
ISSN:

Print - 2277 - 0755

Online - 2315 - 7453

© FUNAAB 2017

**Journal of
Agricultural
Science
and Environment**

STORABILITY AND PRE-SOWING TREATMENTS OF AFRICAN STAR APPLE (*CHRYSOPHYLLUM ALBIDUM* G. Don) SEEDS

***¹D.O. ADELANI, ²M. A. ADURADOLA AND ³I.O.O. AIYELAGBE**

¹Federal College of Forestry Mechanization, P.M.B 2273, Afaka, Kaduna, Nigeria

^{2,3}Federal University of Agriculture, Abeokuta, P.M.B 2240, Ogun state, Nigeria

***Corresponding Author:** adelani.olusegun@yahoo.com

ABSTRACT

Chrysophyllum albidum is a prominent, indigenous, economic fruit tree species found in compound farm agro-forestry systems. Investigation was conducted to overcome difficulty in germination and storability of *C. albidum* seeds in the forest nursery of Federal University of Agriculture, Abeokuta, Nigeria. The trial employed a 3x3 factorial experiment with three replications laid out in a completely randomized design to determine the effect of seed coat treatments including clipping at 2mm from distal, circumference and micropyle end; dipping in 10% sulphuric acid and no seed coat treatments and durations of seed storage 1, 5 and 9 days on the germination of *C. albidum* seeds. Pre-sowing and storage treatments significantly ($p < 0.05$) affected the germination of seeds. Percentage germination ranged from 17% to 61% for clipping to no seed coat treatment. Highest germination of 61% was recorded for seeds not pre-sowed. The percentage germination ranged from 16% to 60% for seeds stored for nine days to those stored for one day. Highest germination of 60% was recorded for seeds stored for one day. A significant ($p < 0.05$) decrease in percentage germination was recorded with increasing days of storage. The result of interaction effect revealed that highest germination of 86% was recorded for seeds stored for 5days without pre-sowing treatments. Storing of seeds for 5days is recommended for mass production of *C. albidum* seedlings in agro-forestry nursery.

Key words: Clipping, Dipping, length of storage, Sulphuric acid, Indigenous trees species

INTRODUCTION

African star apple or White star apple is a climax tree species of tropical rainforest that belongs to the family Sapotaceae (Wole, 2013., Olaoluwa *et al.*, 2012) which has up to 800 species and make up almost half of the order (Ehiagbonare *et al.*, 2008). The Yoruba name is "Osan Agbalumo" (Rahaman, 2012) while in Igbo and Hausa languages, it is called "Udara" or "Udala" (Wole, 2013) and Agbaluba or Agbaluma respectively. It exists without

regeneration, principally as a volunteer or deliberately protected plant in its natural habitats, villages, backyard gardens and so on from where fruits are collected for direct consumption and marketing. This 'wild fruit' tree species of West and Central Africa (Rahaman, 2012) is equally reported in diverse eco-zones of Cameroon and Cote d'Ivoire (Bada, 1997 and Wole, 2013).

It is cherished by all and sundry, eaten fresh and popular with mature and older people

(Olaoluwa *et al.*, 2012 and Rahaman, 2012) and capable of producing from 14,000 – 15,000 per tree fruits annually (Dike *et al.*, 1997). It is among the forest tree species which is integrated in the traditional agroforestry system (Ureigho and Ekeke, 2010; Laurent *et al.*, 2012) that provide Non Timber Forest Products (NTFPs) of immense domestic importance to rural and urban dwellers in West Africa, with great export potentials (Nwoboshi, 2000). *C. albidum* has been noted to be of great economical (Adebisi, 1997, Oboh *et al.*, 2009, Onyekwelu *et al.*, 2011 and Olaoluwa *et al.*, 2012), nutritional, medicinal (Adisa, 2000 and Onyekwelu and Stimm, 2011) and industrial (Amusa *et al.*, 2003, Olaoluwa *et al.*, 2012, Rahaman, 2012) as well as ecological values (Aduradola *et al.*, 2005).

The centre of widest diversity of *Chrysophyllum* germplasm in Nigeria (Onyekwelu *et al.*, 2011) is the Southern rainforest zone with considerable variations in plant morphology, yield and other agronomic characters (Denton, 1997). This area, which is about 129,500km², represents about 14% of the total land area of Nigeria (Denton, 1997). Ladipo *et al.* (1997) reported that the diversity in *C. albidum* types, adaptability to local environment and resistance to biotic stresses make them potentially useful for crop improvement. Extensive human activities deplete the population of unregenerate *C. albidum* (Onyekwelu *et al.*, 2011) during irreversible conversion of forest areas to other uses.

