Soaking of seeds in acids should also be regulated in order to avoid eating up of the cotyledon which may invariably hamper the germination of seeds. This is equally in alignment with Oyebamiji *et al.* (2019).

The seeds soaked in water at room temperature, hot water and acid performed lower than expectation when compared to mechanical scarification technique.

Table 5: Effect of soil locations and pre-sowing treatments on leaflet areas at 2-10 WAS

	Leaflet areas				
	Weeks after sowing (WAS)				
Treatment	**2**	**4**	**6**	**8**	**10**
Soil Locations					
Zaria	0.10	0.12[a]	0.13	0.14	0.15
Dutsin-ma	0.10	0.10[b]	0.12	0.14	0.14
SE±	0.033	0.034	0.040	0.040	0.045
Pre-Sowing Treatments					
A	0.11[b]	0.12[b]	0.13[b]	0.15[b]	0.16[b]
HW	0.10[cb]	0.12[cb]	0.12[bc]	0.13[cb]	0.14[c]
W	0.09[c]	0.09[cd]	0.11[cd]	0.12[cd]	0.12[dc]
MS	0.14[a]	0.16[a]	0.19[a]	0.20[a]	0.22[a]
Control	0.05[d]	0.08[d]	0.09[d]	0.10[d]	0.11[d]
SE±	0.016	0.011	0.018	0.017	0.019

Means followed by the same letters within the same column and treatment are not significantly different at 5 % level of probability using Least Significant Difference (LSD). ***SE±****: Standard Error,* ***A****: Acid,* ***MS:*** *Mechanical scarification,* ***HW:*** *Hot water,* ***W:*** *Water at room temperature.*

This is possible as a result of imbibition of seeds which could have ruptured the cotyledons or affected the embryo in such a way that rapid and better germination of seeds is poorly affected. The poor growth parameters observed in the control treatment is an indication that seeds of *P. africana* strongly needed pre-sowing treatments before sowing in the nursery in order to enhance its germination, which will in turn promote its seedlings growth.

Conclusions: It is concluded that seeds sowed in Zaria soil performed better than Dutsin-ma soil. The pre-sowing treatment of mechanical scarification among others was significantly enhanced the seedlings growth of *P. africana*. Although, other pre-sowing treatments were very vital, but, mechanical scarification of seeds was concluded to be the best pre-sowing treatment and therefore recommended for improved seedling growth and development of *P. africana* seeds.

Acknowledgments: The authors acknowledge Mr. Ilyasus Banabas for his efforts to collect the field data.

REFERENCES

Adesoji, AG; Oyebamiji, NA; Abubakar, IU (2020). Influence of incorporated lablab planted at various spacings on productivity of maize (*Zea mays* l.) varieties in northern guinea savanna zone of Nigeria. *Fudma J. Sci.* 4(3): 358-365.

Agbogidi, OM; Bosah, BO; Eshegbeyi, OF (2007). Effects of acid pre-treatment on the germination and seedling growth of African Pear (*Dacryodes edulis* Don. G. Lam. H.J.). *Inter. J. Agric. Res*. 2(11): 952-958.

Allison, LE (1965). Organic carbon. In: Black, CA (ed.) Methods of Soil Analysis Part 2. Chemical and Microbiological Properties. *Amer. Soc. Agron*. Madison, Wisconsin. 1376-1378.

Amusa, TO; Jimoh, SO; Aridanzi, P; Haruna, MA (2010). "Ethnobotany and conservation of plant resources of kainji lake national park, Nigeria" .*Ethnobot. Res. Appl.* 8: 181-194.

Ariana, OM; Ojas, R; Re'chiga, A; Aria, K; Guilar, MAA; Jardan, G; Olubov Maria; Andujano, GM (2011). Effect of Gibberellic Acid on germination of seeds of five species of cacti from the chihuahuan desert, Northern Mexico. *The Southwestern Natural.* 56(3):393-400.

Atiku, M; Bello; AG; Alao, JS (2013). Study of some tree characteristics at Tangaza North Forest Reserve in Sokoto State, Nigeria. *Agric. Sci. Res. J.* 3(10): 318-323.

Ayanwuyi, LO; Yaro, AH; Abodunde, OM (2010). Analgesic and anti-inflammatory effects of methanol stem bark extract of *Prosopis africana*. *Pharma. Biol*. 48(3): 296-299.

Azad, MS; Malik, MR; Hassan, MS; Matin, MA (2011). Effect of different pre-sowing treatments on seed germination percentage and growth performance of *Acacia auriculiformis*. *J. Forest. Res.* 22(2): 183-188.

Azad, MS; Paul, NK; Matin, A (2010). Do pre-sowing treatments affect seed germination in *Albizia richardiana* and *Lagerstroemia speciosa*? *Frontiers of Agric. in China.* 4(2): 181-184.

