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EFFECTS OF BOILED WATER ON GERMINATION POTENTIAL AND EARLY GROWTH OF Faidherbia albida. (Del.) A. Chev. SEEDS IN KADUNA NORTHERN GUINEA SAVANNAH AGROLOGICAL ZONE OF NIGERIA

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Abstract

Boiled water pre-sowing treatment regime for improvement of germination, survival and early growth performance of Faidherbia albida (Delile) A. Chev. Seeds.The study was conducted in Savannah Forestry Research nursery at Bomo, Zaria. Matured seeds of F. albida were harvested, dried and cleaned, each treatment replicate, one hundred (100) F. albida seeds were immersed in boiled water (100ºC) for 0, 15, 30, 60, 90 and 150 seconds and then, soaked in water at room temperature for 24 hours as control. Seeds were then sown in drills on well prepared seed beds, watering was done to keep the soil moist in the morning and late evening and then observed for germination. The experiment was laid down using Completely Randomized Block Design (CRBD). The results revealed that Germination index (P= 0.72), Mean Germination Time (P = 0.77), Days to Final Germination (P= 0.34), and Number of leaves (<0.001) were not significantly influenced by pre-sowing treatment. While, pre-sowing treatment significantly influenced Final Germination percentage (<0.001), Germination Rate (<0.001), Survival Percentage (P =0.05), Seedling height (<0.003), Root length (<0.004), Total seedling length (<0.001) and Collar diameter (P=0.0014). Boiled water pre-sowing treatment was found to be effective in enhancing the seed germination and growth of F. albida seedlings at varying degrees in Kaduna Northern Guinea Savannah Ecological zone. However, it is recommended that for easy multiplication of seedlings of Faidherbia albida for plantations establishment in Kaduna Northern Guinea Savanna Ecological Zone, immersing seeds in boiled water at 100^{0}C for 15seconds or 150 seconds before soaking in tap water for 24 hours T3(15/24) and T7(150/24) were effective and recommended for nursery workers.

Key Words: *Savannah, Boiled water, Growth, Germination, Kaduna, Dormancy, Inhibition*

Introduction

Faidherbia albida (Del.) A. Chev. belongs to the genus *Acacia* sub-family Mimosoideae of the family Leguminosae (Fagg, 1995; Barnes and Fagg, 2003). It is a tree, up to 30m high. Its crown is usually rounded in mature trees with spreading branches (Barnes and Fagg, 2003). In West Africa the species thrive in humid tropical conditions with mean annual rainfall of 1800 mm and a mean annual temperature of 28°C (Dutta, 1984) within an absolute range of 0-42°C (Baumer, 1983). Where rainfall is low, its occurrence is therefore generally limited to watercourses where groundwater is present. *F. albida* occurs on a remarkably wide range of soils. Most characteristically, it colonizes deep sandy clay soils, particularly alluvial deposits along the flood plains of rivers (Sturmheit, 1989; Sanusi *et al.,* 1992). It will, however, grow on sandy soils (Acocks, 1988; Alexandre and Ouedraogo, 1991; Brouwer *et al.,* 1991).

In Nigeria, *F. albida* occurs in various habitats, ranging from alluvial soils of perennial or seasonal water courses, to open savanna woodland and cultivated land. The trees occur singly or gregariously, widespread along rivers and water depressions (Sahni, 1968; El Amin, 1990). Herbivores are the main dispersal agents; the pods are highly palatable and nutritious and eaten in huge quantities (Wickens, 1969). The tree is best used in agroforestry; its nitrogen rich leaves which are shed at the beginning of the rainy season, significantly improve and fertilize the soil, and thus benefit crop growth (Vogt, 1995). The pods, which are rich in crude proteins and carbohydrates (Hassan, *et al.,* 2007), serve as feed for livestock in the dry season. These beneficial roles of the tree make it a preferred candidate in the choice of tree species for domestication especially in Africa, where affordability for inorganic fertilizers is the lowest (Morris, 2007), and livestock feed availability in the dry season is of major concern (Adzitey, 2013).