In spite of enormous benefits of *C. albidum*, it has been greatly neglected particularly with respect to its regeneration. There is dearth of quantified information on the germination and storability requirement of the *C. albidum* seeds for biodiversity conserva-

tion. The *C. albidum* seeds have hard seed coat which is impermeable to water to hasten germination. This characteristic is a major reason for seed dormancy leading to uneven germination which is a major setback in reforestation programmes (Aduradola *et al.*, 2005). In view of this, pre-sowing and storage trials were conducted to assess the germination and storability of *C. albidum* seeds for mass production of its seedlings for agroforestry conservation programmes.

MATERIALS AND METHODS

Study Site

The experimental site was the forestry nursery of the Federal University of Agriculture, Abeokuta, Nigeria. The nursery is located within latitude 7°N and 7°N 55' and longitude 3° 20'E and 3°37'E of the Federal University of Agriculture, Abeokuta. The Federal University of Agriculture, Abeokuta is located within the rain forest zone of South Western Nigeria (Amujoyegbe *et al.*, 2008). It is next to Ogun-Osun River Basin Development Authority (OORBDA), along Osiele-Abeokuta road, off Abeokuta-Ibadan road. It is in the North Eastern end of Abeokuta and lies approximately on latitude 7°30' N and longitude 3°54' E. It lies within the humid lowland rain forest region with two distinctive seasons. The wet season extends from March to October while the dry season extends from November to February (Aiboni, 2001). The rainfall has a characteristic bimodal distribution with peaks in July and September and breaks in August. Generally, the rainfall could be heavy and erosive sometimes accompanied by lightning and thunderstorm at the beginning and the end of rainy season. The mean monthly temperature varies from 22.9°C in August to 36.32°C in March. The relative humidity is high ranging from 75.52°C in February to 88.15°C in July (Aiboni, 2001). The vegetation of the

area comprises of low land forest become secondary rainforests or forest re-growth because of the increase in land use and exposure. The vegetation has the characteristics of tropical rain forest such as high forest and growth of massive trees and twinning shrubs. The forest is covered with liters of fallen trees by both human and natural activities (Ufoegbune and Fabiyi, 2016).

Seed procurement

Sweet variety of average sized 5cm diameter fruits of *C. albidum* were sourced from one mother-tree at Osiele town in Ogun State and transported to the nursery. Freshly extracted 810 randomly seeds were sterilized with 70% ethanol (C₂H₅OH) and 60% sodium hypochlorite for 10 seconds and rinsed with distilled water. The randomly picked samples of the seeds were cut open with chisel to assess the viability through the cutting method (Schmidt, 2000).

Dipping seeds in 10% concentrated H₂SO₄ (VI) acid

Sulphuric acid treatment was carried out to assess the effect of sulphuric acid on germination percentage of *C. albidum* seeds. A factorial experiment with 3 replications laid out in a completely randomized design was used. Thirty seeds represented a replicate. Ninety (90) seeds dipped in 10% concentrated H₂SO₄ (VI) acid for 10 seconds and sown on days 1, 5 and 9 after treatment respectively. Three replicates of seeds on each day were sown in 4cm depth (Adelani, 2015) of potting mixture of 200°C sterilized river sand and 3 days sun dried saw dust. The total weight of potting mixture was 6kg. Seeds watered to pot capacity in 27cm by 22cm poly bag size at 70ml/seed daily. Seeds were kept at 27°C average room temperature before sowing for experimental periods. *C. albidum* seeds started germinat-

ing 30days after sowing. Seed germination was monitored for 60 days after sowing.

Mechanical seed scarification

Mechanical seed scarification of *C. albidum* was carried out using the method of uniform seed coat clipping which involved clipping seeds at 2mm from the micropyle, around seed circumference and 2mm from distal end. A factorial experiment with 3 replicates laid out in a completely randomized design was used. Thirty seeds represented a replicate. Ninety (90) seeds clipped at 2mm from distal end, around seed circumference and 2mm from micropyle end and sown in a potting mixture of sawdust sundried for three days and river sand sterilized at 200°C on days 1, 5 and 9 respectively. Ninety (90) seeds on each day sown in 4cm depth (Adelani, 2015) of potting mixture of 200°C sterilized river sand and 3days sundried sawdust. Seeds watered to pot capacity in 27cm by 22cm poly bag size at 70ml/seed daily. Seeds were kept at 27°C average room temperature before sowing for experimental periods

Data analysis

Data were collected on the effects of duration of seed storage and seed coat treatments on the germination of *C. albidum* seeds. The data were subjected to analysis of variance (ANOVA) using "Fischer's Least Significant Difference (LSD)" at 5% level of significance. Germination count was recorded after the emergence of the plumule. Germination count was converted to germination percentage, which was obtained as the number of seeds germinated divided by the total number of seeds planted and multiplied by 100.

$$\text{Germination Percentage} = \frac{\text{Total seed germinated}}{\text{Total seed sown}} \times 100$$

RESULTS AND DISCUSSION

Effects of seed coat treatments and durations of seed storage on the germination of *C.albidum* seeds.