Baskin, CC; Baskin, JM (2004). Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination. Academic Press, San Diego. 29: 11-20.

Black, CA (1965). Methods of Soil Analysis II. Chemical and Microbiological Properties. Madison Wisconsion. American Society of Agronomy.152 p.

Bray, RH; Kurtz, LT (1945). Determination of total organic and available form of P in soil. *Soil Sci.* 59: 39-45.

Bremner, JM (1965). Total nitrogen. In Black, CA (ed.) Methods of Soil Analysis part 2: Chemical and Microbiological Properties. American Society of Agronomy, Madison, Wisconsin. 1149-1178.

Clifton-Brown, JC; Lewandowski, I (2000). Water use efficiency and biomass partitioning of three different Miscanthus genotypes with limited and unlimited water supply. *Annals of Bot.* 86: 191-200.

Luna, T; Wilkinson, K; Dumroese, RK (2009). Seed germination and sowing options. In: Dumroese, RK; Luna, T; Landis, TD (eds) Nursery manual for native plants: A guide for tribal nurseries—Volume 1: Nursery management. Agriculture Handbook, Vol. 730. Department of Agriculture Forest Service, Washington DC, pp 133–151.

Fasidi, IO; Samani, T; Kadiri, M; Agboola, DA (2000). “Dormancy types and water uptake in seeds of *Parkia biglobosa*. *J. Nat. Appl. Sci.* 1: 14-20.

Finch-Savage; Leubner-Metzger (2006). Seed dormancy. Retrieved from http://www.ehow.com from, http://www.ingentaconnect.com.

Missanjo, E; Chioza, A; Kulapani, C (2014). Effects of different pre-treatments to the seed on seedling emergence and growth of *Acacia polyacantha*. *Inter. J. Forest. Res*. doi:10.1155/ 2014/583069

Murphy, J; Riley, JR (1962). A modified single solution method for the determination of P in natural waters. *Annal Chem. Acta*. 27: 31-36.

Mwase, WF; Mvula, T (2011). Effect of seed size and pre-treatment methods of *Bauhinia thonningii* Schum. On germination and seedling growth, *Afr. J. Biotech.* 10(26): 5143-5148.

Okwu, DE; Okwu, ME (2004). Chemical Composition of *Spondia mombin* plants. *J. Sustain. Manage.* 8: 55–58.

Orji, CU (2000). Evaluation of the physical properties of breadfruit seeds (*Treculia africana*) necessary for shelling. *J. Agric. Engineer. Tech*. 8: 55–58.

Oyebamiji, NA; Abdulrahman, HD; Ogor, AA (2019). Improvement of *Parkia* seedling growth using various seed dormancy breaking technologies in different soil media. *World News Nat. Sci*. 22(2019): 139-150.

Oyebamiji, NA; Fadimu, OY; Adedire, MO (2014). Best pre-germination techniques on *Spondias mombin* Linn, seed for plantation establishment. *American-Eurasian J. Agric. Environ. Sci*. 14(6): 575-579.

Oyebamiji, NA; Ogor, AA; Jamala, GY (2018). The effects of pre-germination treatments and soil media on seed germination and seedling growth of Tamarind *(Tamarindus indica* (Linn) in Katsina State, Nigeria. *Tanz. J. Forest. Nat. Cons.* 88(1): 18-28.

Oyebamiji, NA; Jamala, GY; Adesoji, AG (2017). Soil chemical properties as influenced b by incorporated leafy biomass and nitrogen fertilizer in soil with maize (*Zea mays* L.) in a semi-arid environment. *Fudma J. Agric. Agric. Tech.* 3(1): 93-103.

SAS (2015). SAS Institute Inc. SAS/STAT® 14.1 User’s Guide. Cary, NC: SAS Institute Inc.

Tomlinson, H; Ng’andwe, M; Nikiema, A (2000). Field and in vitro methods of propagation of the African locust bean tree (*Parkia biglobosa* (Jacq) (Benth.). *J. Hort. Sci. Biotech*. 75: 42-49.

Tukur, M; Kan, A (2013). Ecological implications of climate change on the genetic diversity and distribution of African locust bean *Parkia biglobosa* in Central Nigeria. IOP Conference series; *Earth Environ. Sci.* 6(37): 20-26.

Vickery, MI; Vickery, B (2007). Plant Product of Tropical Africa, Macmillan International College Edition. Macmillan Press Limited, London.

Wang, YR; He, XQ; Hanson, J; Mariam, YW (2011). Breaking hard seed dormancy in diverse accessions of five wild Vigna species by hot water and mechanical scarification. *Seed Sci. Tech.* 39: 12-20.

Zida, D; Tigabu, M; Sawadogo, L; Oden, PC (2005). Germination requirements of seeds of four woody species from the Sudanian savanna in Burkina Faso, West Africa. *Seed Sci. Tech.* 33: 581-593.