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Evaluation of Seed Pre-sowing Treatment Effects on Seedling Emergence and Morphological Growth Parameters of *Acacia auriculiformis* (Australian Wattle) in Different Soil Types

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The multiple products derivable from *Acacia auriculiformis* in terms of its soil nutrient augmentation by virtue of its nitrogen fixation capabilities are incontrovertible. This is in addition to being an ornamental, evergreen and shade providing tree, But its seed dormancy and dearth of knowledge regarding its growth rates in different soil types had hampered large scale production of its seedlings. Thus, an evaluation of the effects of some seed pre-sowing treatments on its seedling emergence (rates and percentages) and morphological growth parameters (external) in different soil types were investigated at the Screen House of the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria for a period of 8 weeks. The experimental design was a 4 × 3 factorial experiment in completely randomized design comprising 4 different soil types, 3 pre – sowing treatment methods (replicated thrice). Seedling emergence (rates and percentages) and external morphological growth indices (plant height, collar girth, number of leaves and leaf area) were investigated. Analysis of variance (ANOVA) test was

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employed in processing the data collected by employing relevant statistical package (SPSS 20.0). Results indicated that seeds pretreated with concentrated sulphuric acid and sowed in sandy loam (a_3b_1) emerged as the best treatment combination in terms of seedling emergence rate and percentage, morphological growth indices (significant at $P<0.05$) while the control (aobo: river sand with untreated seeds) had the lowest values.

Keywords: Pre-sowing treatments; Acacia auriculiformis; seedling emergence; soil types; growth rates.

1. INTRODUCTION

Ornamental plants are plants that are cultivated for aesthetic purposes in horticultural landscape projects, homes/ residential areas and gardens. Many ornamental plants are grown for the display of aesthetic features in them which include flowers, leaves, branching pattern, scent, fruit, stem, bark and even prominent thorns. Basically, the motive is to bring about pleasure for gardeners, visitors and/or the public. Similarly some trees are also used in garden or landscape settings, such kinds of trees can also be regarded as ornamental trees while in some countries, trees in utilitarian landscape used for screening or road side plantings are called amenity trees. Interestingly, some plants are often employed for both functional and aesthetic purposes. A prominent example of such plant species is *Acacia auriculiformis* that is planted as avenue/ornamental plant for shade, aesthetics and soil nutrient improvement especially in agro forestry farms.

Acacia auriculiformis (A. Cunn. ex Benth) is commonly named as the Australian wattle, northern black wattle, ear leaf acacia, ear pod wattle or tan wattle. It belongs to the family Fabaceae, native to Australia, Indonesia and Papua New Guinea, fast growing (about 30 m in height), has about 47,000 seeds Kg^{-1} and found extensively in tropical zones of southeast Asia, Africa and Latin America [1]. It thrives well on infertile, waterlogged and saline soil [2]. Some degrees or levels of dormancy are naturally associated with its viable seeds which should be pretreated prior to sowing [3,4,5,6]. It is an evergreen tree that is very useful for erosion control and water conservation [7]. It can fix nitrogen after nodulating with a range of rhizobium and brady-rhizobium strains [8].

2. MATERIALS AND METHODS

The experiment was carried out in the screen house of the Department of Plant Science and Biotechnology, Faculty of Science, Adekunle Ajasin University Akungba Akoko, Ondo State, Nigeria. Akungba Akoko is located in the Akoko South West Local Government Area in Ondo State, Nigeria (Latitude 7º28'^{N} and Longitude 5º44'E).The study area lies in the tropical vegetation. However, frequent and prevailing human activities have disrupted the natural ecosystem. Some of the prevailing activities include bush burning, intensive farming and uncontrolled exploitation. It receives an annual rainfall ranging between 1500-2000 mm and a mean (average) annual temperature of about 30^C and the vegetation is presently degraded.

In conducting the experiment, a propagator was constructed and black polythene pots (perforated at the base) were filled with the different soil types (2Kg) after proper identification, *Acacia auriculiformis* seeds were collected within the University campus (opposite the Department of Economics Annex).The soil types used for the experiment were clayey soil, sandy soil, sandy loam and washed river-sand as control. The nature of the experiment was a 4×3 factorial experiment in completely randomized design consisting of twelve (12) treatment combinations and three (3) replicates. The experimental plot lay-out is as shown in Table 1.