The effects of the seed coat treatments and durations of seed storage on the germination of *C. albidum* seeds are presented in (Table 1). A significant decrease in percentage germination was recorded with the various pre-sowing treatments. Percentage germination ranged from 17% to 61% for clipping to no seed coat treatment. The highest germination percentage of 61% was obtained in untreated seeds. A significant decrease in percentage germination was recorded with the increasing days of storage. The percentage germination ranged from 16% to 60% for seeds stored for nine days to those stored for one day. Lengths of seed storage, irrespective of seed coat treatment significantly affected germination of *C. albidum* seeds. *C. albidum* seeds cannot be stored for long time. Similar observations on seeds that can only withstand short period of storage have been reported by Idowu *et al.* (2013) (*Treculia africana*), Jonathan and

Olawole (2007) (*Treculia africana*), Aduradola (2004) (*Piliostigma reticulatum*), Okunomo (2010) and Koyejo and Okonkwo (2012) (*Tetrapleura tetraptera*). Contrary to these reports are the findings of Baiyeri and Mbah (2006) who stated that *Treculia africana* seeds stored for three to six days before planting emerged earlier than those planted immediately after extraction from the fruit pulp or those stored for nine days.

Decrease in the germination rate of the *C. albidum* seeds after 5 days of storage showed that it cannot be stored for long time before it loses its viability because it is recalcitrant. Similar observations have been reported by Denton (1997) (*Chrysophyllum albidum*), Tompsett (1992) (from *Shorea dasyphylla* to *Hopea hainanensis*), Schmidt (2000) (*Azadirachta indica*), Thomsen (2000) (*Hopea odorata*) and FAO *et al.* (2004) (*Araucaria* spp and *Agathis* spp). Recalcitrant seeds do not have the ability to stay alive for a long time. Recalcitrant seeds have short physiological storability, which can only be slightly extended by storing them under controlled conditions (Schmidt, 2000).

Table 1: Effects of duration of seed storage and seed coat treatments on germination potential of *Chrysophyllum albidum*

Treatments	Germination %	Days	Germination %
0	61a	1	60a
1	30b	5	34b
2	17c	9	16c
SE	1.15	SE	1.15

Trt 0 = control

Trt 1 = sulphuric acid

Trt 2 = clipping treatment

1 = Day 1

5 = Day 5

9 = Day 9

abc Means on the same row having different superscripts are significantly different (P<0.05).

Results interaction effect showed that percentage germination ranged from 0% to 86% for seeds stored for day 5 with and without seed coat treatments (Table 2). Highest significant germination percentage of 86 was recorded in seeds stored for 5 days with no seed coat treatment. Seed coat treatment and increased lengths of seed storage did not enhance germination of *C. albidum* seeds. Sulphuric acid treatment did not enhance germination of *C. albidum* seeds partly because of the destructive penetration of seed coat to destroy embryo by the acid. Sulphuric acid was not able to scarify seed coats and softening seed coat to accelerate water uptake which results in earlier and faster germination. This is in line with the reports of Atiku *et al.* (2013) (*Acacia seyal*), Adeogun and Solomon (2013) (*Phoenix dactylifera*), Igboanugo *et al.* (2010) (*Etanda gigas*), Okunomo (2010) (*Tetrapleura tetraptera*), Aduradola and Adejumo (2005) (*Erythrophleum suaveolens*), Ajiboye *et al.* (2009) (*Parkia biglobosa*), Afrasyab and Reza (2007) (*Ferula gummosa*), Salami and Salami (2009) (*Adansonia digitata*), Mandujano *et al.* (2005) (*Opuntia rastrera*), Zarchini *et al.* (2011) (*Cycas revoluta*) and Michael *et al.* (2008) (*Terminalia sericea*).

On the other hand, El-siddig *et al.* (2001) reported the effectiveness of acid treatment on seed germination. Acid treatments have been found to be effective for seeds of several tree species such as *Lupinus campestris* (Pedro *et al.*, 2010), *Tamarindus indica* (Mohammad and Amusa, 2003), *Piliostigma reticulatum* (Aduradola, 2004), *Delonix regia* (Akande *et al.*, 2010), *Prosopis africana* and *Dialium guineense* (Ajiboye and Agboola, 2008), *Aconitum heterophyllum* (Pandey *et al.*, 2000), *Parkia biglobosa* and *Albizia lebeck*