Germination is key to the successful regeneration and propagation of plants. The condition where an intact, viable seed fails to germinate under favourable conditions is known as dormancy (Bewley, 1997). The intensity of dormancy could be influenced by the species, genome and the type of dormancy (Zoghi *et al.,* 2011). Most leguminous tree seeds, including *F. albida,* are noted for their hard seededness (Joker, 2000; Sinhababu and Benerjee, 2013) resulting in their resistance to imbibition, a very crucial process required for the initiation of germination (Van der Burg *et al.,* 2014). Common methods that have been suggested to break physical dormancy in seeds include scarification by nicking (Nwase, 2011), hot water and acid treatments (Missanjo *et al.,* 2014), stratification (Vandenbeldt, 1992) Most *F. albida* trees growing in today are believed to have originated as natural regenerations (Miehe, 1986). The species is threatened by increasing rate of exploitation for various uses and wildfires (Miehe, 1986).

However, very little effort has been directed towards using this indigenous tree in afforestation programs. The main problem encountered in propagating seedlings of most indigenous trees for afforestation programs in arid and semi-arid areas is as a results of dormant seeds (Bewley, 1997). Seeds of such species need to be subjected to some chemical or physical treatment to break dormancy and obtain uniform germination (Monohar, 1966; Hossain *et al.,* 2005). To overcome the challenge of seed dormancy, various

studies have recommended hot water treatment but with varying durations of exposure to the hot water. According to Shapo (2015), pre-sowing treatment methods need to be easy to apply even under local conditions and easy for the local farmer to adopt. Hot water treatments should therefore be considered as alternative to sulphuric acid (which poses danger to the farmer), nicking (which is laborious), and seed gun (which requires expertise and precision). The determination of an appropriate duration of *F. albida* seeds in boiled water will improve germination and early growth, and will subsequently contribute tremendously to the successful domestication and up scaling of the tree. This study compared the effects of different durations of seed immersion in boiled water (100°C), and later in tap water for 24 hours, on the germination and early growth performance of *F. albida* seedlings in Kaduna Northern Guinea Savannah Agrological zone of Nigeria. Little is known about the germination requirements of indigenous tree species, it is expected to help identify the optimal time required for improved germination and growth of *F. albida* seedlings to upscale the population of the tree in Kaduna Northern Guinea Savannah Agrological zone of Nigeria.

Materials and Methods

Study Area

The study was conducted in Savanna Forestry Research Station nursery situated in Institute for Agricultural Research (I.A.R) farm Samaru in Bomu village. Located at latitude 11°11′N and longitude 7°38′E and 686m above sea level. It is located in Sabon – gari local government area of Kaduna state. The vegetation in the local Government Area is the Northern Guinea Savannah woodland type, with annual mean rainfall of 1000 mm – 1500 mm, temperature of 25.6°C (78.1°F), precipitation of 1,117.6 mm and humidity of 69% respectively (Figure 1).

