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Research Article

Effects of pre-sowing techniques on selected seeds of savanna agroforestry tree species

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Abstract

The ability of a forest ecosystem to regenerate is crucial for its sustainable exploitation and conservation. Hence, seed is a fundamental material for regeneration. Germination requirements of seeds were investigated at the Forest Nursery Unit of Federal University Dutsin-Ma to assess the effects of pre-sowing techniques on selected seeds of savanna agroforestry tree species. A 5 x 5 factorial in randomized complete block design was used for this experiment in four replicates. The factors were agroforestry tree seeds (AFTS); *Acacia nilotica* (AN); *Parkia biglobosa* (PB); *Diospyros mespiliformis* (DM^k); *Detarium microcapum* (DM^t); *Adansonia digitata* (AD) and pre-sowing treatments; Seeds soaked in 60 % diluted Tetraoxosulphate (VI) acid (H_2SO_4) (A); mechanical scarification (Ms); hot water at 60^0 C (HW); seeds soaked in water for 24 hours (W); control (C). AD seeds had significantly higher values (13.84, 4.64, and 10.50) on the wet weight of shoot (WWS), dry weight shoot (DWS), and wet weight of root (WWR) at 10 weeks after sowing (WAS), respectively. *A. digitata* seeds experienced consistent significantly higher values (13.81. 13.84, 13.89, 13.89 and 13.81, and 4.62, 4.72, 4.60, 4.57 and 4.71) on WWS and DWS at 10 WAS respectively. Mechanically scarified seeds had significantly higher value (2.11) on DWS at 10 WAS. Therefore, mechanical scarification significantly affects the agroforestry tree species of *A. digitata* among others. Based on this, we recommend mechanical scarification as an effective pre-sowing technique to break seed dormancy and increase seedling biomass.

Key words: Seeds, pre-sowing techniques, growth performance, tree species

Résumé

La capacité d'un écosystème forestier à se régénérer est cruciale pour son exploitation et sa conservation durables. Par conséquent, la semence est un matériau fondamental pour la régénération. Les exigences de germination des graines ont été étudiées à l'unité de pépinière forestière de l'Université fédérale Dutsin-Ma pour évaluer les effets des techniques de pré-semis sur des graines sélectionnées d'espèces d'arbres agroforestiers de savane. Un factoriel de 5 x 5 dans une conception en blocs complets randomisés a été utilisé pour cette expérience en quatre répétitions. Les facteurs étaient les semences d'arbres agroforestiers (AFTS); Acacia nilotica (AN); Parkia biglobosa (PB); Diospyros mespiliformis (DMk); Detarium microcapum (DMt); Adansonia digitata (AD) et traitements de pré-semis; Graines trempées dans de l'acide tétraoxosulfate (VI) dilué à 60 % (H2SO4) (A); scarification mécanique (Ms) ; eau

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chaude à 600 C (EC); graines trempées dans l'eau pendant 24 heures (W); contrôle (C). Les graines AD avaient des valeurs significativement plus élevées (13,84, 4,64 et 10,50) sur le poids humide de la pousse (WWS), le poids sec de la pousse (DWS) et le poids humide de la racine (WWR) à 10 semaines après le semis (WAS), respectivement. Les graines d'A. digitata ont présenté des valeurs significativement plus élevées (13,81, 13,84, 13,89, 13,89 et 13,81, et 4,62, 4,72, 4,60, 4,57 et 4,71) sur WWS et DWS à 10 WAS respectivement. Les graines scarifiées mécaniquement avaient une valeur significativement plus élevée (2,11) sur DWS à 10 WAS. Par conséquent, la scarification mécanique affecte de manière significative les espèces d'arbres agroforestiers d'A. digitata entre autres. Sur cette base, nous recommandons la scarification mécanique comme technique de pré-semis efficace pour briser la dormance des graines et augmenter la biomasse des semis.
Mots clés : Semences, techniques de pré-semis, performances de croissance, espèces d'arbres