The pretreatment methods employed include: **(a) Sulphuric acid treatment:** Twenty four (24) seeds of *Acacia auriculiformis* (0.0009 kg) were immersed into 100ml of concentrated sulphuric acid followed by continuous stirring with a dry stick. The seeds were removed after 20 minutes and washed thoroughly with clean water(thrice). The seeds were then air dried at room temperature **(b) Hot water treatment:** Clean water was boiled and a thermometer was then used to check the temperature level at 80ºC and continuous stirring was ensured with a dry stick for ten minutes after putting the seeds **(c) Control:** following the extraction of the seeds, simple *v*iability test was done on the seeds (floating method), the seeds were then removed and air-dried at room temperature. The sowing method entailed the use of polythene pots (perforated at the base to prevent water logging) which were filled with the different soil types (2 Kg) and arranged in a 4×3 factorial experiment in

Table 1. Experimental plot lay-out (Three replicates)

Pretreatment methods	Soil types			
	WRS	**CS**	**SS**	**SL**
	a_0	**a_1**	**a_2**	**a_3**
b_o	a_0b_0, a_0b_0, a_0b_0	a_1b_0, a_1b_0, a_1b_0	a_2b_0, a_2b_0, a_2b_0	a_3b_0, a_3b_0, a_3b_0
b_1	a_0b_1, a_0b_1, a_0b_1	a_1b_1, a_1b_1, a_1b_1	a_2b_1, a_2b_1, a_2b_1	a_3b_1, a_3b_1, a_3b_1
b_2	a_0b_2, a_0b_2, a_0b_2	a_1b_2 , a_1b_2, a_1b_2	a_2b_2, a_2b_2, a_2b_2	a_3b_2, a_3b_2, a_3b_2,

Legend: a_0 = WRS (Washed river sand: control for the soil types), a_1= CS (Clay soil), a_2 = SS (Sandy soil), a_3 = SL (Sandy loam), b_0= Control (Untreated seeds), b_1= Conc. sulphuric acid, b_2= Hot-water

completely randomized design inside the propagator. During sowing, a strong stick was used to make a hole in each of the polythene pots at 2 cm depth before putting each of the seeds in the hole followed by pressing the soil firmly with the seeds and watering immediately.

The tending operations employed were watering [which was carried out twice daily: early in the morning at 7.00 am and late in the evening at 6.00 pm)], weeding (which was done when weeds started to grow in the polythene pots to prevent weed competition with the seedlings for nutrients which might likely lead to stunted growth of the seedlings [9,10], Thinning (reduction in seedling population per unit area or per polythene pot and leaving the most vigorous one) was done 2 weeks after seedling emergence and hardening-off was carried out 4 weeks after sowing, the seedlings were removed from the propagator and exposed to the normal conditions of the environment in the screen house. This is to pave way for rapid acclimatization/adjustment so as to ensure effective growth and development of the seedlings.

The seedling emergence rate was recorded per treatment combination (from the 7th to the 9th day after sowing) while the seedling emergence percentage was determined by dividing the total number of emerged seedlings by the number of seeds sowed then multiplied by 100. Pertaining to the morphological growth parameters measured, plant height was measured (in cm) with a meter rule from the soil level to the base of the terminal bud and this was done on weekly basis till the end of the study and the number of leaves was also assessed at weekly interval by physical counting, Leaf area was calculated (in cm^2) with the use of a ruler to measure the length of the leaf and the average breadth of the leaf at three points before determining the leaf area (length x breadth). Stem collar girth was measured (in cm)by means of a thread tied round the basal portion of the stem. (2 cm above ground level) and stretching the thread on a ruler to determine the dimension of the girth. Data collected were subjected to statistical analysis of variance (ANOVA) techniques to determine the level of variation/significant differences among the treatment combinations and Duncan Multiple Range Test (DMRT) was employed in mean separation.

3. RESULTS AND DISCUSSION

The results from Table 2 indicated that the P^H ranged between 6.1 and 7.5, it was (sandy soil (a_2) that had the highest P^H (7.5) and this was followed by soil type a_0 river-sand (7.2), sandy loam (a_3) was 6.5 while soil type a_1 (clayey soil) had the lowest P^H (6.1).