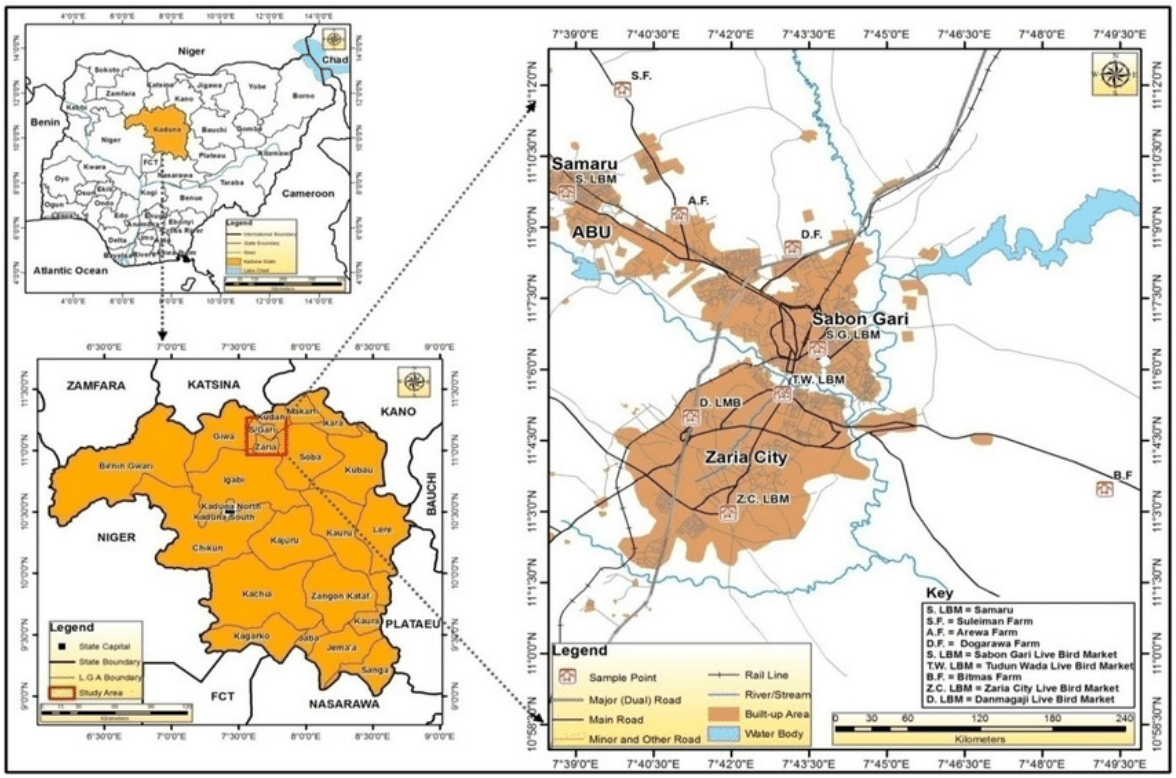

Fig. 1: Showing Map of the Study Area
Source: Hamisu *et al.* (2016)

Seed Collection and Treatment

Matured *F. albida* pods were collected from a matured tree in Katsina State where it occurs naturally, in August, 2018 and transported in sacks to Savanna Forestry Research Station, Zaria. The pods were shelled and seeds extracted.

Treatments and Experimental Design

The following treatments were used. T1 (0/0) where *F. albida* seeds were sown directly without being immersed in boiled (100° C) water nor soaked in tap water; T2 (0/24) where seeds were soaked in tap water for 24 hours; T3 (15/24) where seeds were immersed in boiled water for 15 seconds and then soaked in tap water for 24 hours; T4 (30/24) where seeds were immersed in boiled water for 30 seconds and then soaked in tap water for 24 hours; T5 (60/24) where seeds were immersed in boiled water for 60 seconds and then soaked in tap water for 24 hours; T6 (90/24) where seeds were immersed in boiled water for 90 seconds and then soaked in tap water for 24 hours; and, T7 (150/24) where seeds were immersed in boiled water for 150 seconds. The 7 lots of *F. albida* seeds, each comprising of 100 seeds were sown in drills at 15cm spacing on the seedbeds and watered twice a day (Morning and Evening) to keep the soil moist until germination commenced. However, each treatment was replicated 3 times.

Data Collection

Data were collected on the number of seeds that germinated at 3days intervals. However, germination in this setting referred to the emergence of the seeds radicle above the soil surface on the nursery bed.

Data Analysis

Germination parameters assessed in this research include the following:
Final Germination Percentage (FGP)

$$FGP = \frac{\text{Final number of seeds germinated in seed lot}}{\text{Total number of seeds in seed lot}} \times 100$$

Germination Rate (GR)
$GR = \sum n/t$, where, n is the number of germinated seeds in day

Germination Index (GI)
$GI = (\sum Ti\ Ni)/S$
where, Ti is the number of days after sowing, Ni is the number of germinated seeds in that day, and S is the total number of seeds sown

Mean Germination Time (MGT)
$MGT = \sum f * x/\sum f$ where f is the number of seeds germinating on day x

Seedling Survival Rates/Percentage (SP)
Survival Rate/Percentage (SP) = {(Total germinated seedlings – Dead seedlings)/ Total germinated seedlings} x 100 Days to final germination

Days to final germination (DFG)
DFG = No. of days between date of germination experiment (sowing) and the last day of seed germination

Data on total seedling length, shoot height, collar diameter, root length and number of leaves were collected on 120 and 165 days after sowing (DAS). Total seedling length, shoot height and root length were measured with measuring tape, whiles collar diameter was measured with Vernier calipers. For each measured variable normal distribution was tested using the Shapiro-Wilks W-test for homogeneity of variances. Variables that conformed to normal distribution were analyzed using two-way analysis of variance (ANOVA). Where significant differences were observed, treatment means were separated using Least Significant Difference (LSD) test at the $P<0.05$ level. Similarly, seedling height, collar diameter, root length and number of leaves for each treatment were also subjected to ANOVA and Least Significant Difference (LSD) was also used to separate the mean.

Results and Discussion

Germination

Independent/main Effects of Pre-Sowing Treatment on Germination Parameters

Germination index (GI), Mean Germination Time (MGT) and Days to Final Germination (DFG) were not significantly ($P<0.05$) influenced by pre-sowing treatment. However, pre-sowing treatment significantly influenced ($P< 0.05$) Final Germination (FGP), Germination Rate (GR) and Survival Percentage (SP) as shown in Table 1 below.

