



Research Article

Some aspects of the Seed Germination and Seedling Growth of two Savanna tree Species: *Prosopis africana* and *Dialium guineense*

Ajiboye A.A.¹, Fawibe O.O.², Atayese M.O.³ and Agboola D.A.^{2*}

¹Department of Biological Sciences, P.M.B. 4494, Osun State University, Osogbo, Osun State, Nigeria.

²Department of Biological Sciences, Federal University of Agriculture; P.M.B 2240, Abeokuta, Ogun State, Nigeria.

³Department of Plant Physiology and Crop Protection, Federal University of Agriculture; P.M.B 2240, Abeokuta, Ogun State, Nigeria.

Abstract: Studies were made on some aspects of the seed germination and seedling growth of two multipurpose trees. These include the effect of pre-sowing treatments, seed sizes and gibberellic acid on the germination of seeds and seedling growth. The tree species include *Prosopis africana* (Guill. & Perr.) Taub. and *Dialium guineense* (Wild). Two seed sizes designated small-size (Ss) and Big-size (Bs) were identified in the seed. The effect of gibberellic acid (GA₃) had a greater significance effect ($P \leq 0.05$) on seed germination of both *D. guineense* and *P. africana* seeds. The big size seeds had a significant effect ($P \leq 0.05$) on the seed germination when compared to the small size seeds. The hydration/dehydration, pre-sowing treatments on the seeds did not have any significant effects on germination.

Keywords: Seed germination, Seedling savanna trees, *Prosopis africana*, *Dialium guineense*, Pre sowing treatments.

1. Introduction

The savanna in Nigeria covers more than half of the country's land expanse (Agboola, 2004). It is delimited into three major zone types including the Guinea Savanna woodland (with northern and southern area), Sudan and Sahel savannah from the south to the North of the country. The delimitation is based on the woodiness, open space and areas covered by grasses (Nelson, 1965)

The savanna tree species of economic importance in Nigeria include *Vitellaria paradoxa*, *Parkia biglobosa*, *Albizia lebbek* and *Senna siamea* (Lam.), *Acacia albida*, *Azelia africana* etc.

The role of the legume trees in the Nigerian savanna cannot be under-estimated. The complex, balanced ecological situation assures that most of the nitrogen required by grass species is fixed naturally by leguminous plants. Wild species of the savanna plants, especially tree legumes, have been a significant source of edible fruits, vegetables, medicine, charcoal, gum,

resin and timber for carnival and construction and provide shade for man and livestock (Agboola, 2004). *Prosopis* trees are very drought resistant and are well adapted to the heat and poor soils of dry regions. The genus *Prosopis* thrives in light sandy or rocky soil. They are medium-size shrubs, short-trunked trees which can develop up to 20m tall. *D. guineense* is the most widespread in Nigeria. The tree is about 20m high.

Almost all plant species of natural agro-ecosystems of the tropics are under mycorrhizal infestations almost 85% of these tree species are infected by vesicular-arbuscular (VA) mycorrhiza. The ectomycorrhiza though found on fewer species are important because they occur on some of the most valuable timber trees of tropical forests. In the overwhelming majority of plant species that are mycorrhizal, their fungal associates occupy those distal parts of the roots which are involved in absorption of nutrients from the soil (Read, 1991). The importance of the ectomycorrhizal partnership is shown in the close physical relationship

*Corresponding author:
E-mail: jareagbo@yahoo.com.

between the fungus and its host tree. The mycorrhizas are vital for uptake and accumulation of ions from soil and translocation to host because of their high metabolic rate and strategically diffuse distribution in the upper soil layers (Mukerji *et al.*, 1991).

The fungus serves as a highly efficient extension of the host root system. Minerals like Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Silicon (S), Zinc (Zn) and Copper (Cu) absorbed from soils by mycorrhizal fungi are translocated to the host plant (Smith, 1992).

The aim of this research work is to study the germination of the seeds in two savanna multipurpose trees with the aim of reducing/terminating their physical dormancy. The study also aims at finding means of enhancing seedling growth and to initiate a symbiotic association between seedlings and ectomycorrhiza through soil inoculation. This is with a view to improving nutrient and water uptake of seedlings, thus enhancing their growth.