Introduction

Agroforestry tree species provide an array of medicinal, nutritional, and industrial products which have direct importance to the safety of the people of the most African countries, especially in the West and Central parts of the tropics (Kokutse *et al.,* 2014; Alaba *et al.,* 2015). Most indigenous agroforestry tree species are raised in the nursery and also grown naturally in the wild and are widespread in the various ecological zones for their multiple uses (Mathowa *et al*., 2014). Seed is fundamentally the major material for regeneration (both natural and artificial), hence, without viable seeds tree establishment may not be possible (Oyebamiji *et al.,* 2014). It should be noted that propagation through seeds is a very cheap method of agroforestry tree establishment and also ensures accuracy in terms of quantity when raised in the nursery (Oyebamiji *et al.,* 2018a). Germination of seeds are mainly through sexual means, and this dominate most of savanna tree species regeneration (Ky-Dembele *et al.,* 2007). Germination of some savanna seeds are often times difficult due to their hard seed coats even when the conditions for germination such as moisture, oxygen, light and soil are favourable (Jaiswal and Chaudhary, 2005) However, to overcome this problem, several methods including mechanical scarification, soaking in water and acids (Patane and Gresta, 2006), chilling and heating (Iakovoglou and Radoglou, 2015) and irradiation (Jan *et al*., 2012; Aref, 2016) are used to pre-treat the seeds before sowing. Asinwa *et al.* (2008); Jegede *et al.* (2011) and Adeniji *et al.* (2017) used hot water treatment to break dormancy of *Canavalia ensiformis, Diospyrosmes piliformis* and *Acacia auriculiformis* seeds. They observed that seed germination responded positively to hot water treatments.

These and several pre-sowing treatments have been used and proven successful to overcome seed coat-imposed dormancy (Tigabu and Oden, 2001). For smoke treatment, particularly *Terminalia avicennioides*, results did not agree with the findings of Dayamba *et al.* (2008) where smoke had positive effect on germination, although the overall germination was low. Dayamba *et al.* (2008) used aerosol smoke which was more efficient than smoked water (Flematti *et al.*, 2004). Smoke and heat did not have any additive effect, although, seed coat could be cracked by heat, but the dose of liquid smoke used might not be sufficient to stimulate germination (Dayamba *et al*., 2008). However, the germinated species of *Prosopis africana*, *Poliostigma thonningii* and *Poliostigma reticulatum*) had the results which were consistent with those obtained by Razanamandranto *et al.* (2005) and Dayamba *et al.* (2008) who discovered that smoke treatment under laboratory conditions was not very efficient in stimulating germination in seeds with physical dormancy as being discovered in their study. There is a need for pre-germination treatments on the seed in order to break the hard seed coat that hinders the permeability of water into the seed for easy domestication (Desbiolles, 2002).

Pre-sowing treatments for seed germination have resulted in significant improvements in rapid and uniform field emergence, which essentially determine uniform growth, improved seedling quality, increased yield, and ultimately profits (El-Dengawy, 2005).

Seeds which are not given appropriate pre-treatment may fail to germinate altogether. Germination may be slow or can take place in an individual seed over a long period of time. The germination of this species can be improved using suitable pre-sowing techniques (explain this trend and reference it). Conscientious efforts must be made to promote appropriate and adequate seed pre-germination methods to make seedlings available for re-afforestation and reclamation projects to meet both local and international demands (Oyebamiji *et al.,* 2018b). Pre-sowing treatments of seed are intended to improve the survival or germination of seeds after sowing, and this is especially important in species which exhibit dormancy. The recent awareness of the potential of the species has increased the demand for its seedlings (Ademola *et al.,* 2005), even though, the trees are endangered aandgoing to extinction from our tropical high forest ecosystem even. Hence, the study investigated effective techniques of breaking seeds dormancy of some selected savannah agroforestry tree species for their improved physiological growth.

Materials and Methods

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 (Fig 1) with an annual rainfall of 700 mm, which is spread from May to September. The mean annual temperatures range from 29-31º C; 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.,* 2018b).