Table 1: Summary on ANOVA Indicating P-values Effects on Pre-Sowing Treatment on Various Germination of *Faidherbia albida* Seeds

Parameters	FGP	GR	GI	MGT	SP	DFG
Pre-Sowing treatment	<0.001	<0.001	0.69	0.73	0.05	0.77

FGP = Final Germination Percentage; GR = Germination Rate; GI = Germination Index; MGT = Mean Germination Time; DFG = Days to Final Germination; SP = Survival Percentage

There was a general improvement in final germination percentages using the boiled water pre-sowing treatments for different periods over the control (where the seeds were sown directly without immersing in boiled (100°C) water and soaking in tap water overnight) immersion in boiled water for between 15 and 90 seconds yielded significantly higher FGPs. This finding corroborates that of Sinhababu and Banerjee (2013) that hot water pre-treatment to be the most effective method for improving upon the germination percentage in 4 tree species belonging to the *Leguminosae (Fabaceae)* family, including Bauhinia variegate, *Cassia fistula, Delonix regia and Peltophorum pterocarpum*. This improvement in seed germination could be due to increased permeability of the seed coat induced by the hot water.

Effects of Boiled Pre-Sowing Treatment on Final Germination Percentage (FGP)

T3(15/24) and T7 (150/24) produce significantly($P>0.05$) higher FGPs than the control as shown in figure 2 below.

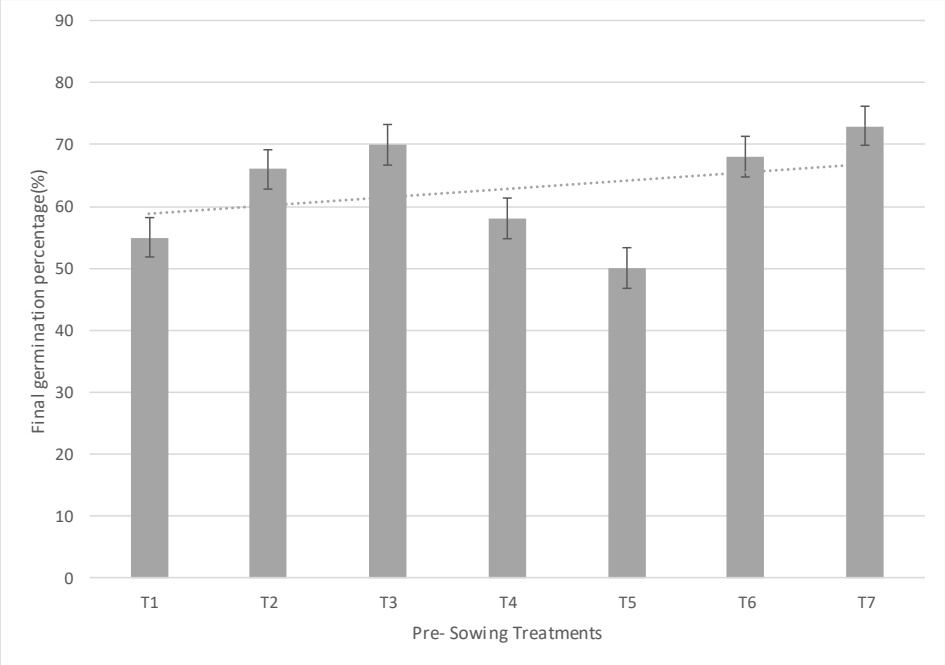

Fig. 2: Effects of boiled water pre-sowing treatment on Final Germination Percentage (FGP) of *F. albida*

T1(0/0), T2(0/24), T3(15/24), T4(30/24), T5(60/24), T6(90/24), T7(150/24)

Final Germination Percentage (FGP) is significantly higher (P<0.05) in T7 (150/24) than any other pre-sowing treatment, while treatment T5 (60/24) gave the least FGP. The germination percentage of hot water treated *F. albida* seeds is noted to rather increase with time and show a more extended germination period (days to final germination ranging between 42 and 74 days) as was demonstrated in this study. However, such staggered germination pattern has the advantage of spreading the recruitment of seedlings into saplings and adult trees and insurance against species extinction (Soriano *et al.,* 2017). This results is in agreement with the work of Shapo (2015) in an experiment to assess the effects of a wide variety of pre-sowing treatment methods on the germination of some agroforestry tree species, where it was observed that the immersion of seeds in boiling water gave reliable and improved germination in most of the species tested.

