



An International Journal

Journal

OF RESEARCHES IN AGRICULTURAL SCIENCES

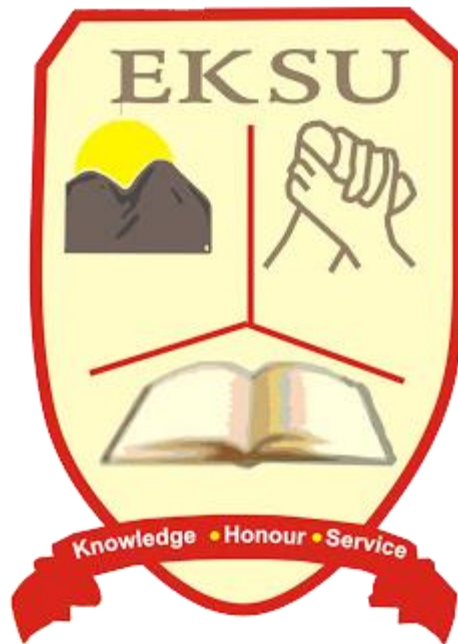
Formerly known as Agricultural Sciences Research Journal

Volume 7, Nos 1 & 2

JOURNAL OF RESEARCHES IN AGRICULTURAL SCIENCES

Volume 7, Nos 1 & 2

EKITI STATE UNIVERSITY
FACULTY OF AGRICULTURAL SCIENCES



JOURNAL OF RESEARCHES IN AGRICULTURAL SCIENCES

VOLUME 7, NUMBERS 1 & 2, 2019

JRAS Editorial Office,
Faculty of Agricultural Sciences,
Ekiti State University,
Ado-Ekiti, Nigeria.

E-mail: foas.jras@eksu.edu.ng
jras.foas@gmail.com

Website: _____

ISSN: 2006 - 0041
Code: RAS 2008

Published by: *Journal of Researches in Agricultural Sciences*

JRAS Editorial Office
Faculty of Agricultural Sciences
Ekiti State University,
Ado-Ekiti, Nigeria.

Website: _____

All rights reserved. No part of this Journal may be reproduced, stored in a retrieval system, or transmitted in any form or any means, electronic, mechanical, photocopying, recording or otherwise, without the written permission of the Editor- in-Chief.

EDITORIAL BOARD

Professor O. J. Ayodele
Professor F A. S. Dairo
Professor (Mrs.) O. M. Apata
Professor A. O. Fasuyi
Dr. Tope Jegede
Dr. F O. Osundare
Dr. A. O. Borisade
Dr. (Mrs.) O. O. Olayode
Dr. J. O. Orimaye

Editor-in-Chief
Assistant Editor-in-Chief
Assistant Editor-in-Chief
Associate Editor
Associate Editor
Assistant Editor
Assistant Editor
Assistant Editor
Business / Distribution Manager

EDITORIAL ADVISERS /

Professor A.S. Fasina
Professor T Oluwagbemi
Professor V. A. Aletor
Professor A. Olayinka
Professor A. O. Ogunkunle
Professor R. D. Aladesanwa
Professor E. O. Idowu
Professor G. E. Onibi
Professor B. Olufemi
Professor E. O. Adeparusi
Professor J. O. Ariyo
Professor I. O. O. Aiyelaagbe
Professor J. S. Ogeh
Professor M. G. Solomon
Professor I. A. Ayodele
Professor P A. Okuneye
Professor A. Omotayo

CONSULTING EDITORS

- Federal University, Oye-Ekiti
- Kogi State University, Ayingba, Kogi State
- Federal University of Technology, Akure
- Obafemi Awolowo University, Ile-Ife
- University of Ibadan, Ibadan
- Federal University of Technology, Akure
- Obafemi Awolowo University, Ile-Ife
- Federal University of Technology, Akure
- Federal University of Technology, Akure
- Federal University of Technology, Akure
- Federal University of Agriculture, Abeokuta
- Federal University of Agriculture, Abeokuta
- University of Benin, Benin
- University of Calabar, Calabar
- University of Ibadan, Ibadan
- Federal University of Agriculture, Abeokuta
- Federal University of Agriculture, Abeokuta