Experimental procedure

The experimental materials used were: 60 % diluted Tetraoxosulphate (VI) acid (H_2SO_4) solution, water, river sand, topsoil and cow dung, watering can, 40 cm x 32 cm polythene tubes and emery cloth. A potting mixture was prepared by sieving the topsoil, river sand and cow dung with a mixture ratio of 1:1:1 (topsoil plus river sand plus manure) using 2 mm sieve. The topsoil and river sand used were collected from the Department of Forestry Dutsin- Ma Local Government of Katsina State. Cow dung was collected at the Federal University Dutsin-Ma Livestock Farm, while agroforestry tree seeds (*Parkia biglobosa, Acacia nilotica, Detarium microcarpum, Diospyros mespiliformis and Adansonia digitata*) were procured from the Federal College of Mechanization, Afaka, Kaduna State, Nigeria. The viability test was carried out before experimentation, using the simple floating method following the procedure of Agbogidi *et al.* (2007). The seeds were dropped into a beaker containing water. The seeds that floated indicated that they were not viable. Such seeds were removed and replaced. One thousand (1000) viable seeds were sterilized with 5 % sodium hypochlorite solution for 45 seconds to make the seeds free of contamination and healthy before sowing and then thoroughly rinsed in distilled water. A total of 200 viable seeds were treated for each of the agroforestry tree seeds to make a total of 1000 seeds. The experiment was then laid out as a 5 x 5 factorial in a Randomized Complete Block Design (RCBD) with agroforestry tree seeds and pre-germination treatments as factors. The dormant seeds of agroforestry trees that were subjected to pre-sowing treatments and the experimental design of the research are presented in Table 1 below:

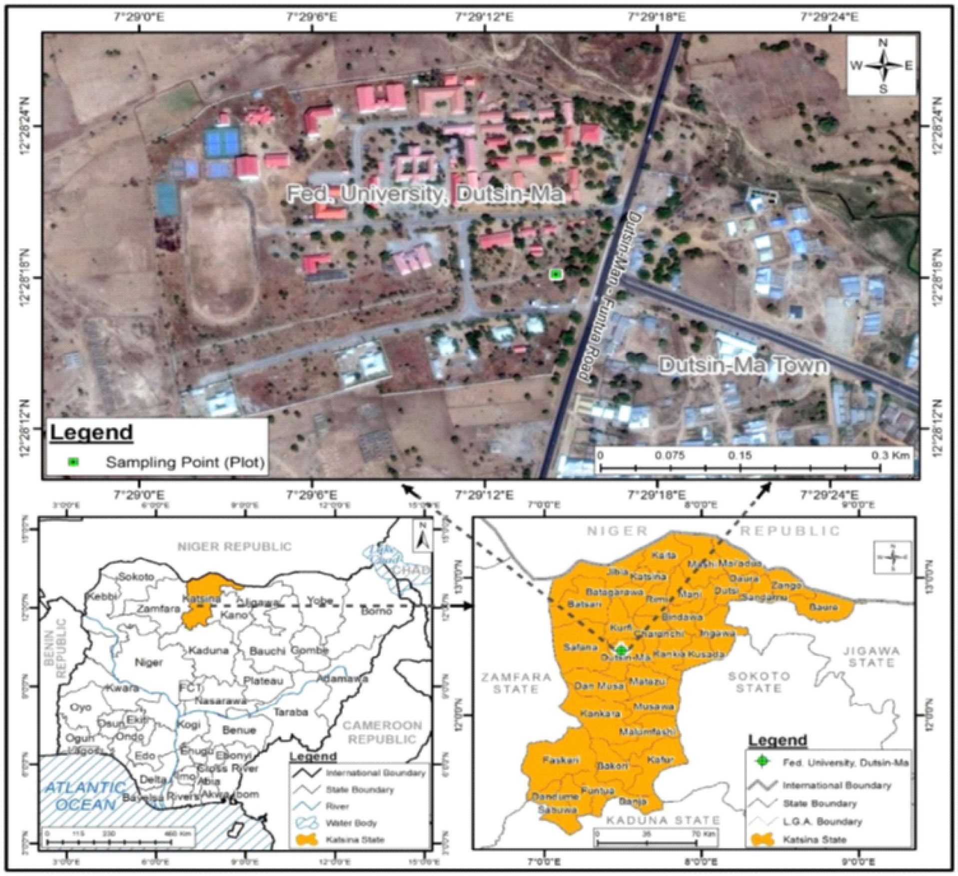

Fig 1: Study area, Federal University Dutsin-Ma showing.
Source: Map Gallery, Geography Department, ABU, Zaria (years)

Table 1: Dormant seeds of agroforestry trees subjected and pre-sowing treatments.