Effects of Boiled Water Pre-Sowing Treatment on Germination Rate (GR)

This as similar effects on Germination Rate (GR) across the treatment and the trends observed were similar to those of FGP. T3(15/24) and T7 (150/24) significantly higher (P>0.05) in GR than all the others treatments as shown in figure 3 below.

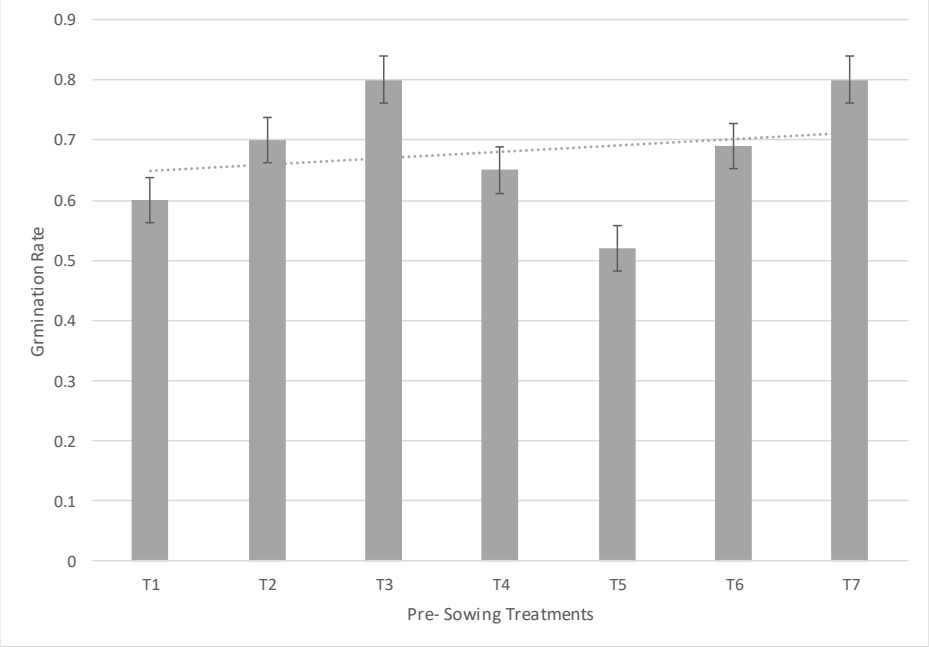

Fig. 3: Effects of boiled water pre-sowing treatment on Germination Rate (GR) of *F. albida* T1(0/0), T2(0/24), T3(15/24), T4(30/24), T5(60/24), T6(90/24), T7(150/24)

Germination Rate (GR) is significantly higher (P<0.05) in T3 (30/24) and T7 (150/24) than any other pre-sowing treatment, while treatment T5 (60/24) gave the least GR. It was however evident that, the appropriate duration of immersion in the hot water was crucial, as seeds of *Sesbania sesban* completely failed to germinate after being immersed in boiling water for 8 minutes. As observed in this study, immersing seeds in boiling water for 15 seconds or 150

seconds and soaking in tap water for 24 hours was more effective than direct seed sowing. These results corroborate the observation of Joker (2000) that, hot water pre-sowing treatments have variable effects on the same *F. albida* seed lots in different ecological zones, and therefore suggest that specific boiled water pre-sowing treatments should only be recommended for each specific ecological zone.

Growth

Effects of Boiled Water Pre-Sowing Treatment Interaction on Growth Parameters of F. albida Seedlings

Pre-sowing treatment significantly (P<0.05) influenced seedling height, root length, total seedling length and collar diameter it was only number of leaves that were not significantly (P<0.05) influenced by pre-sowing treatment (Table 2).