2. Materials and Methods

2.1 Seed procurement and processing

Seed of *P. africana* were collected from the tree stands after fruit fall in January-February 2005 from the savanna forest within the campus of the University of Ilorin, Ilorin (8.32N and 4.34E) Nigeria; the seeds of *D. guineense* were collected from the seeds store section of the Forestry Research Institute of Nigeria (FRIN) Jericho, Ibadan, Nigeria (Longitude 7°N and Latitude 4°E). The dried pods were cracked using gentle strokes from a granite stone of moderate size. The good seeds were hand-picked while the damaged ones were discarded.

2.2 Initial germination studies

Randomly selected seeds were surface sterilized with 5% sodium hypochlorite solution for 30 seconds and then rinsed in several changes of distilled water. The seeds (100) were put in 9cm Petri dishes lined with sterile filter paper and moistened with 5ml distilled water. The Petri dishes were kept in the laboratory at 30±2°C and germination was recorded daily.

2.3 Pre-sowing treatments

2.3.1 Chemical scarification

Seed lots were soaked in concentrated sulphuric acid (H₂SO₄) for the periods of 5-15 minutes. The seeds were then washed several times in distilled water and then plated for germination.

2.3.2 Mechanical treatments

Seed lots were mechanically scarified by abrasion of the testa using emery cloth (sandpaper) and

coarse sand for a period ranging from 5-30 minutes before plating for germination.

2.3.3 Wet heat treatments

Seeds subjected to wet heat treatments were immersed in hot water having 50°C, 60°C, 70°C, 80°C, 90°C and 100°C temperatures till they were cool in each case before preparing them for germination. The experimental design was the randomized block type. Data were subjected to analysis of variance.

2.4 Effect of Ectomycorrhiza on seed germination and seedling growth

A forty gram of ectomycorrhizal soil, which was procured from pine plantation of the Forestry Research Institute of Nigeria (FRIN) Jericho, Ibadan, Oyo state, Nigeria was added to both sterilized and unsterilized soil. Scarified seeds were sown into the inoculated soil. Seedling development was monitored in the greenhouse belonging to the Department of Plant Physiology and Crop Production of the Federal University of Agriculture (FUNAAB), Abeokuta, Nigeria. Growth parameters including plant height, petiole length, stem girth, leaf area and leaf number were taken at every week for a period of 12 weeks.

2.5 Relative field mycorrhiza dependency

Ectomycorrhiza and non-ectomycorrhizal inoculated seedlings of both *D. guineense* and *P. africana* were put in an oven preset to 103°C (Drying period). Their dry weight contents were determined according to the method of Plenchette (1975).

$$\text{RFMD} = \frac{\text{Dry wt. of inoculated plant} - \text{Dry wt. of noninoculated plant}}{\text{Dry wt. of noninoculated plant}} \times 100$$

The experimental design used was the randomized block type. Data were subjected to analysis of variance and means compared with least significance difference test (LSD¹).

3. Results

Fresh seeds of *D. guineense* required the treatments of 10-15 minutes of chemical scarification in H₂SO₄ for dormancy to be terminated (Fig. 1) while seeds of *P. africana* require 15 minutes of soaking in the same acid treatment to give up to 80-100% germination (Fig. 2).

Mechanical scarification by emery cloth abrasion had a significant effect ($P < 0.05$) on germination of *D. guineense* seeds. About 20-60% seed germination was recorded within 5-20 days after sowing. Whereas, 80% germination was observed within 25 days of sowing (Fig. 3).

However, no evidence of germination was observed in *P. africana* seeds when subjected to the same treatment.