Abbreviation	***Agroforestry trees subjected***
AN	*Parkia biglobosa* seeds
PB	*Acacia nilotica* seeds
DM^k	*Detarium microcarpum* seeds
DM^t	*Diospyros mespiliformis* seeds
AD	*Adansonia digitata* seeds
	Pre-sowing treatments
A	Seeds soaked in 60 % diluted Tetraoxosulphate (VI) acid (H_2SO_4)
Ms	Mechanical scarification at the micropyle
HW	Hot water at 60^0 C
W	Seeds soaked in water for 24 hours

Observation was daily, while data was collected at a 2-week interval. The physiological parameters of wet and dry weight of shoots and roots were measured on three (3) randomly tagged seedlings and recorded.

Data analysis

The data on Influence of pre-sowing techniques on some selected seeds of savanna agroforestry tree species as it improves their physiological growth potentials were subjected to Analysis of Variance (ANOVA) with the general linear model (GLM) procedures of Statistical Analysis System

(SAS, 2003) software. The Fishers' Least Significant Difference (F- LSD; P= 0.05) was used to separate the means of differences among the treatments.

Results

Wet and dry weight of shoot

A. digitata seeds had significantly higher values (13.84 and 4.64) on the wet and dry weight shoot at 10 WAS. *D. mespiliformis* seeds had significantly lower values (0.77 and 0.38) for wet and dry weight of shoot at 10 WAS respectively. Meanwhile, seeds that were mechanically scarified had significantly higher values (2.11) on dry weight of shoot at 10 WAS. There was no significant difference among the pre- sowing treatments on wet weight of shoot at 10 WAS (Table 2).

Table 2: Pattern of agroforestry tree seeds and pre-sowing treatments in the wet and dry weight shoot at 10 weeks after sowing.

Treatment	Wet weight shoots	Dry weight shoots
AF tree seeds		
Acacia nilotica	3.25^{d}	2.15^{b}
Parkia biglobosa	3.41^{c}	1.70^{c}
Detarium microcarpum	3.60^{b}	1.49^{d}
Diospyrus mespiliformis	0.77^{e}	0.38^{e}
Adansonia digitata	13.84^{a}	4.64^{a}
SE±	0.108	0.015
Pre- sowing treatments		
Acid	4.97	2.06^{ab}
Mechanical scarification	4.99	2.11^{a}
Seeds soaked in hot water at 60^{0} C	4.98	2.04^{b}
Seeds soaked in water at room temperature for 24 hours	4.96	2.05^{ab}
Control	4.98	2.09^{ab}
SE±	1.05	0.324
Interaction		
ST	S*	S*

Means followed by the same letters within the same column and treatment are not significantly different at 5 % level of probability using Fisher's Least Significant Difference (F-LSD). SE±: Standard Error, ST: Interaction between agroforestry tree seeds and pre-sowing treatments, S*: Significant, AF: Agroforestry.

Wet and dry weight of root

A. digitata seeds had a significantly higher value (10.50) on wet weight of root among other selected seeds at 10 WAS. Meanwhile, *D. microcarpum* had a significantly higher value (4.09) on dry weight of root than the others. There was no significant difference in pre-sowing treatments on both wet and dry weight of root (Table 3).

Table 3: Pattern of agroforestry tree seeds and pre-sowing treatments in the wet and dry weight root at 10 weeks after sowing.

Treatment	Wet weight of root	Dry weigh root
AF tree seeds		
Acacia nilotica	0.80[d]	0.57[d]
Parkia biglobosa	1.80[b]	1.17[c]
Detarium microcarpum	1.07[c]	4.09[a]
Diospyros mespiliformis	0.19[e]	0.12[e]
Adansonia digitata	10.50[a]	2.04[b]
SE±	0.033	0.694
Pre- sowing treatments		
Acid	2.88	0.93
Mechanical scarification	2.81	4.34
Seeds soaked in hot water at 60^0 C	2.85	0.90
Seeds soaked in water at room temperature for 24 hours	2.91	0.92
Control	2.91	0.91
SE±	0.883	0.801
Interaction		
ST	S*	S*

Means followed by the same letters within the same column and treatment are not significantly different at 5 % level of probability using Fisher's Least Significant Difference (F-LSD). SE±: Standard Error, ST: Interaction between agroforestry tree seeds and pre-sowing treatments, S*: Significant, AF: Agroforestry

Interaction between agroforestry tree seeds and pre-sowing treatments on the wet and dry weight of shoot

The wet weight of the shoot was comparable among the seeds and treatments. *A. digitata* seeds experienced consistent significantly higher values (13.81. 13.84, 13.89, 13.89, and 13.81) in the wet weight shoot at 10 WAS. While *D. mespiliformis* experienced significantly lower values (0.80, 0.78, 0.75 and 0.80) on the wet weight of shoot among other agroforestry tree seeds at 10 WAS. Furthermore, *A. digitata* consistently had significantly higher values (4.62, 4.72, 4.60, 4.57 and 4.71) on the dry weight of shoot at 10 WAS, while *D. mespiliformis* had significantly lower values (0.40, 0.40, 0.37, and 0.40) on dry weight of shoot at 10 WAS respectively (Table 4).