CONTENTS

MARCH

1. Bitumen Seepage: Impact and Interaction on Heavy Metal Concentrations in Surface Water – Ogunmusa and Adeleke
2. Performance Evaluation of African Catfish (*Clarias gariepinus*) Fingerlings Fed African Locust Bean (*Parkia biglobosa*) Meal Diets – Obe et al
3. Supplemental values of Poultry litter, *Leucaena leucocephala* and Groundnut haulms on growth, nutrient digestibility, and economy of Yankasa rams' fattening
4. Comparative Evaluation of Bird Species Diversity in Different Ecosystems of Akure Forest Reserve, Ondo State – Ogunyemi
5. Boldness-aggression Syndromes in the zebrafish and the guppies – Oriyomo et al
6. Genetic Variability of some Tilapia Species from three different Reservoirs in Southwestern Nigeria - Onyeabor and Bello-Olusoji
7. Germination and Seedling Growth of African Star Apple (*Chrysophyllum albidum* G. Don Syn. *Gambeya albida*) in Soils of Ekiti State – Olayode
8. Comparative Assessment of the Avifauna Species Composition of the Beach Environment in Badagry-West Local Government, Lagos State. – Kolawole
9. Heavy Metals Concentration in African Mud Catfish (*Clarias gariepinus*) and Obscure Snakehead (*Parachanna obscura*) from River Ogbese, Ondo State, Nigeria – Abidemi-Iromini

SEPTEMBER

1. Water Physico-Chemical Parameters Inter-Relationship and Heterotrophic Fungal Count of Ureje Dam in Ekiti State, Nigeria – Akin-Obasola et al
2. Nutritional and Anti-nutritional Composition of *Parkia biglobosa* and *Adansonia digitata* in Guinea Savanna region, Taraba state, Nigeria – Sobola O.O
3. Effects of Quarry Activities on Physical and Chemical Properties of Soils in Ondo State, Nigeria – Olusola et al
4. Climate Change Impacts on Ecosystem Services and Livelihoods of Fringe Forest Communities in Ondo State, Nigeria. – Oyerinde and Adedoyin
5. Heavy Metal contents of Cocoa (*Theobroma cacao* L.) Beans and Plantation Soils in Ondo State, Nigeria - Fayinmiinu et al
6. Gender Role in Decision-making among Maize Farmers in Isaga-Orile Community of Ogun State, Nigeria – Fakoya et al.
7. Evaluation of the Nutritional Qualities of Edible Portions of Two Commercially Important Prawns in Southwest Nigeria - Oghini O
8. Poaching and its impact on Wildlife Population in Ise Forest Reserve, Ekiti State. – Orimaye et al.



Germination and Seedling Growth of African Star Apple (*Chrysophyllum albidum* G. Don Syn. *Gambeya albida*) in Soils of Ekiti State

O.O. Olayode

Department of Forest Resources and Wildlife Management, Ekiti State University, Ado-Ekiti

E-mail: olufunke.olayode@eksu.edu.ng

Abstract

Most indigenous forest tree species are of utmost importance yet they are not largely domesticated for many ecological reasons. Therefore, this study examined the germination and early seedling growth of African star apple (*Chrysophyllum albidum*) in the soils collected from Ikere and Ado-Ekiti (rain forest), Ayede-Isan and Igede (Savanna) in Ekiti State. *C. albidum* seeds were extracted from matured fruits, subjected to four treatments control (untreated seeds), hot water scarification and cold water before sowing. Laboratory analysis of some soil properties was done to determine differences among the locations. Seedling growth variables were monitored every fortnight for twelve weeks. Coldwater produced germination that ranged between 11.1-100% followed by scarification with the germination of 33.3-88.9% among the locations. Likewise, the control produced germination of between 11.1-55.6% whereas seeds pretreated with hot water did not germinate. Analysis of variance did not reveal any significant difference for seedling height but the highest mean height value of 8.95cm, followed by 8.77cm and the least of 5.25cm were obtained in Igede-Isan, Ikere and Ado respectively in the locations throughout the assessment period. Also, the highest mean collar diameter value (0.35cm) was obtained in Igede-Isan and the least (0.30cm) in Ado Ekiti. Therefore, scarification and cold water can be used to overcome dormancy in *C. albidum* seeds. Also, *C. albidum* can be successfully raised in the two ecological zones of Ekiti State since there were no marked differences among the locations studied.