(Ajiboye *et al.*, 2009), *Acacia auriculiformis* (Olatunji *et al.*, 2012), *Acacia sieberiana* (Atiku *et al.*, 2013), *Canna indica* (Joshi and Pant, 2010), *Acacia fistula* (Amira and Mohamed, 2013), *Azelia africana* (Amusa, 2011), *Adansonia digitata* (Falemara *et al.*, 2013), *Dacryodes edulis* (Agbogidi *et al.*, 2007), *Asparagus racemosus* (Gupta, 2002), *Lupinus varius* (Karaguzel *et al.*, 2004), *Calligonum* species (Ren and Tao (2004), *Tetracarpidium conophorum* (Ehiagbonare and Onyibe, 2007), *Zizyphus spinachristii* (Aduradola, 2000), *Cassia auriculata* (Negi *et al.*, 2011), *Cassia siamea* and *Cassia roxburghii* (Al-Menaie *et al.*, 2009), *Pasiflora edulis* seeds (Mabunza *et al.*, 2010) and *Parkia biglobosa* (Isah, 2012).

Mechanical scarification did not enhance the germination of seeds of *C. albidum* because it damages the endosperm as well as embryo during treatment. Contrary to this report are the findings of various investigators as Isah (2012) (*Parkia biglobosa*), Olujobi *et al.* (2009) (*Azelia africana*), Morteza *et al.* (2011) (*Citrullus cococynthis*), Aduradola *et al.* (2005) (*Chrysophyllum albidum*), Aliero (2004) (*Parkia biglobosa*), Sxitus *et al.* (2003) (*Ulex europaeus*), Uzen and Aydin (2004) (*Ferula gummosa*), Nadjafi *et al.* (2006) (*Teucrium polium*), Okunlola *et al.* (2011) (*Parkia biglobosa*), Babatunde (2004) (*Chrysophyllum albidum*), Dogon Daji (2002) (*Tamarindus indica*, *Adansonia digitata* and *Acacia nilotica*), Hossain *et al.* (2005) (*Terminalia* species), Michael *et al.* (2008) (*Terminalia sericea*), Akinnifesi *et al.* (2007) (*Sclerocarya birrea*), Jun and Ling (2004) (*Calligonum* species) and Oyun *et al.* (2005) (*Tamarindus*, *Prosopis africana* and *Parkia biglobosa*) that further confirmed the efficacy of mechanical scarification in releasing seed dormancy.

Table 2: Interaction effects seed coat treatments and duration of seed storage on germination of *Chrysophyllum albidum*

Parameters	Treatments								
	0			1			2		
Days	1	5	9	1	5	9	1	5	9
% Germination	74b	86a	23c	59ab	0d	3c	20c	13c	19c
SE	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99

abc means on the same row having different superscripts are significantly different ($P < 0.05$)

CONCLUSION

Investigation conducted into the storability and pre-sowing treatment of *C. albidum* seeds for biodiversity conservation revealed that it cannot be stored for more than 5 days in ambient temperature before germination percentage start decreasing.

REFERENCES

- Adebisi, A. A. 1997.** Preliminary survey of post harvest and marketing constraints of *Chrysophyllum albidum* in Nigeria: In the proceedings of National Workshop on the potentials of the Star apple in Nigeria 84pp.
- Adelani, D.O. 2015.** Effect of hydro-priming and potassium nitrate priming on the germination of *Balanites aegyptiaca*. *Applied Tropical Agriculture* 20(2):17-23.
- Adeogun, P.F. and Solomon, T. 2013.** Evaluation of date palm (*Phoenix dactylifera*) seedling performance under some silvicultural treatments and the implications on economic aspects in arid zones of Nigeria. In: Popoola, L., Idumah., F.O., Ogunsanwo, O.Y and
- Azeez, I.O. (eds).** Forest Industry in a Dynamic Global Environment. *Proceedings of the 35th Annual Conference of the Forestry Association of Nigeria*. Pp. 709 – 719.
- Adisa, S.A. 2000.** Vitamin C, Protein and Mineral Content of African star apple (*Chrysophyllum albidum*). In: Garba, S.A., Ijagbone, I.G., Iyagba, A.O., Iyamu, A.O., Kilani, A.S., Ufaruna, N (eds). *Proceedings of the 18th Annual Conference of NIST*. Pp. 141 – 146.
- Aduradola, A.M. 2000.** Effect of some pre-treatments on the germination in seeds of *Acacia nilotica* (C) Wilf ex Del and *Zizyphus spinachristii* (C) Del. *The Bioprospector* 2:62-70.
- Aduradola, A.M. 2004.** Preliminary investigation of some factors affecting germination in seeds of *Piliostigma reticulatum* Hochst. L. *Journal of Agriculture and Environment* 4(1):29-34.
- Aduradola, A.M. and Adejumo, A. 2005.** The effect of some pre-treatments on germination of seeds of *Erythrophleum suaveolens*. In: Popoola, L., Oni, P.I., Otu I.I., Jimoh, S.O., Adekunle, V.A. J., Ogunsanwo, O.Y and Azeez, I.O. (eds). *Sustainable Forest Management in Nigeria: Lessons and Prospects. Proceedings of the 30th Annual Conference of Forestry Association of Nigeria*. Pp 496 – 501.
- Aduradola, A.M., B.F. Adeola and M.O. Adedire. 2005.** Enhancing germination in seeds of African Star Apple, *Chrysophyllum*