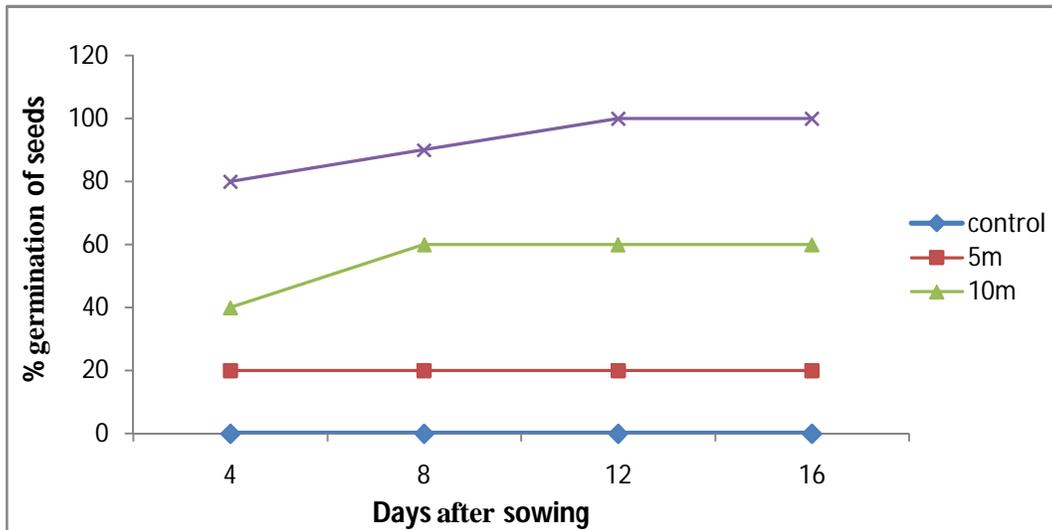


Fig. 1. Germination of *Dialium guineense* seeds treated with conc. sulphuric acid (H₂SO₄).

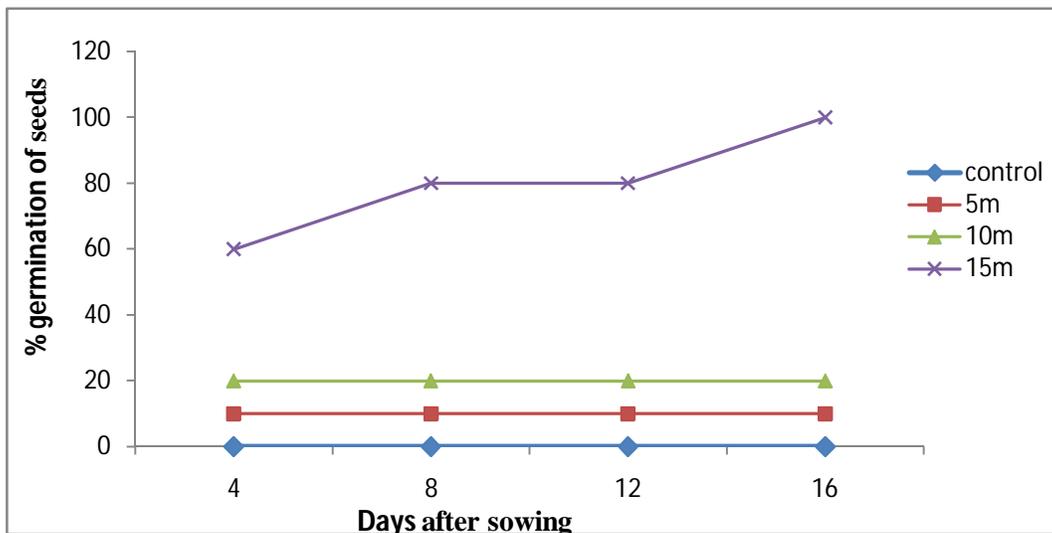


Fig. 2. Germination of *Prosopis africana* treated with conc. sulphuric acid (H₂SO₄).