Keywords: Indigenous fruit tree, soil effects, pretreatments, seedling emergence

Cite as: Olayode O.O (2019). Germination and seedling growth of African Star Apple (*Chrysophyllum albidum* G. Don Syn. *Gambeya albida*) in soils of Ekiti State. *Journal of Researches in Agricultural Sciences*. 7(1): 58-65

Introduction

Many indigenous tropical fruit tree species are of great economic potentials. Sales of some of these edible fruits serve as a means of livelihood for many rural people in Nigeria. Some of these fruit tree species include African pear *Dacryodes edulis*; Bush mango *Irvingia gabonensis*; Velvet tamarind *Dialium guineense*; Yellow mombin *Spondias mombin*; Soursop *Annona muricata*; Breadfruit *Artocarpus altilis*; African breadfruit *Treulia africana* and *Chrysophyllum albidum* (syn. *Gambeya albida*). *C.*

albidum commonly called African star apple or White star apple is from the family Sapotaceae. It is called different names by the diverse tribes in Nigeria. It is known as “agbalumo” in Yoruba, “udara” in Ibo, Efik, and Ibibio; “ehya” in Igala and “agwaluma” in Hausa (Olayode and Otufale, 2018). It is primarily a forest tree species and its natural occurrence has been reported in diverse ecozones in Nigeria, Uganda, Niger Republic, Cameroon, and Cote d’Ivoire (Bada, 1997). The tree often grows to a height of 36.5m. The African star apple fruit is a

large berry containing 4 to 5 flattened seeds or sometimes fewer due to seed abortion (Gbile, 1997). Many people both old and young relish the fruit of *C. albidum*, therefore they are considered to be of great commercial interest wherever they exist. Likewise, research has buttressed the fact that the economic potentials of *C. albidum* have improved significantly in recent times (Kazeem-Ibrahim *et al.*, 2013).

Perhaps the popularity of *C. albidum* is as a result of the many uses derivable from it. Its fruit is said to be very rich in ascorbic acid (1000 to 3,300mg per 100g of edible fruit) up to about 100 times that of orange and 10 times that of guava or cashew. Likewise, its fruit has been explored for the preparation of wine, spirits, soft drinks, jams, and jellies (Umelo, 1997). Its wood is said to be valued because it is easy to saw and suitable for construction purposes. Also, its seeds are a source of oil that is used for many purposes (Orwa, *et al.*, 2009). Furthermore, the various plant parts of *C. albidum* such as its leaves, cotyledon in the seed, and roots have been used for diverse purposes many of which are medicinal (Olapade, 1997; Amusa *et al.*, 2003; Okunomo and Egho, 2010).

C. albidum has been reported to be found in the semi-deciduous lowland rainforests underlain by ferruginous tropical soils of basement complex and also ferrallitic tropical soils of coastal plains sands (Bada, 1997). The medium in which any tree species is growing is very crucial to its survival and ability to attain its maximum potential in terms of development. The roles of soil in the growth and development of plants are diverse; they range from the provision of mechanical support, nutrients, air, water to harbouring many microorganisms some of which are very beneficial to plant growth (Boyle, 2005). An ideal soil is that which has about half of its content being solid while the remaining half is occupied by water and air in equal proportions (Crouse, 2018). However, it is known that this hardly occurs in reality due to the various modifications that might have taken place on such soil consequent upon anthropogenic activities with some aiding plant growth while others are detrimental to it. All seeds require adequate moisture and air in the soil to commence internal processes as well as permit gaseous exchange respectively as conditions necessary for germination to occur. Air, water, and nutrients present in any soil vary from location to location, and even in a particular site, there can be

variations based on the slope as well as the physical properties of the soil. Furthermore, soil varies both laterally and vertically. Soil variability can be a result of the interaction among the soil-forming factors which are topography, parent materials, climate, soil physical and chemical processes, biological activities, cropping system and tillage practice. There seems to be limited information on site preferences for *C. albidum* although Bada (1997) reported that the species grows well in undulations with deep soils and good drainage based on existing stands. This study, investigates seed germination and early growth of *C. albidum* on soils from selected locations in Ekiti State to prescribe the location that would best support its growth.

Materials and Methods

The experiment was carried out at the nursery site of the Faculty of Agricultural Sciences, Ekiti State University, Ado-Ekiti, Nigeria (EKSU). Ekiti State enjoys a tropical climate with two distinct seasons. These are the rainy season (April–October) and the dry season (November–March). Temperature ranges between 21 C and 28 C with high humidity. The south-westerly wind and the northeast trade wind blow in the rainy and dry (Harmattan) seasons respectively. The tropical forest exists in the south, while savanna occupies the northern peripheries. The soils derived from the basement complex rocks are mostly well-drained, having a medium to a fine texture.

The topsoil used for this study was collected from four locations in Ekiti State with two locations from the rainforest and two from the derived savanna. The two rainforest locations are Ado-Ekiti and Ikere-Ekiti while the derived savanna locations are Ayede-Ekiti and Igede-Isan Ekiti. This topsoil was collected from the teak plantation in each of these locations to eliminate bias from the depth of 0 – 7cm.