- albidum* (G. Don). *Journal of Food, Agriculture and Environment* 3(2):292-294.
- Afrasyab, R.G. and Reza, T.A. 2007.** Methods for dormancy breaking and germination of galbanum seeds (*Ferula gummosa*). *Asian Journal of Plant Sciences* 6(4): 611-616.
- Agbogidi, O.M., B.O. Bosah and O.F. Eshegbeyi. 2007.** Effects of acid pre-treatment on the germination and seedling growth of African pear (*Dacryodes edulis* G. Don Lam. H.J.) *International Journal of Agricultural Research* 2(11):952-958.
- Ajiboye, A.A and Agboola, D.A. 2008.** Effects of seedsize and phytohormone on the germination of seeds of two forest tree species, *Prosopis africana* (Guill) and *Dialium guineense* (Wild). *In: Proceedings of Third Conference on Science and National Development* 3:145-150.
- Ajiboye, A.A., M.O. Atayese and D.A. Agboola. 2009.** Effect of pre-sowing treatments on seed germination and percentage starch content levels in *Tamarindus indica*, *Prosopis africana*, *Parkia biglobosa* and *Albizia lebbek*. *Journal of Applied Sciences Research* 5 (10): 1515 – 1519.
- Akande, M.T., Sodimu, A.I., Chiroma, C.P. and Akesode, A. 2010.** Effect of different pre-treatment and potting media on the growth performance of seedlings of *Delonix regia*(Hook). *Journal of Agricultural Research and Policies* 5(4):75-78.
- Akinnifesi, F., Sileshi, A., Mkonda, A., Ajayi, O.C., Mhango, J. and Chilanga, T. 2007.** Germplasm supply, propagation and nursery management of miombo fruit trees. *In: Akinnifesi, F.K., Sileshi, G., Ajayi, O., Tchoundjeu, Z., and Matakale, P. (eds)* *Indigenous fruit trees in the tropics. Domestication, utilization and commercialization*. CABI Publishing, pp368.
- Aiboni, V. U. 2001.** Characteristics and classification of soil of a representative topographical location in University of Agriculture, Abeokuta. *Asset Series A* 1(1): 51–61.
- Aliero, B.L. 2004.** Effects of sulphuric acid, mechanical scarification and wet heat treatments on germination of seeds of African Locust Beans Tree, *Parkia biglobosa*. *African Journal of Biotechnology* 3(3):179 – 181.
- Al-Menaie, H.S., O. Al-Ragom, A. Al-shatti and M. Matthew 2009.** Germination behaviour of seeds of four flowering trees of the genus *Cassia* under arid climatic conditions of Kuwait. *European Journal of Scientific Research* 38 (3):373 – 379.
- Amira, Sh. S and Mohamed, S.A. 2013.** Effects of sulphuric acid and hot water pre-treatments on seed germination and seedling growth of *Cassia fistula* L. *American-Eurasian Journal of Agriculture and Environmental Science* 13(11):07-15.
- Amujoyegbe, B. J., Bamire, A. S and Elemo, K. O. 2008.** Agronomic analysis of fertilizer effect on maize/cowpea intercrops in Ile-Ife and Abeokuta, South-western Nigeria. *Asset Series A*, 8 (1): 62-72.
- Amusa, N.A., Ashaye, O.A. and Oladapo, M.O. 2003.** Biodeterioration of African star apple (*Chrysophyllum albidum*) in storage and the effect of its food value. *African Journal of Biotechnology* 2:56-59.
- Amusa, T.O. 2011.** Effects of Three pre-treatment techniques on dormancy and germination of African star apple (*Chrysophyllum albidum*) seeds.