The organic carbon from the analysis ranged between 16.71% and 52.7%, soil type a_3 (sandy loam) had the highest percentage of organic carbon (52.7%) while soil type a_1 (clay soil) had the lowest percentage of organic carbon (16.71). The total nitrogen (TN) ranged between 1.96% and 8.75%, soil type a_1 {clay soil) had the highest percentage TN (8.75) which was then followed by soil type a_3 (3.55) and the soil type with the lowest percentage TN was river sand (a_0) which was 1.96.The available phosphorus from the analysis ranged from 28.44- 42.02 ppm, soil type a_3(sandy loam) had the highest phosphorus content (42.02) which was followed by soil type a_1 (clay soil:33.38) and soil type a_0 (river sand) with the lowest phosphorus content (28.44), the potassium content ranged from 0.29- 0.43,it was sandy loam that had the highest potassium content (0.43), followed by clay soil (0.36) and the least was sandy soil (0.29). Calcium was between 0.26 and 0.33, it was sandy soil that had the highest calcium content (0.33), followed by sandy loam (0.29) and the lowest was river-sand (0.26). The Magnesium (Mg) values ranged between 0.50% and 2.28, sandy loam had the highest magnesium content (2.28) which was then followed by clay soil (1.20) and the soil type with the lowest magnesium content was

Table 2. Physicochemical analysis of the four (4) different soil samples and their textural classes

Parameters	Washed river sand	Clayey soil	Sandy soil	Sandy loam
P^H (H_20)	07.20	06.10	07.50	06.50
O.C (%)	18.93	16.71	30.48	52.70
T.N (%)	01.96	08.75	03.55	05.45
Av. P (ppm)	28.44	33.38	32.58	42.02
K (cmol (+) kg^1)	00.34	00.36	00.29	00.43
Ca (mg/kg)	00.26	00.28	00.33	00.29
Mg (cmol (+) kg^1)	00.50	01.20	01.00	02.28
Cu (cmol (+) kg^1)	03.43	08.26	02.33	08.26
Na (cmol (+) kg^1)	00.42	00.29	00.34	00.34
Ca (mg/kg)	00.26	00.28	00.33	00.29
Mn (cmol (+) kg^1)	03.70	04.80	03.70	04.30
Fe (mg/kg)	25.30	03.80	21.30	28.30
Zn (mg/kg)	01.53	01.83	00.55	01.54
Exchangeable acidity(cmol (+) kg^1)	00.42	00.50	00.42	00.83
ECEC (cmol (+) kg^1)	36.16	21.60	30.59	46.86
Sandy (%)	78.60	60.00	70.60	80.00
Clay (%)	06.00	04.60	06.00	04.60
Silt (%)	-	35.40	21.10	11.40
Textural class	I River-sand	Clay	Sand	Loam

river sand (0.50), The copper (Cu) from the analysis ranged between 2.33 and 8.26, sandy loam had the highest copper content (8.26) and this was followed by clay soil while river sand had the lowest copper content (3.43). The sodium (Na) content ranged between 0.29 and 0.42,river sand had the highest sodium content(0.42) which was then followed by sandy loam(0.34) and the soil type with the lowest sodium content was clay soil (0.29), The exchangeable acidity was between 0.42 and 0.83, sandy loam that had the highest exchangeable acidity (0.83) followed clay soil (0.50) and the least was river-sand (0.42), ECEC (21.6 - 46.86), it was sandy loam that has the highest ECEC value (46.86),this was followed by river sand with ECEC value of (36.16) while (clay soil) had the lowest ECEC value (21.6).

3.1 Seedling Emergence Rates and Percentages

It was observed that all those seeds treated with conc.H_2S0_4 for 20 minutes) prior to sowing emerged first (i.e. before others) irrespective of the growth medium at the 7^{th} day after sowing. With regard to emergence percentage, five(5) treatment combinations (a_0b_1, a_1b_1, a_2b_1, a_3b_1, a_0b_2) had the highest emergence percentage of 100% followed by four (4) treatment combinations (a_0b_0, a_1b_0, a_2b_2, a_3b_2) at the 9^{th} day after sowing. The lowest was a_2b_0 (untreated seed planted in sandy soil). It was also observed that at seedling stage, immediately after emergence, bi-pinnate leaves emerged. Subsequent leaf formation resulted to phyllodes which were enlarged ear – like leaf stalks with few true leaves. At the fifth leaflet, only flattened leaf stalks which were leaves that resembled human ears, thick and greenish in color were produced. These features make this plant adaptable to hot climates and drought [7]. Analysis of variance (ANOVA) indicated significant differences ($P<0.05$) among soil types and seed pretreatment methods of the *Acacia auriculiformis* from the different treatment combinations.