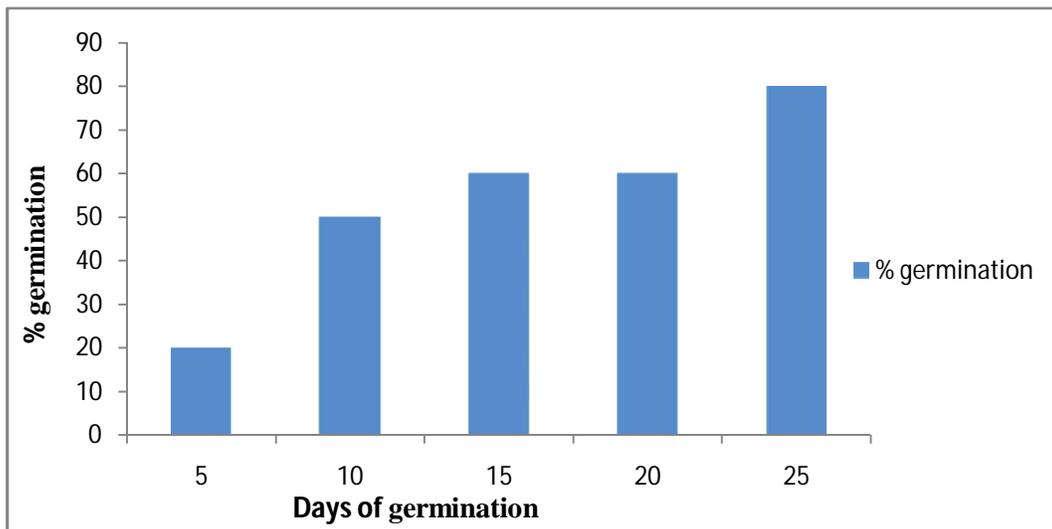


Fig. 3. Effect of emery cloth scarification on germination of *Dialium guineense* seeds.

The effect of wet heat treatments on germination of *P. africana* seeds at 50°C gave 10% germination within 9-12 days and 20% within 15 days (Fig. 4). The germination percentage increased sharply to about 50-60% within 18-24 days. The same trend was observed in seeds under wet heat treatment of 60°C. The result showed no germination percentage within 3-6 days of sowing (Fig. 4). Wet heat treatments on seeds at 70°C showed 0-10% germination in 3-10 days, and 30% within 12-24 days. There was no germination in seeds under 80°C treatment. Seeds under 90°C wet heat treatments showed 10-40% germination within 9-15 days and 50% germination within 21-24 days after sowing. Seeds in the wet heat of 100°C gave up to 10-30% germination within 3-24 days. The untreated seeds served as a control experiment (Fig. 4).

The effect of wet heat treatments on *D. guineense* showed about 0-20% germination within 3-12 days. 40-

50% germination was observed for the seeds subjected to 50°C; 10-30% germination within 3-15 days and 40-50% germination within 18-24 days (Fig. 5). The temperature adjusted to 70°C showed 20% germination within 3-15 days, 30% within 18 days and 40% within 21-24 days after sowing. There was similar germination in seeds under 80°C which showed 10-20% within 3-15 days, 30% within 18 days and 40% in 21-24 days.

The germination percentage decreased sharply in seeds under 90°C temperature treatment. This gave up to 0-10% germination within 3-15 days and 20% within 18-24 days (Fig. 5). The seeds treated with hot water (100°C) for this species showed 0-10% germination within 3-15 days, 20% in 18th day and up to 30% germination within 21-24 days. There was no germination observed in seeds in the control condition (Fig. 5).

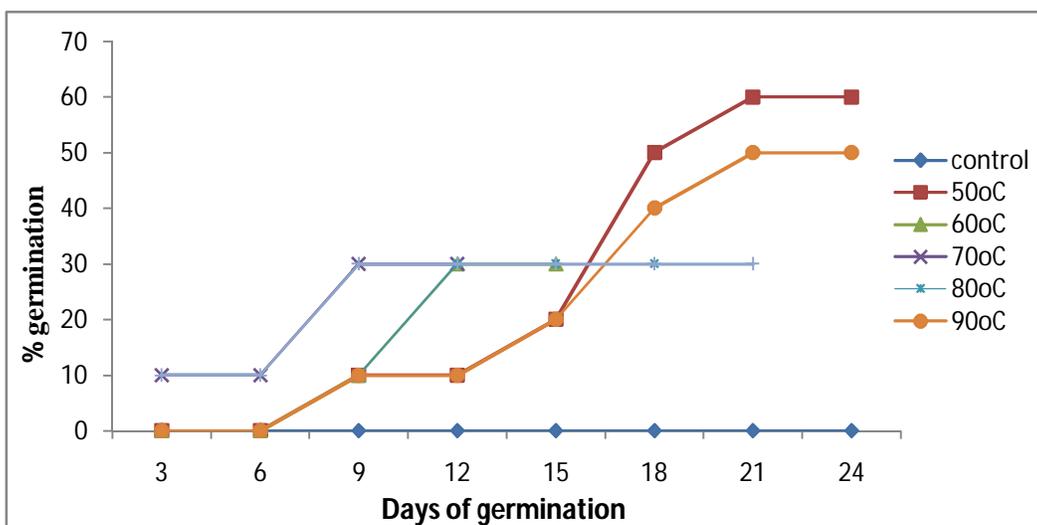


Fig. 4. Effect of wet heat treatments on germination of *Prosopis africana* seeds.