Matured fruits of *C. albidum* were collected from its area of natural range in Ekiti State. Seeds were extracted from the fruits, de-pulped, washed in water, and air-dried before sowing. Samples of the topsoil collected from the four locations were analyzed in the laboratory for their physical and some chemical properties (Nitrogen, Phosphorus, Potassium, and pH) to determine differences. Samples were analyzed according to the official methods of analysis described by the Association of Official Analytical Chemists (A.O.A.C., 2005).

The pretreatments used for breaking seed dormancy were scarification, hot water, cold water, and control. Scarification was achieved by scratching the seed hilum on sandpaper while hot water pretreatment was achieved by soaking the seeds in water brought to boil and allow the water to cool with the seeds overnight. Coldwater pretreatment was done by soaking seeds in water at room temperature for 12 hours while the seeds under control did not receive any form of pretreatment. One hundred and forty-four seeds were used with thirty-six seeds subjected to each treatment and sown in the polythene pots previously filled with topsoil collected from the various locations thereby making the topsoil from each location the replicate for each pretreatment. Polythene pots were watered daily in the morning and germination count was done daily till no further germination occurred for about 7 days. Uniformly growing seedlings were then later separated to continue into the phase of seedling growth assessment. Data collected were subjected to 2-way analysis of variance (ANOVA) while Duncan's Multiple Range Test (DMRT) was used to separate the means that were significantly different at the 5% probability level.

Results

Germination of *Chrysophyllum albidum* in Soils from Four Locations in Ekiti State under Different Pretreatments

The germination data of *C. albidum* seeds in the soils of the different locations subjected to different pretreatments are shown in Table 1. Germination began in Ikere under control at 33 Days After Sowing (DAS) and was completed at 40 DAS with germination of 55.6%. No germination was observed under hot water treatment until the experiment was terminated. Germination began under scarification at

29 DAS and was completed at 39 DAS giving germination of 55.6%. In cold water treatment, germination began at 26 DAS and ended at 38 DAS with 100% germination obtained. Figure 1 shows the germination percentage at different assessment periods in Ikere.

Furthermore, in Ayede, germination began in control at 32 DAS and was completed at 37 DAS with germination of 55.6%. However, hot water gave germination of 0% whereas, under scarification, germination began at 28 DAS and ended at 39 DAS with germination of 77.8%. Under cold water, germination began at 26 DAS and was completed at 32 DAS with germination of 66.7%. Figure 2 reveals germination in Ayede during the assessment period. In Igede-Isan, germination began in control at 33 DAS and ended on 39 DAS with germination of 33.3%. A similar result to what was got in the other locations aforementioned was observed under hot water treatment with no germination till the experiment was concluded. On the other hand, scarification began at 31 DAS and was completed at 40 DAS with germination of 88.9% whereas, in cold water, germination was first observed at 32 DAS and ended on 39 DAS with germination of 33.3%. Germination in Igede-Isan under the various pretreatments are shown in Figure 3.

Lastly in Ado, germination was first observed under control at 43 DAS and none was observed after that day. Meanwhile, as it was observed in other locations, hot water did not germinate throughout the duration of the experiment. Nevertheless, scarification produced germination of 33.3% with germination first observed at 26 DAS while it was completed at 37 DAS. Germination started in cold water at 35 DAS and ended the same day producing germination of 11.1%. Figure 4 shows germination under the different pretreatments in Ado.

Table 1: Germination of *C. albidum* Seeds Subjected to Different Pretreatments across the Locations

Loc.	Control			Hot Water			Scarification			Cold Water		
	GP (%)	Onset of Germ. (DAS)	End of Germ. (DAS)	GP (%)	Onset of Germ. (DAS)	End of Germ. (DAS)	GP (%)	Onset of Germ. (DAS)	End of Germ. (DAS)	GP (%)	Onset of Germ. (DAS)	End of Germ. (DAS)
Ikere	55.6	33	40	0	-	-	55.6	29	39	100	26	38
Ayede	55.6	32	37	0	-	-	77.8	28	39	66.7	26	32
Igede-Isan	33.3	33	39	0	-	-	88.9	31	40	33.3	32	39
Ado	11.1	43	43	0	-	-	33.3	26	37	11.1	35	35