Interaction between agroforestry tree seeds and pre-sowing treatments on the wet and dry weight of root

A *digitata* also had consistently significantly higher values (10.50, 10.34, 10.54, 10.70, and 10.44) on wet weight of root at 10 WAS, while *D. mespiliformis* had significantly lower values (0.18, 0.20, 0.18, 0.21, and 0.20) on wet weight of root at 10 WAS among other agroforestry tree seeds, respectively. However, *A. digitata* had significantly higher values (2.02, 2.09, 2.02, 2.10 and 2.12) at 10 WAS among other agroforestry tree seeds on dry weight of root at 10 WAS, while *D. mespiliformis* had significantly lower values (0.13, 0.12, 0.12, 0.12, and 0.12) on dry weight of root at 10 WAS respectively (Table 5).

Table 4: Interaction between agroforestry tree seeds and treatments on wet/dry weight of shoot at 10 weeks after sowing.

Treatment	Acid	Mechanical Scarification	Hot water	Water	Control
AF tree seeds	WWS at 10 WAS				
Acacia nilotica	3.21^{ef}	3.34^{d-f}	3.30^{d-f}	3.17^{f}	3.30^{d-f}
Parkia biglobosa	3.43^{cd}	3.40^{dc}	3.43^{cd}	3.38^{de}	3.43^{cd}
Deterium microcarpum	3.60^{bc}	3.60^{bc}	3.59^{bc}	3.63^{b}	3.60^{bc}
Diospyros mespiliformis	0.80^{g}	0.78^{g}	0.75^{g}	0.75^{g}	0.80^{g}
Adansonia digitata	13.81^{a}	13.84^{a}	13.89^{a}	13.89^{a}	13.81^{a}
SE±	0.055	0.047	0.039	0.051	0.043
	DWS at 10 WAS				
Acacia nilotica	2.15^{c}	2.20^{c}	2.08^{c}	2.20^{c}	2.20^{c}
Parkia biglobosa	1.71^{d}	1.71^{d}	1.69^{d}	1.71^{d}	1.72^{d}
Deterium microcarpum	1.50^{e}	1.53^{e}	1.48^{e}	1.48^{e}	1.48^{e}
Diospyros mespiliformis	0.40^{f}	0.40^{f}	0.40^{f}	0.37^{f}	0.40^{f}
Adansonia digitata	4.62^{ab}	4.72^{a}	4.60^{b}	4.57^{b}	4.71^{a}
SE±	0.028	0.041	0.024	0.089	0.028

Means followed by the same letters within the same column and treatment are not significantly different at 5 % level of probability. SE±: Standard Error.

Table 5: Interaction between agroforestry tree seeds and treatments on wet/dry weight of root at 10 weeks after sowing.

Treatment	Acid	Mechanical Scarification	Hot water	Water	Control
AF tree seeds					
	WWR at 10 WAS				
Acacia nilotica	0.90^{de}	0.66^{e}	0.70^{e}	0.75^{e}	1.05^{d}
Parkia biglobosa	1.80^{c}	1.82^{c}	1.75^{c}	1.80^{c}	1.81^{c}
Deterium microcarpum	1.08^{d}	1.10^{d}	1.10^{d}	1.10^{d}	1.06^{d}
Diospyros mespiliformis	0.18^{f}	0.20^{f}	0.18^{f}	0.21^{f}	0.20^{f}
Adansonia digitata	10.50^{ab}	10.34^{b}	10.54^{ab}	10.70^{a}	10.44^{ab}
SE±	0.058	0.073	0.062	0.028	0.106
	DWR at 10 WAS				
Acacia nilotica	0.58^{b}	0.60^{b}	0.57^{b}	0.58^{b}	0.57^{b}
Parkia biglobosa	1.28^{b}	1.13^{b}	1.11^{b}	1.12^{b}	1.20^{b}
Deterium microcarpum	0.68^{b}	0.74^{b}	0.70^{b}	0.70^{b}	0.64^{b}
Diospyros mespiliformis	0.13^{b}	0.12^{b}	0.12^{b}	0.12^{b}	0.12^{b}
Adansonia digitata	2.02^{a}	2.09^{a}	2.02^{a}	2.10^{a}	2.12^{a}
SE±	0.022	3.433	0.016	0.017	0.025

Means followed by the same letters within the same column and treatment are not significantly different at 5 % level of probability. SE±: Standard Error.