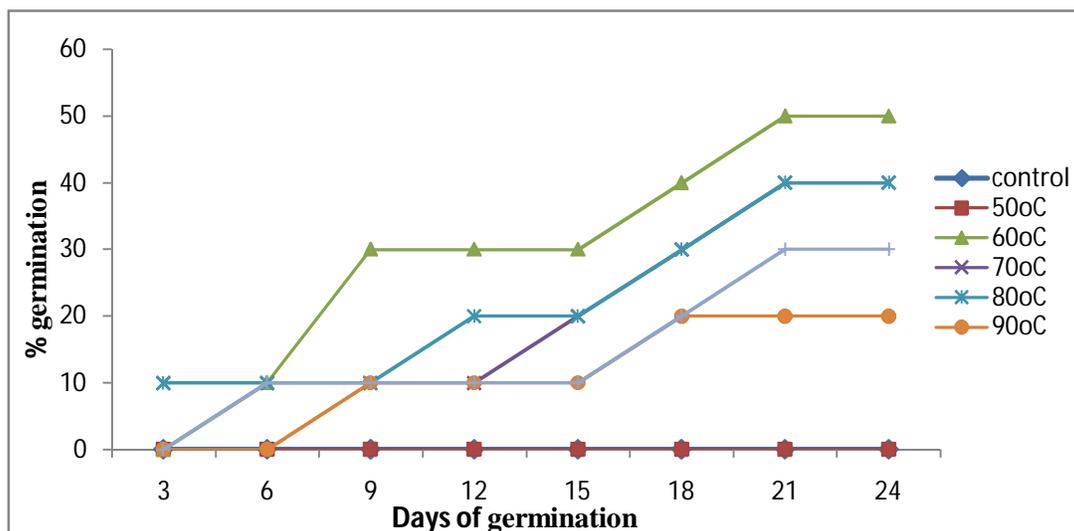


Fig. 5. Effect of wet heat treatments on germination of *Dialium guineense* seeds.

There was high significant effect ($P < 0.05$) of ectomycorrhiza on seedling growth of both *D. guineense* and *P. africana*. The ectomycorrhiza enhanced petiole length, growth, stem girth and leaf area on *D. guineense* seedlings while it did not in *P. africana* seedlings. For example, in *D. guineense* mean leaf areas of seedling in inoculated, non-sterilized, water stressed soil (M⁺NSWS) gave 11.03cm² when compared to 7.6cm² in seedlings in inoculated non sterilized soil water stressed soil. The mean stem girth of seedlings in (M⁺NSWW) non-inoculated, non-sterilized and well watered soil showed 0.18cm compared to 0.15cm shown in (M⁻NSWW). The petiole length of seedlings of *P. africana* was 0.80cm in inoculated non sterilized and well watered soil and 4.33cm in non-inoculated, non-sterilized and well watered soil (Table 1-2).

The relative field ectomycorrhizal dependency (RFMD) was 66 and 33% in *P. africana* and *D. guineense* respectively.

4. Discussion

Hard seed covering have been found to be impervious to water and gases. The proper enzymatic actions and proper mobilization of food materials for the growth of the embryo are hampered due to the impervious nature of their seed coats. Hence seeds of *P. africana* and *D. guineense* germinate readily after reducing the thickness of the seed coats by various methods of partial removal of the seed coats. Agboola (1996), showed the dry and wet heat treatments also reduce dormancy in the seeds of *P. africana* and *D. guineense*. There have been various instances where high temperature may cause changes in the structure of the seed coat, thereby causing permeability to water and