Table 2: Summary of ANOVA Indicating P-Values of Effects of Pre-Sowing Treatment on Various Growth Parameters of *Faidherbia albida* Seed

Parameters	Seedling height	Root length	Total Seedling length	Collar Diameter	Number of leaves
Pre-Sowing treatment	0.002	0.003	<0.001	0.0016	<0.001

Growth is dependent on the flux of carbon from the shoot to the root (through the phloem) and that of nitrogen from the roots to the shoots (through the xylem). The direction of these fluxes is dependent on the concentration gradient of these two resources (carbon and nitrogen) between the two plant components. The root plays important roles in the supply of ecosystem services such as primary production, carbon storage, soil conservation and nutrient cycling (Marziliano *et al.,* 2015). The relatively higher root growth in the drier semi-arid zone is in agreement with the work of Vandenbelt (1991), who observed that the deep rooting habit of *F. albida* was dependent on ecological factors. These trends were also, observed in the root length, shoot height and the shoot to root ratios. The tree *(F. albida)* is known to respond to dry soil conditions by developing roots at a fast rate towards the water table, a trait that makes it to be classified among phreatophytes (Roupsand *et al.,* 1991). Khurana and Singh (2001), corroborated this finding when they observed that the primary roots rapidly elongated in search of a suitable moisture zone, and that 6 months old seedlings were only 8 cm tall and yet had tap roots up to 70 cm long. Dangasuk *et al.* (1999) observed that the semi-arid West African provenances were characterized by slow shoot growth and collar diameter. Though, the relative dry matter accumulation in the roots and shoots of a plant is mainly genetically controlled however, environmental factors could play significant roles in the eventual architecture of the plant.

Effects of Boiled Water Pre-Sowing Treatment Methods on Root Length

Apart from T4 (30/24) and T6 (90/24) treated seedlings, roots of seedlings were significantly (P<0.05) longer than the control as shown in figure 4 below.

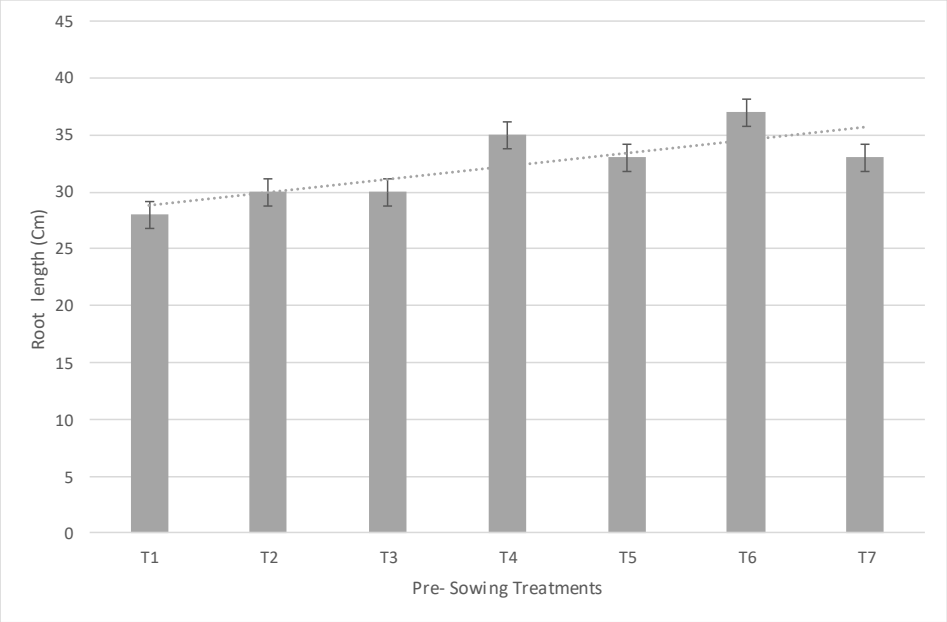

Fig. 4: Effects of boiled water pre-sowing treatment on Root Length of *F. albida*
T1(0/0), T2(0/24), T3(15/24), T4(30/24), T5(60/24), T6(90/24), T7(150/24)

The above results are in agreement with the observation of Missanjo *et al.* (2014) that pre-sowing treatment regime could influence the post germination development of plants. It was demonstrated that some boiled water pre-sowing treatments (immersing in boiled water for between 30 and 90 seconds) could result in increased plant (shoot + root) growth in the Guinea Savannah zone.

Effects of Boiled Water Pre-Sowing Treatment methods on Total Seedling Length

Pre-sowing treatment seedlings T4 (30/24) were significantly ($P<0.05$) longer but not as T6 (90/24) as shown in figure 5 below.