- mination of seeds of *Azela africana* (Sm. Ex Pers). *Journal of Horticulture and Forestry*, 3(4):96-103.
- Atiku, M., Bello, A.G., Adda, M. and M.D. Almoukhtari 2013.** Effects of different methods of seed treatment on germination of *Acacia seyal* and *Acacia sieberiana*. In: Popoola, L., Idumah, F.O., Ogunsanwo, O.Y and Azeez, I.O. (eds). *Forest Industry in a Dynamic Global Environment. Proceedings of the 35th Annual Conference of the Forestry Association of Nigeria*. Pp. 345 – 350.
- Babatunde, F.A. (2004).** *Seed germination in Chrysophyllum albidum* B. Forestry Project. Department of Forestry and Wildlife Management, Federal University of Agriculture. Abeokuta. 50p
- Bada, S.O. 1997.** Preliminary information on the ecology of *Chrysophyllum albidum*. G. Don, in West and Central Africa' In the *Proceedings of a National Workshop on Potentials of Chrysophyllum albidum in Nigeria*. Pp. 16-17.
- Baiyeri, K.P. and Mbah. B. N. 2006.** Surface sterilization and duration of seed storage Influenced emergence and seedling quality of African bread fruit (*Treculia africana Decne*). *African Journal of Biotechnology*, 5 (15):1393 – 1396.
- Denton, L. 1997.** Germplasm collection and strategy for *Chrysophyllum albidum*. In: *Proceedings of a National Workshop on the Potentials of the Chrysophyllum albidum in Nigeria*. Gbile, Z. (eds). Pp. 130.
- Dike, M.C; Adewusi, H.G and Sarumi, M.B. 1997.** *Chrysophyllum albidum* G.Don in the compound farm systems of Southeastern Nigeria: in the proceedings of a National workshop on the potentials of the *Chrysophyllum albidum* in Nigeria, p55.
- Dogon Daji, D. 2002.** *Effects of Pre-sowing treatment on Seed Germination of Three Indigenous Tree Species in Semi-arid Environment*. M.Sc. Dissertation (Unpublished). UDU Sokoto, Nigeria. Pp. 60
- Ehiagbonare, J.E., Onyibe, H.I. and Okegwale, E.E. 2008.** Studies on the isolation of normal and abnormal seedlings of *Chrysophyllum albidum*. A step towards sustainable management of the taxon in the 21st Century. *Science Research and Essay*, 3(12):567-570.
- El-Siddig, K., Ebert, G and Ludders, P. 2001.** A Comparison of pre-treatment methods for scarification and germination of *Tamarindus indica* L. seeds. *Seed Science Technology*, 29: 271 – 274.
- Falemara, B.C., Nwadike, C. and E.O. Obashola 2013.** Germination response of baobab seeds (*Adansonia digitata* L.) as influenced by three pre-treatment techniques. In: Popoola, L. Idumah; F.O., Ogunsanwo, O.Y and Azeez, I.O. (eds). *Forest Industry in a Dynamic Global Environment. Proceedings of the 35th Annual Conference of the Forestry Association of Nigeria*. Pp. 45 – 55.
- FAO, FLD, IPGRI. 2004.** *Forest Genetic Resources Conservation and Management*. In Vol 3: plantation and genebanks (ex situ). International Plant Genetic Resources Institute Rome, Italy, pp86.
- Gupta, S.C. 2002.** Seed dormancy studies in some *Ocimum* Species and its control through chemical treatments. *Journal of Medicinal and Aromatic Plant Science* 24: 957 – 950.