gases and enhance germination (Fasidi *et al.*, 2000). The seeds *P. africana* and *D. guineense* are among those that survive the annual bush burning. Some of the seeds affected sprout with early rains which could be explained by the changes in the structure of the testa due to temperature fluctuation in the savanna areas. This leads to the high influx of water with consequent development of the embryo and hence germination. These findings compared more closely with those of (Fasidi, Kadiri and Agboola, 2000). The degrees of dormancy in seeds have been associated with many reasons, including hardseededness (Hyde, 1954; Esau, 1965; Agboola, 1995; Diagne, 1992). Studies by Kozlowski (1991) have increasingly pointed out that the barrier effect of the seed coat could be due to the physical or chemical characteristics of the seed coats as well as the permeability changes to water, gases or solutes (Khan, 1980). The scarcity of water available to the embryo due impervious seed coats is no doubt an important aspect of dormancy (Agboola and Etejere, 1991). The higher significant effect found in the leaf number and petiole length of *D. guineense* and *P. africana* seedlings might be due to the inoculation of ectomycorrhiza to both sterilized and non-sterilized soils. The increased root length might be due to higher phosphorus contents in the soil. According to Pandey and Sinha (1972), phosphorus promotes healthy root growth. High nitrogen content of the soil increases the height, number of leaves, leaf and biomass production. Gerdemann (1975) defined responsiveness or relative field mycorrhizal dependency (RFMD) as the extent to which a plant requires mycorrhizal infection to produce its maximum growth and yield at a given level of soil fertility. This concept was modified by Plenchette *et al.*, (1983) for use with crop plants under field conditions.

Table 1. Effect of Ectomycorrhiza on the growth of *Dialium guineense* seedlings.

Soil Treatment	Plant Height (cm)	Stem Girth (cm)	Stalk Length (cm)	Leaf Number	Leaf Area (cm ²)
M ⁺ SSWM	6.74 ± 1.01	0.12 ± 0.41	3.63 ± 2.19	4.50 ± 0.55	7.64 ± 2.25
M ⁺ SSWS	7.91 ± 4.36	0.13 ± 0.05	6.33 ± 0.51	1.46 ± 0.27	10.5 ± 4.40
M ⁺ NSWS	9.68 ± 0.68	0.18 ± 0.04	3.85 ± 0.51	3.87 ± 0.36	11.03 ± 0.85
M ⁺ NSWW	7.89 ± 1.19	0.14 ± 0.04	2.82 ± 0.24	3.21 ± 1.62	6.23 ± 2.51
M ⁻ SSWS	8.12 ± 1.12	0.20 ± 0.00	5.83 ± 0.41	2.15 ± 0.08	11.43 ± 2.67
M ⁻ SSWW	9.15 ± 1.32	0.53 ± 0.14	5.00 ± 1.00	1.62 ± 0.69	8.51 ± 3.73
M ⁻ NSWW	6.73 ± 1.41	0.51 ± 0.15	3.09 ± 2.66	3.14 ± 1.56	7.42 ± 3.19
M ⁻ NSWS	8.33 ± 0.28	0.20 ± 0.00	6.50 ± 0.55	1.60 ± 0.42	9.12 ± 2.18

*significant; **highly significant (p= 0.05); M⁺ --- With mycorrhiza; M⁻ --- no mycorrhiza; SS --- sterilized soil; NS --- non sterilized soil; WW --- well watered; WS --- water stressed.

Table 2. Effect of ectomycorrhiza on the growth of *Prosopis africana* seedlings.

Soil Treatment	Plant Height (cm)	Stem Girth (cm)	Stalk Length (cm)	Leaf Number	Leaf Area (cm ²)
M ⁺ NSWS	5.96 ± 2.10	0.20 ± 0.00	0.93 ± 0.12	4.67 ± 0.58	4.13 ± 0.55
M ⁺ NSWW	4.78 ± 0.72	0.20 ± 0.00	0.80 ± 10.00	2.06 ± 0.89	4.26 ± 1.41
M ⁻ SSWS	10.96 ± 2.83	0.17 ± 0.06	8.67 ± 3.06	1.57 ± 0.26	15.10 ± 0.89
M ⁻ SSWW	6.79 ± 4.10	0.18 ± 0.05	4.33 ± 5.04	1.91 ± 0.15	9.31 ± 6.28
M ⁻ NSWW	7.47 ± 3.74	0.20 ± 0.00	4.63 ± 4.48	1.98 ± 0.58	9.38 ± 6.44
M ⁻ NSWS	8.93 ± 0.38	0.17 ± 0.06	9.67 ± 2.08	1.50 ± 0.36	± 3.72

*significant; **highly significant (p= 0.05); M⁺ --- With mycorrhiza; M⁻ --- no mycorrhiza; SS --- sterilized soil; NS --- non sterilized soil; WW --- well watered; WS --- water stressed.