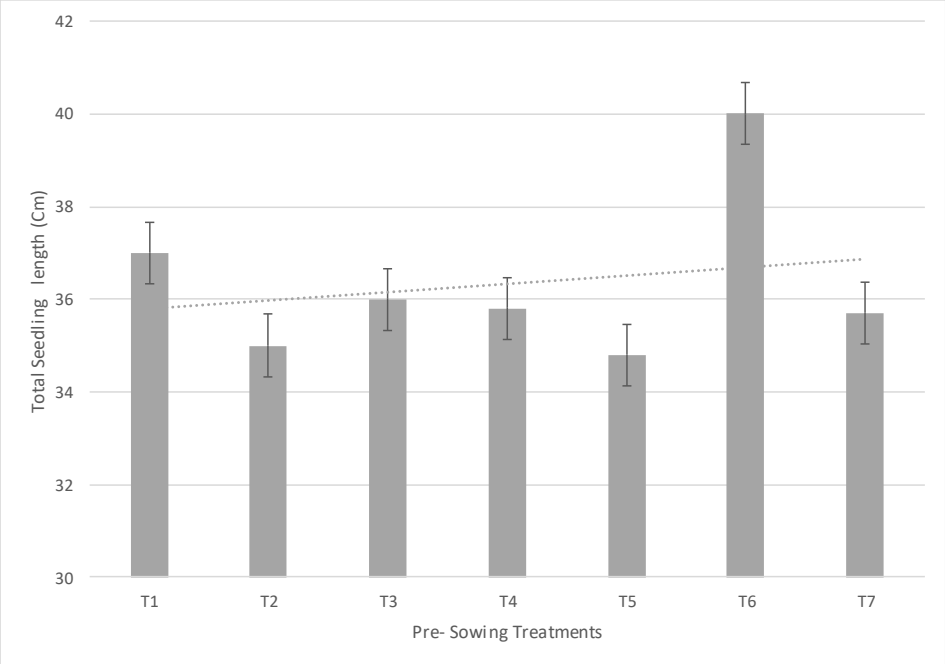

Fig. 5: Effects of boiled water pre-sowing treatment on total seedling Length of *F. albida* T1(0/0), T2(0/24), T3(15/24), T4(30/24), T5(60/24), T6(90/24), T7(150/24)

The above results are in agreement with the observation of Shapo (2015) in an experiment to assess the effects of a wide variety of pre-sowing treatment methods on the germination of some agroforestry tree species, where it was observed that the immersion of seeds in boiling water gave reliable and improved germination as well as total seedling length in most of the species tested. Missanjo *et al.* (2014) also corroborated this results, that pre-sowing treatment boiled water regime could influence the post germination development of plants and total seedling length growth in the Guinea Savannah Ecological zone.

Effects of Boiled Water Pre-Sowing Treatment methods on Number of Leaves

Highest number of leaves was in T3 (15/24), followed by T5(60/24), T1(0/0), T6(90/24), T4(30/24) = T7(150/24) and T2(0/24) in decreasing order. That is, T3(15/24) seedlings had significantly ($P<0.05$) more leaves than all other treatment as shown in the figure 6 below.

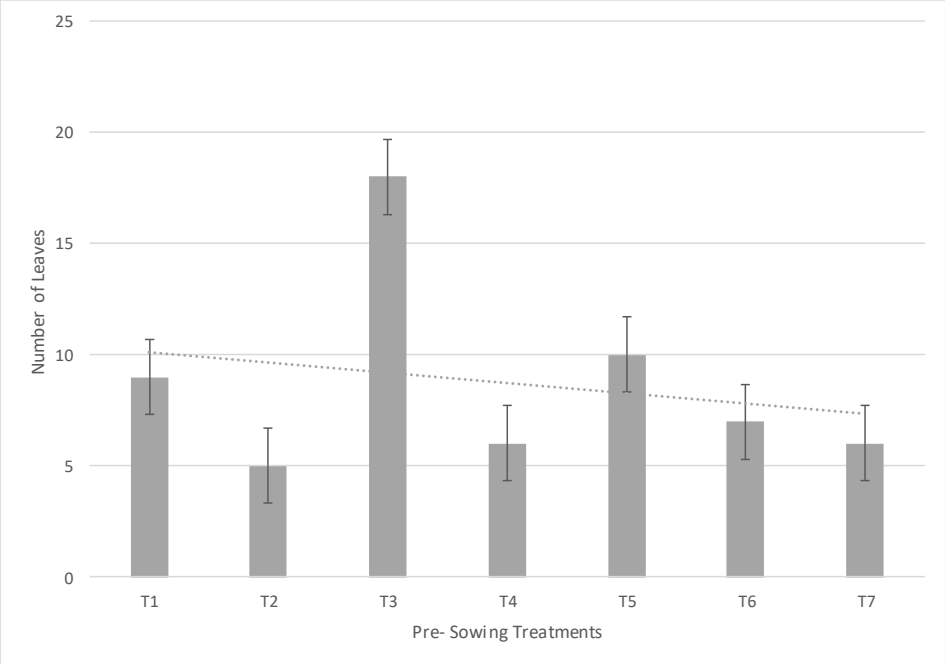

Fig. 6: Effects of boiled water pre-sowing treatment on number of leaves of *F. albida* T1(0/0), T2(0/24), T3(15/24), T4(30/24), T5(60/24), T6(90/24), T7(150/24)