Loc. = Locations, GP = Germination percentage, DAS = Days After Sowing

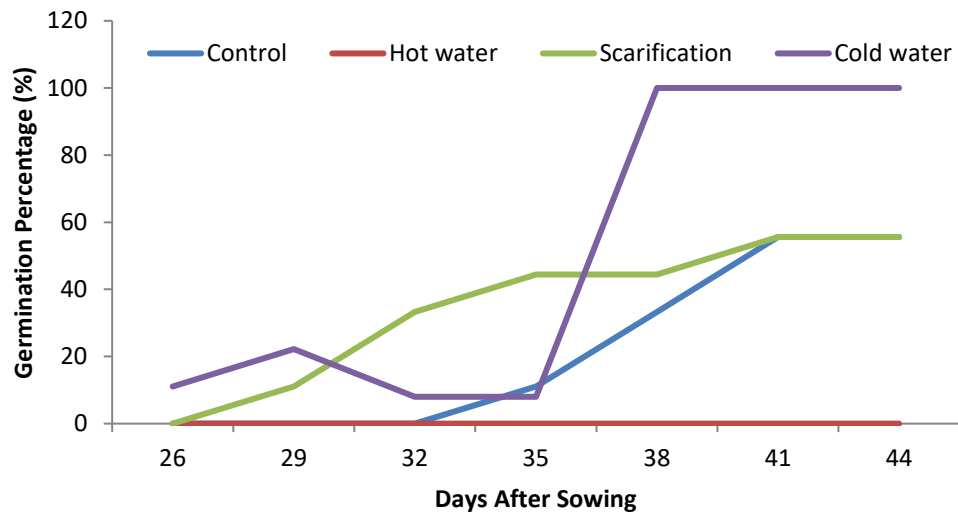


Figure 1: Germination of *C. albidum* seeds under the various pretreatments sown in Ikere soil

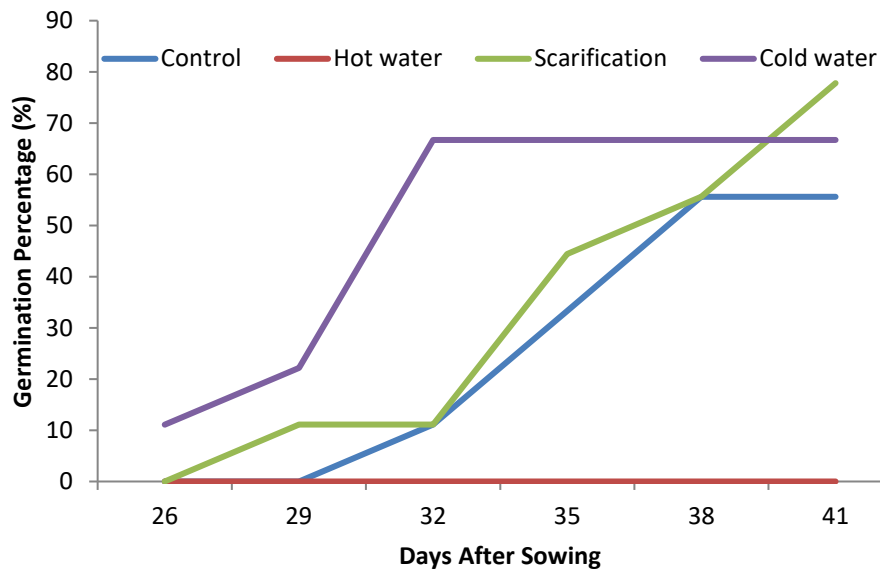


Figure 2: Germination rate of *C. albidum* seeds subjected to various pretreatments raised in Ayede soil

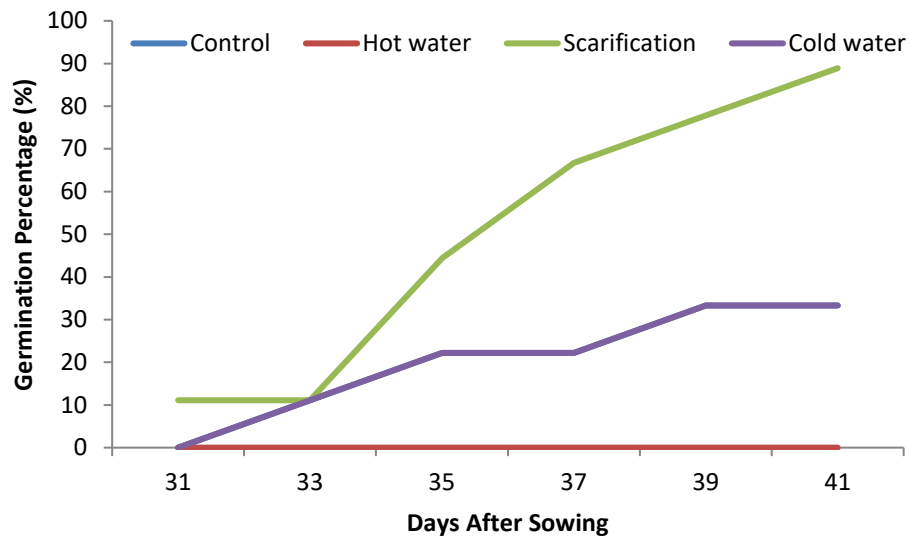


Figure 3: Germination of *C. albidum* seeds under different pretreatments sown in Igede-Isan soil