Acknowledgment

The authors wish to acknowledge the cooperation and assistance of Dr. M.A. Atayese in the Department of Plant Physiology and Crop Production and the technologist in the Department of Biological Sciences at the Federal University of Agriculture, Abeokuta.

References

- [1]. Agboola, D.A. (1995). The effect of storage condition and soil depth on the longevity and germination of seeds of *P. africana*. *Journal of Tropical Forestry*, 11(11): 116-120.
- [2]. Agboola, D.A. (1996). Effect of seed pretreatments on the germination of seeds of some varieties of soya beans. *Madras Agricultural Journal*, 83 (4): 212-217.
- [3]. Agboola, D.A. and Z.O. Etejere (1991). Studies on seed dormancy of selected economic tropical forest tree species. *Nigerian Journal of Botany*, 4: 115-126.
- [4]. Agboola, D.A., A.O. Ebofin, A.M. Aduradola and A.A. Ajiboye (2004). Effect of presowing treatments on seed germination of two savanna tree legumes. *Journal of Tropical Forestry*, 20 (I & II): 17-24.
- [5]. Diagne, O. (1992). Current developments on *Prosopis* species in Senegal including work on nitrogen fixation. In *Prosopis Species: Aspects of their Value, Research and Development* ed. Dutton, R.W. pp. 47-60. Durham, UK: CORD, University of Durham.
- [6]. Esau, K. (1965). Seed coat. In: *plant Anatomy 2nd* ed. John Willey and Sons. Inc. New York Pp. 617-623.
- [7]. Fasidi, I.O., Tsamani, T., Kadiri, M. and Agboola, D.A. (2000). Dormancy types and water uptake in seed of *Parkia biglobosa* (Jacq.) R. Br. ex. G. Don. *Journal of Natural and Applied Sciences*, 1(1): 14-20.
- [8]. Gerdemann, V.W. (1975). Vesicular-Arbuscular Mycorrhizae. In: Torrey, J.G. and Clarkson, D.T. (eds); the development and function of roots. Academic Press, New York Pp. 575-591.
- [9]. Hyde, E.O.C. (1954). The function of the helium in some papilionaceae in relation to ripening of the seed and the permeability of the testa. *Annals of Botany*, 18: 241-256.
- [10]. Khan, A.A. (1980). The physiology and biochemistry of seed dormancy and germination. North Holland Co., New York, pp. 29-32.
- [11]. Kozlowski, T.T. (1971). Growth and development of trees. New York: Academic Press, vol. 1, pp 71-81.
- [12]. Mukerji, K.G., Jagpal, R., Bali, M. & Rani, R. (1991). The importance of mycorrhiza for roots. In B.L. McMichael & H. Persson (eds.). *Plant roots and their environment*, Elsevier, Amsterdam, Netherlands. pp. 290-308.
- [13]. Nielsen, M.S. (1965). Introduction to the Flowering plants of West Africa. University of London Press Ltd. Pp. 39-49.
- [14]. Pandey, S.N. and B.K. Sinha (1972). *Plant Physiology*. Vikas Publishing House, New Delhi, pp. 105-201.
- [15]. Plenchette, C., Fortin, J.A. and Furlan, V. (1983). Growth responses of several plant species to mycorrhizae in a soil of moderate P-fertility. I. Mycorrhizal dependency under field conditions. *Plant and soil*, 70: 199-209.
- [16]. Read, D.J. (1991). Mycorrhizas in ecosystems. *Experientia*, 47: 376-391.
- [17]. Smits, W.T.M. (1992). Mycorrhizal studies in Dipterocarp forests in Indonesia. In: Read D.J., Lewis, D.H., Fitter, A.H. and Alexander, I.J. (eds.). *Mycorrhizas in Ecosystems*. CAB International Wallingford, U.K., pp. 283-392.