- Hossain, M.A., Arefin, M.K., Khan, B.M., Rahman, M.A. 2005.** Effects of seed treatments on germination and seedling growth attributes of Horitaki (*Terminalia chebula Retz.*) in the nursery. *Research Journal of Agriculture and Biological Science* 2:135-141.
- Idowu, O.J., Olanite, J.A., Arigbede, O.M., Adedire, M.O., Adeoye, S.A. and Adelusi, D.O. 2013.** Effect of storage methods on germination, growth and proximate composition of *Treculia africana* Var. decne seedlings. *Journal of Agricultural and Biodiversity Research* 2(6): 117-123
- Igboanugo, A.B.I., Nsien, I.B., Ojo, A.R., Yakubu, F.B., Ijeoma, N.U., Akinyemi, G.O. and Asinwa, I.O. 2010.** Effects of pre-germination treatments on the germination of the seeds of *Etanda gigas* (Sea heart). *International Journal of Agriculture* 2(1):69-73.
- Isah, A.D. 2012.** Effects of Pre-treatments on seed germination of *Parkia biglobosa* and *Tamarindus indica*. In: Onyekwelu, J.C., Agbeja, B.O., Adekunle, V.A.J., Lameed, G.A., Adesoye, P.O and Omole, A.O. (eds). De-reservation, Encroachment and Deforestation Implications for the Future of Nigerian Forest Estate and Carbon Emission Reduction. *Proceedings of the 3rd Biennial, National Conference of the Forest and Forest Products Society*, Pp: 324- 328.
- Jonathan, C.O. and Olawole, J.F. 2007.** Effects of storage methods on the germination and proximate composition of *Treculia africana* seeds. Paper presented at the *Conference on the International Agricultural Research for Development Tropentas, Germany* 9pp.
- Joshi, S.C. and Pant, S.C. 2010.** Effects of H₂SO₄ on seed germination and viability of *Canna indica* L. a medicinal plant. *Journal of American Sciences* 6(6):24-25.
- Jun, R and Ling, T. 2004.** Effects of different Presowing seed treatments on germination of 10 Calligonum species. *Forest Ecology and Management*.195:291-300.
- Karaguzel, O., Cakmakci, S., Ortacesme, V and Aydinoglu. B. 2004.** Influence of seed coat treatments on germination and early seedling growth of *Lupinus varius* L. *Pakistan Journal of Botany* 36 (1):65 – 74.
- Koyejo, O.A. and Okonkwo, H.O. 2012.** Influence of storage temperature on the shelf-life of *Cola lepidota* (K. schum) fruit pulp. *Research for Development, in Forest, Forest Products and Natural Resources Management*. In: Onyekwelu, J.C., Agbeja, B.O., Adekunle, V.A.J., Lameed, G.A., Adesoye, P.O and Omole, A.O. (eds). *Proceedings of the Third National Conference of the Forests and Forest Products Society*. Pp. 300-305.
- Ladipo, D.O., Fondoun, J.M. and Ganga, N. 1997.** Domestication of the bush mango (*Irvingia spp*). some exploitable in transpecific variations in West and Central Africa. In *the Proceedings of the International Conference in Domestication and Commercialization of Non Wood Forest Products in Agroforestry System* Pp. 12.
- Laurent, G.H., Toussaint, O.L., Francis, G.H.G., Lisette, E. S.A. and Brice, S. 2012.** Ethno-botanical study of the African star apple (*Chrysophyllum albidum* G. Don) in the Southern Benin (West Africa). *Journal of Ethnobiology and Ethnomedicine* 8:40-47.

- Mabundza, R.M., Wahome, P.K and Masarirambi, M.T. 2010.** Effects of different pre-germination treatment methods on the germination of passion (*Passiflora edulis*) seeds. *Journal of Agriculture and Social Science* 6:57-60.
- Mandujano, M.C., Montana, C and Rojas-Arechiga, M. 2005.** Breaking seed dormancy in *Opuntia rastera* from the Chihuahua desert. *Journal of Arid Environment* 62:15-21.
- Michael, G.L., Joyce, P.N., Weston, F.M and Clement, Z.C. 2008.** Effects of seed collection times and pretreatment methods on the germination of *Terminalia sericea* Burchi. *African Journal of Biotechnology* 7 (6):2840-2846.
- Morteza, S., Farajollah, T. and Soheila, N. 2011.** Comparison the effect of different treatments for breaking seed dormancy of *Citrullus colocynthis*. *Journal of Agricultural Sciences* 3(4):62-67.
- Muhammad, S. and Amusa, N.A. 2003.** Effects of sulphuric acid and hot water treatments on seed germination of tamarind (*Tamarindus indica* L.). *African Journal of Biotechnology* 2(9): 276 – 279.
- Nadjafi, F., Bannayan, M., Tabrizi, L and Rastgoo, M. 2006.** Seed germination and dormancy breaking techniques for *Ferula gammosa* and *Teucrium polium*. *Journal of Arid Environments* 64:542-547.
- Negi, R.S., Sharma, K.C and Sharma, M. 2011.** Micro propagation and anatomical comparison of in vivo and in vitro developed shoot and root in *Cassia auriculata* L. A medicinally important plant. *Indian Journal of Fundamental and Applied Life Sciences*, 1:21-29.
- Nwoboshi, L.C. 2000.** *The Nutrient Factor in Sustainable Forestry*. Ibadan University Press, Nigeria, 303pp.
- Oboh, I.O., Aluyor, E.O. and Audu, T.O.K. 2009.** Use of *Chrysophyllum albidum* for the removal of metal ions from aqueous solution. *Scientific Research and Essay*, 4(6):632-635.
- Okunlola, A.I., Adebayo, R.A and Orimogunje, A.D. 2011.** Methods of breaking seed dormancy on germination and early seedling growth of African locust beans (*Parkia biglobosa*) (JACQ) Benth. *Journal of Horticulture and Forestry* 3(1):1-6.
- Okunomo, K. 2010.** Seed germination of *Tetrapleura tetraptera* (Taub) as influenced by various nursery techniques. *African Journal of Agricultural Research and Development* 3(2):1-28.
- Olaoluwa, T.A, Muhammed, N.O and Oladiji, A.T. 2012.** Biochemical assessment of the mineral and some anti-nutritional constituents of *Aspergillus niger* fermented *Chrysophyllum albidum* seed meal. *African Journal of Food Science*, 6(1):20-28.
- Olatunji, D., Maku, J.O. and Odumefun, O.P. 2012.** Effects of pre-treatments on the germination and early seedling growth of *Acacia auriculiformis* Cunn. Ex. Benth. *African Journal of Plant Science* 6(14):364 – 369.
- Olujobi, O.J., Olayode, O.O. and Dahunsi, O.M. 2009.** Breaking seed dormancy in *Azelia africana* (sm. Ex. Pers) towards plantation establishment for sustainable production. In: Popoola, L; Idumah, F.O; Adekunle, V.A.J and Azeez, I.O. (eds). *The Global Economic Crisis and Sustainable Renewable Natural*