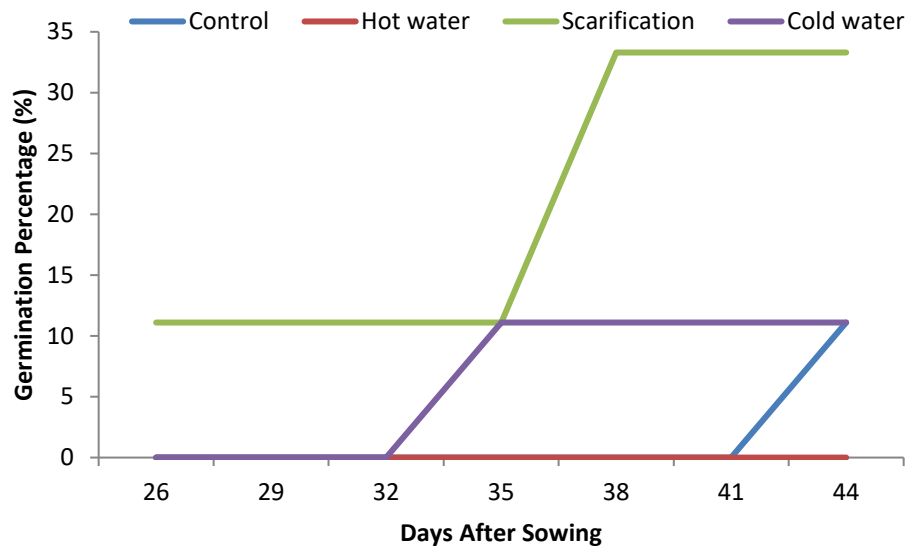


Figure 4: Germination rate of *C. albidum* seeds subjected to various pretreatments raised in Ado soil

Seedling Growth Variables

Results of the seedling growth variables of *C. albidum* are presented in Table 2. ANOVA result for the mean number of leaves revealed significance at 6 and 8 weeks, however, when DMRT was used to separate the means, it showed that at 6 weeks, the mean number of leaves for Ado was different from both Ikere and Ayede but not different from that of Igede-Isan. However, the means across the locations were not significantly different from one another at 8 weeks. Moreover, Ikere had the highest mean value of 3.17 while the least mean value was 2.00 and this was obtained across all the locations at different times during the assessment period.

ANOVA result did not indicate a significant difference in mean seedling height values of *C. albidum* in all the different locations throughout the

assessment period. However, when the mean values were considered, Igede-Isan had the highest value of 8.95 cm at 12 weeks, followed by 8.77 cm in Ikere while the least value of 5.25 cm was recorded in Ado at 2 weeks.

The result of ANOVA for mean collar diameter values of *C. albidum* revealed significant differences at 4, 6, and 8 weeks. When DMRT was used to separate the means, it showed that at 4 weeks, mean collar diameter values were not different from one another. Nevertheless, at 6 weeks, Igede-Isan differed from the other locations. Likewise, Igede-Isan differed from both Ikere and Ayede at 8 weeks but was not different from Ado. The highest mean collar diameter value of 0.35 cm was recorded in Igede-Isan at both 10 and 12 weeks closely followed by 0.34 cm under the same location while the least value of 0.30 cm was obtained in Ado at 4 weeks.

Table 2: Mean Values for Seedling Growth Variables in the Study Locations across the Assessment Period

Weeks	Mean Number of Leaves				Mean Seedling Height (cm)				Mean Collar Diameter (cm)			
	Ikere	Ayede	Igede-Isan	Ado	Ikere	Ayede	Igede-Isan	Ado	Ikere	Ayede	Igede-Isan	Ado
2	3.00	2.00	2.00	2.00	6.88	5.50	6.95	5.25	0.32	0.31	0.31	0.30
4	2.00	2.00	2.00	2.00	7.02	5.67	7.23	6.20	0.31	0.31	0.33	0.30
6	2.80 ^a	2.70 ^a	2.50 ^{ab}	2.00 ^b	7.68	6.35	8.10	6.30	0.31 ^b	0.31 ^b	0.34 ^a	0.31 ^b
8	3.00	3.00	3.00	3.00	8.03	6.73	8.23	6.40	0.31 ^b	0.31 ^b	0.34 ^a	0.33 ^{ab}
10	3.17	3.00	3.00	3.00	8.38	7.23	8.53	6.50	0.32	0.32	0.35	0.32
12	3.17	3.00	3.00	3.00	8.77	8.00	8.95	7.50	0.32	0.32	0.35	0.31