Immersing seeds in boiled water for 15 seconds also favoured the growth and retention of leaves of seedlings in Northern Guinea Savannah which eventually culminate into better dry matter accumulation and hence growth, the leaves which are rich in nitrogen shed at the beginning of the rainy season and serve to significantly improve and fertilize the soil, and thus benefit crop growth Perhaps, this could also affect the reverse phenology trait exhibited by *F. albida* in the drier semi-arid zone. The above results are in agreement with the work of Vogt (1995) and Morris (2007) who observed that *F. albida* tree because of its leaves components, it one of a preferred candidate in the choice of tree species for domestication especially in Africa, where affordability for inorganic fertilizers is the lowest.

Effects of Boiled Water Pre-Sowing Treatment methods on Collar Diameter

Collar diameter of boiled water pre-sowing treatment of T3(15/24) was significantly($P<0.05$) higher than those of T1(0/0) but statistically similar to all other treatment as shown in table 3 below.

Table 3: Effect of Pre-Sowing Treatment on Seedlings Collar Diameter

Pre-Sowing Treatment	Collar Diameter(mm)
T1(0/0)	1.03b
T2(0/24)	1.14b
T3(15/24)	1.32ab
T4(30/24)	1.24ab
T5(60/24)	1.24ab
T6(90/24)	1.24ab
T7(150/24)	1.14ab
P-value	0.012
LSD	0.20

Pre-sowing treatments: The numerator in parenthesis represents the number of seconds seeds were immersed in boiled water, denominator represents number of hour's seeds were soaked in tap water.

The above results are in agreement with the observation of Hossain *et al.* (2005) that pre-sowing treatment regime could influence the post germination development and collar diameter of plants. Dangasuk *et al.* (1999) observed that the semi-arid West African provenances were characterized by slow shoot growth and collar diameter.

Effects of Boiled Water Pre-Sowing Treatment Methods on Seedling/Shoot Height

Seedling height observed due to effect of T3(15/24) was significantly ($P<0.05$) higher than that of T4(30/24) and T6(60/24) but statistically similar to all other treatment as shown in table 4.

Table 4: Effect of Pre-sowing Treatment on Seedling/Shoot Height

Pre-Sowing Treatment	Seedling/Shoot Height (cm)
T1(0/0)	13.21ab
T2(0/24)	14.15ab
T3(15/24)	16.06a
T4(30/24)	11.04b
T5(60/24)	11.42b
T6(90/24)	13.55ab
T7(150/24)	13.34ab
P-value	0.003
LSD	2.38

Pre-sowing treatments: The numerator in parenthesis represents the number of seconds seeds were immersed in boiled water, denominator represents number of hour's seeds were soaked in tap water

The above results are in agreement with the observation of Okunomol and Bosah (2007) that pre-sowing treatment influence the post germination development and seedling height of *F. albida.* Sodimu (2020) also corroborated this results, that pre-sowing treatment using boiled water influence the post germination development of plants which in turns increased total seedling height growth in Kaduna Northern Guinea Savannah Ecological zone.

Conclusion

Investigation conducted into the use of boiled water pre-sowing treatment was found to be effective in enhancing the seed germination and growth of *F. albida* seedlings at varying degrees in Kaduna Northern Guinea Savannah Ecological zone. However, immersing seeds in boiled water at 100°C for 15seconds or 150 seconds before soaking in tap water for 24 hours T3(15/24) and T7(150/24)) were effective

Recommendation

Based on the results above it is recommended that for easy multiplication of seedlings of *Faidherbia albida* for plantations establishment in Kaduna Northern Guinea Savanna Ecological Zone nursery workers should adopt immersing seeds in boiled water at 100^0C for 15seconds or 150 seconds before soaking in tap water for 24hrs as a pre-sowing treatment to promote and enhance better germination and seedling growth of the species.

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