- Resources Management. Proceedings of the 33rd Annual Conference of the Forestry Association of Nigeria*. Pp. 205 – 212.
- Onyekwelu, J.C., Stimm, B., Mosandi, R. and Olusola, J.A. 2011.** Domestication of *Chrysophyllum albidum* from rainforest and derived savannah ecosystem – Phenotype variation and selection of elite trees. *Conference on International Research on Food Security, Natural Resource Management and Rural Development*. Tropentage, pp. 7.
- Onyekwelu, J.C and Stimm, B. 2011.** *Chrysophyllum albidum*. In: Roloff, A; Weisgerber, HLang, U; Stimm, B.(Eds): Enzyklopadie der Holzgewachse, Willey VCH, Weinheim, 59 Erg.Lfg.10/11,12pp
- Oyun, M.B. Suberu, S.A., Singh, A. and Mohammed, S. 2005.** Effects of pre-treatment on seed germination and seedling vigour of *Acacia senegal* (L) wild. *Nigerian Journal of Forestry*, 35(2): 108 – 112.
- Pandey H; Nandi, S.K., Nadeem, M and Palni, L.M.S. 2000.** Chemical stimulation of seed germination in *Aconitum heterophyllum* Wall and *Aconitum balfouri* stapf: Important Himalayan species of medicinal value. *Seed Science and Technology* 28:39-48.
- Pedro, G.N; Fernando D.I.G; Jorge, E.B and Alejandro, C.F. 2010.** Effect of scarification, self-inhibition and sowing depth on seed germination of *Lupinus campestris*. *Chilean Journal of Agricultural Research* 70 (3):365-371.
- Rahaman Onike 2012. A review of medicinal value of *Chrysophyllum albidum* (African star apple) *African Traditional Medicine*. 1(1):1-3 (<http://searchwarp.com/rahaman>).
- Ren, J and Tao, L. 2004. Effects of different pre-sowing seed treatments on germination of 10 Calligonium species. *Forest Ecology and Management* 195:291-300.
- Salami, A.O. and Salami, N.T. 2009.** Effects of concentrated hydrochloric acid (HCl) and water pre-treatments on seed germination and seedling emergence of *Adansonia digitata*. *Journal of Agricultural Technology and Rural Development*, 1(1):44-51.
- Schmidt, L. 2000.** *Guide to Handling of Tropical and Subtropical Forest Seeds*. Danida Forest Seed Centre, Humblebaek, Denmark pp.303
- Sxitus, C.R., Hill, G.D and Scort, R.R. 2003.** The effect of temperature and scarification method on *Ulex europaeus* seed germination. *New Zealand Plant Protection* 56:201-205.
- Thomsen, K. 2000.** *Handling of Dessication and Temperature Sensitive Tree Seeds*. Technical notes series 56 Danida Forest Seed Centre, Humbleback, Denmark.
- Tompsett, P.B. 1992.** A review of the literature on storage of dipterocarp seeds. *Seed Science and Technology* 20: 251-267.
- Ufoegbune, G. C and Fabiyi, S. 2016.** Identification of land areas suitable for fadama farming at Federal University of Agriculture, Abeokuta, Nigeria using GIS. *Journal of Applied Sciences and Environmental Management* 20 (4): 1027– 1032.
- Ureigho, V.N. and Ekeke, B.A. 2010.** Nutrient values of *Chrysophyllum albidum* Linn African star apple as a domestic income plantation species. *An International Multi-disciplinary Journal*, Ethiopia 4(2):50-56.

- Uzen, F and Aydin, I. 2004.** Improving germination rate of *Medicago* and *Terifolium* species, *Asian Journal of Plant Science* 3:714-717.
- Zarchini, M., Hashemabadi, D., Kaviani, B., Fallahabadi, P.R. and Negahdar, N. 2011.** Improved germination conditions in *Cycas revoluta* L. by using sulfuric acid and
- Wole Oyebade. 2013.** Unlimited nutritional benefits of African star apple. *Natural Health*, 1(1):1-4.

(Manuscript received: 10th July, 2016; accepted: 28th June, 2017)