Rows without superscript did not indicate significance at that assessment period

Means with the same letter in each row are not significantly different at p 0.05

Some Soil Properties from the Study Locations

The results of the laboratory analysis of some soil properties of the study locations are shown in Table 3. When the soil textural diagram was used for sand, silt, and clay values of each location, it revealed that

Ikere and Igede-Isan are loamy sand while Ayede and Ado have sandy soil. Also, the highest value for Nitrogen was obtained in Ado while the least was obtained in Igede-Isan soil. The result of pH in water revealed all the values across the locations being close to neutral although that of Ikere appeared slightly acidic with the others slightly alkaline.

Table 3: Results of Laboratory Analysis of some Soil Properties from the Study Locations

Locations	pH (H ₂ O)	Sand	Silt	Clay)	N	P	K	Org matter
	g kg ⁻¹	g kg ⁻¹	g kg ⁻¹	g kg ⁻¹	g kg ⁻¹	g kg ⁻¹	g kg ⁻¹	g kg ⁻¹
Ikere	6.80	89.4	4.4	6.2	0.81	12.07	0.12	15.34
Ayede	7.30	90.4	4.4	5.2	1.74	17.06	0.43	36.03
Igede-Isan	7.35	88.4	4.4	7.2	1.64	26.62	0.35	28.27
Ado	7.25	91.4	4.4	4.2	1.69	6.15	0.34	30.34

Discussion

Germination of *Chrysophyllum albidum* in the Soils of the Different Locations subjected to Different Pretreatments. The various pretreatments impacted

the germination of *C. albidum* seeds differently. Scarification and cold water favoured the germination of *C. albidum* best whereas the result from the former appeared more consistent across

the locations. The untreated seeds (control) also germinated well giving above 50% germination in both Ikere and Ayede whereas hot water did not favour germination in all the locations. Aduradola *et al.* (2005) earlier reported that mechanical scarification enhanced germination in *C. albidum* seeds although their scarification method differed from the one adopted in this study. Similarly, Oyebade *et al.* (2012) used the mechanical method to overcome dormancy in *C. albidum* seeds and achieved between 21-53% germination although the description of the method used was not given. Hartmann *et al.* (1997) already defined scarification as any process of breaking, scratching, mechanically altering or softening the seed covering to improve the permeability of water and gases, and includes mechanical, chemical and hot water treatments. Therefore, irrespective of the way it is applied, the most important thing is for such a method to allow the imbibition of water and gases. Also, the fact that untreated seeds gave appreciable germination percentage in some locations in this study is similar to the result obtained by Olayode and Otufale (2018) who reported that freshly extracted seeds of *C. albidum* gave close to 100% germination and in a short time although watering frequency was controlled. However, Aduradola *et al.* (2005) reported that hot water treatment favoured the germination of *C. albidum* seeds. The fact that this result is different from those obtained in this study could be a result of the exposure time which in this study is much longer than what they adopted. It has been opined that sudden dip of seeds in boiling water leads to changes and subsequent germination of the embryo however, it may be detrimental when in excess leading to the death of the embryo.

Seedling Growth Assessment of *C. albidum* in the Soil obtained from the Different Locations

References

- Aduradola, A.M., Adeola, B.F. and Adedire, M.O. (2005). Enhancing germination in seeds of African star apple, *Chrysophyllum albidum* (G. Don). *Journal of Food, Agriculture, and Environment* 3(2): 292-294.
- Amusa, N.A., Ashaye, O.A., and Oladapo, M.O.B. (2003). Bio-deterioration of the African star apple (*Chrysophyllum albidum*) in storage and the effect on its food value. *African Journal of Biotechnology* 2: 56-59.
- Association of Official Analytical Chemists (A.O.A.C.). (2005). Official methods of analysis.
- Bada, S.O. (1997). Preliminary information on the ecology of *Chrysophyllum albidum* G. Don
- The result of the statistical analysis for all the growth variables had shown that there was no significant difference in most of the weeks across all the locations. This might have been because the soil used from each location was collected at a similar depth from forest reserve that harbours plantation. The soils from the various locations must have had similar characteristics as revealed in their properties many of which were very similar. Forest soil usually gets impacted by the recycling of organic matter and nutrients, including wood, litter, debris, and wide varieties of soil-dwelling organisms even where such forests were not naturally forested (Boyle, 2005). Likewise, the observed minor differences in the seedling growth variables might have resulted from the fact that all the locations were subjected to similar anthropogenic activities such as annual burning, cropping, and grazing. Furthermore, the values obtained for the growth variables appeared small. This is similar to the result of Olayode and Otufale (2018) on *C. albidum* seedlings despite the variations in watering frequencies. Also, Oyebade *et al.* (2012) reported data transformation of seedling growth variables in *C. albidum* before analysis; this must have enhanced the figures documented for the seedling growth variables which seemed bigger than what was observed in this study.