Discussion

The results obtained from the study showed that there was a significant effect (P 0.05) of the *A. digitata* agroforestry tree seeds on the wet weight of shoot and root, and the dry weight of shoot and root at 10 WAS, respectively. This is possible because of an increase in morphological growth in terms of seedling plant height, collar diameter, and broad leaf area, and this is in agreement with the report of Oyebamiji *et al.* (2018b), who said increase.morphological components influence increased seedling biomass. This kind of significant relationships were observed between seed morphological characteristics and seedling vigour in *Terminalia invorensi* A. Chev as cited by Okunlola *et al.* (2011). These parameters may be very useful in the promotion of rapid production of vigorous seedlings for nursery establishment or species for plantation establishment (Okunlola *et al.,* 2011).

A significant difference was only observed in the pre-sowing treatment of mechanical scarified seeds on the dry weight of the shoot, among others. Mechanically scarified seeds were observed to have a greater effect on the wet and dry weight of the shoot and root. This is possible as a result of an abrasion effect that has taken off the hard seed coat and thereby provided access for easy penetration of water and oxygen and thereby improved the rapid germination of the seeds (Oyebamiji *et al.,* 2019). Oyebamiji *et al.* (2014) also reported that seeds scarified at the micropyle region experienced improved seedling morphological component development.

However, no significant difference was observed in all the pre-sowing treatments employed on wet weight of shoot, weight of root and dry weight of root respectively. This showed that seeds' pre-sowing treatments did not significantly affect the performance of agroforestry treeseeds investigated.

Furthermore, *A. digitata* agroforestry tree seeds consistently produced improved physiological potentials of biomass on both wet and dry weight of shoot and root at 10 WAS, respectively. The seeds pre-treated with diluted Tetraoxosulphate (VI) acid (H_2SO_4) also induced germination progressively, which in turn must have reduced the hard seed coats of the seeds. This is in line with Olatunji *et al.* (2012) results, who reported that seeds soaked in acid for a few minutes but not more than ten minutes enhance adequate seed germination. Ariana *et al.* (2011) confirmed that seeds left in acid for more than ten minutes may have their embryo damaged or destroyed, preventing germination.

High and deliberate care must be taken with seeds soaked in hot water because seeds soaked above the boiling point could damage the seed embryo (cotyledon) as reported by Mwase and Mvula (2011), and this method has been tested to be preferred in breaking the dormancy of hard-coated seeds of most tropical forest seeds (Azad *et al.,* 2011). Therefore, pre-sowing treatments are necessary in seed germination for improved growth and yield (Dayamba *et al.,* 2014). In practical terms, several pre-sowing treatments such as hot water, the use of Tetraoxosulphate (VI) acid/sulphuric acid and mechanical scarification have been used and tested successfully to overcome hard seed coat that imposed dormancy (Tigab and Oden, 2001). The interaction between agroforestry tree seeds and pre-sowing treatments was comparable, and the seeds pre-treated with different pre-sowing treatments significantly influenced the wet and dry weight of shoot and root at 10 WAS respectively.

Conclusion

The result revealed that the vital role of pre-sowing treatments of seeds before sowing for adequate and approximate germination cannot be underestimated. Therefore, adequate germination of seeds is determined by appropriate pre-sowing techniques employed.

A. digitata seeds that were mechanically scarified had increased biomass of wet and dry shoots and roots, respectively. Generally, agroforestry tree seeds that were mechanically scarified among other techniques were observed to be effective for breaking seed dormancy in the selected savannah seeds for improved shoots and root biomass. This will in turn promote the establishment of plantation and afforestation programmes, reclamation projects by individual interested farmers, government, and non-governmental organizations (NGOs), and soil and wind control mechanisms in the areas where they are most needed.

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