Conclusion

This study had indicated that *C. albidum* can be raised in the two ecological zones of Ekiti State. Furthermore, seeds pretreated with scarification and cold water during the experiment gave the highest germination percentage and rate which makes them the best methods of breaking seed dormancy in *C. albidum*. Untreated seeds of *C. albidum* will also yield good germination if they are sown soon after extraction

- in West and Central Africa *In Proceedings of a National Workshop on the Potentials of the Star Apple in Nigeria CENRAD Ibadan*. [Denton, O.A., Ladipo, D.O., Adetoro, M.A. and Sarumi, M.B. (eds)].
- Boyle, J.R. (2005). Forest Soils. In: Encyclopedia of Soils in the Environment. [Hillel, D., Rosenzweig, C., Powlson, D., Scow, K., Singer, M. and Sparks, D. (eds)]. Academic Press. 2: 73-79.
- Crouse, D.A. (2018). Soils and Plant Nutrients, Chapter 1. In: K.A. Moore and. L.K. Bradley (eds). North Carolina Extension Gardener Handbook. NC State Extension, Raleigh, NC.
<https://content.ces.ncsu.edu/extension-gardener-handbook/1-soils-and-plant-nutrients>
- Gbile, Z.O. (1997). Taxonomy of the African Star Apple (*C. albidum*) and related species *In: Proceedings of a National Workshop on the Potentials of the Star Apple in Nigeria CENRAD Ibadan*. 11-12. [Denton, O.A., Ladipo, D.O., Adetoro, M.A. and Sarumi, M.B. (eds)].
- Hartmann, H.T., Kester, D.E., Davies, F.T. Jr. and Geneve, R.L. (1997). Plant propagation principles and practices. 6th edn. Prentice Hall, New Jersey.
- Kazeem-Ibrahim, F., Asinwa, I.O., Iroko O.A., Aiyeyika, A.K. and Fapojuwomi, O.A. (2013). Investigation of fungi associated with the spoilage of *Chrysophyllum albidum* (G. Don) fruits. *Journal of Agriculture, Forestry and the Social Sciences* 11(1): 56-60.
- Okunomo, K. and Egho, E.O. (2010). Economic importance of some underexploited tree species in Nigeria: Urgent need for separate research centres. *Continental Journal of Biological Sciences* 3: 16-32.
- Olapade, E.O. (1997). Medicinal importance of *Chrysophyllum albidum*. *In: Proceedings of a National Workshop on the Potentials of the Star Apple in Nigeria CENRAD Ibadan*. [Denton, O.A., Ladipo, D.O., Adetoro, M.A. and Sarumi, M.B. (eds)].
- Olayode, O.O. and Otufale, G.O. (2018). Seedling emergence and growth of *Chrysophyllum albidum* G. Don (Syn. *Gambeya albida*) under different watering frequencies. *Academia Journal of Agricultural Research* 6(4): 086-092.
- Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Anthony, S. (2009). Agroforestry database: a tree reference and selection guide version 4.0 (<http://www.worldagroforestry.org/sites/tr-eedbs/treedatabases.asp>)
- Oyebade, B.A., Ekeke, B.A. and Aigbe, H.I. (2012). Provenance variations in *Chrysophyllum albidum* (G. Don) from six localities in Rivers State, Nigeria. *ARPJ Journal of Agricultural and Biological Science* 7(3): 157-162.
- Umelo, R. (1997). Potentials for utilization of Agbalumo (Yor.). (*Chrysophyllum albidum*) for jam making in Nigeria. *In: Proceedings of a National Workshop on the Potentials of the Star Apple in Nigeria CENRAD Ibadan*. [Denton, O.A., Ladipo, D.O., Adetoro, M.A. and Sarumi, M.B. (eds)].