3.2 Morphological Growth Parameters

There were significant differences ($P\leq0.05$) in the plant height of *Acacia auriculiformis* seedlings among different treatment combinations (TC) from weeks 2 to 8. The highest mean value of plant height (15.00 cm) was recorded from seedlings whose seeds were pretreated with concentrated sulphuric acid and sowed in soil type a_3 (sandy loam: TC a_3b_1) while seeds from TC a_2b_2 (seeds pretreated with hot water planted in sandy soil) had the lowest mean value of 7.39 cm (Table 3). Therefore, seeds pretreated with conc. sulphuric acid and sowed in sandy loam had the highest mean value of plant height probably due to high nutrient status in the growth medium and early seedling emergence of the seeds.

There were significant (P≤0.05) differences in the collar girth of the seedlings from different treatment combinations from week 2-8. The highest mean value of collar girth (1.70 cm) was recorded for the seedlings under treatment combination (TC) a_3b_1 (sandy loam pretreated with concentrated sulphuric acid) while the seedlings from TC a_0b_0 (untreated seed sowed in river sand) had the lowest mean value of 0.99 cm, this was probably due to the higher fertility status in loamy soil as opposed to river-sand (Table 5).

There were significant (P≤0.05) differences in the number of leaves of the seedlings from different treatment combinations from weeks 2-8. The highest mean value of number of leaves (5.47) was recorded the seedlings under treatment combination (TC) a_3b_1 (seeds pretreated with conc. sulphuric acid sowed in sandy loam) while the seedlings from TC a_0b_0 (untreated seed planted/sowed in river-sand) had the lowest mean value of 1.90. Also, significant (P≤0.05) differences in leaf area of the seedlings among different treatment combinations from weeks 2-8 were observed. The highest mean value of leaf area (4.82 cm^2) was recorded for the seedlings under treatment combination a_3b_1 (seeds pretreated with conc. sulphuric acid sowed in sandy loam)while the seedlings from TC a_0b_0 (untreated seed planted in river-sand) had the lowest mean value of 1.13 cm^2 (Table 6).

After evaluation of the parameters considered (plant height, collar girth, number of leaves and leaf area), post physicochemical analysis was carried out on the soil types used in order to determine the nitrogen fixing potential or any possible variation in nitrogen content of this plant (*Acacia auriculiformis)* in the different growth media with emphasis on the pH, OC and TN (Table 8).

From Table 8, the p^H ranged between 6.88-7.40, it was soil type a_1 that had the highest p^H (7.40), followed by soil type a_0 (7.12) with the initial p^H of 7.2,while the lowest was soil type a_3 (6.88), The organic carbon ranged between 15.3- 22.6, it was soil type a_3 that had the highest value of organic carbon (22.6), this was followed by soil type a_0 (18.4) while the lowest was soil type a_1 (8.92). The nitrogen content ranged between 1.92 and 8.95, it was soil a_3 that had the highest percentage total nitrogen(8.95) which was followed by soil type a_1 (8.24) while soil type a_0 had the lowest percentage total nitrogen (1.92). The initial %N for the different soil types a_0, a_1, a_2 and a_3 were 1.96, 8.75, 3.55 and 5.45 respectively (Table 2). There was a drop in %N of ao and a1 probably due to absorption and the low nitrogen fixing potentials in those soil types (river sand and clayey soil) as opposed to a2 and a3 (possibly) where there was a higher rate of nitrogen fixation [11,12].

Different approaches of breaking seed dormancy to improve seedling emergence rate wereproposed by many authors [13,12,14,15,4]. Among the methods include physical scarification of seed coat by nicking; filling with needles, knife

Table 3. Extract from statistical analysis on seedling emergence rates and percentages of *Acacia auriculiformis* seedlings showing the treatment combinations, means and standard error

TC	SER /DAP	SE% (9 DAP)
a_0b_0	9	83.33^{a}±16.66
a_1b_0	9	83.33^{a}±16.66
a_2b_0	9	50.00^{a}±00.00
a_3b_0	9	66.66^{a}±16.66
a_0b_1	7	100.00^{b}±00.00
a_1b_1	7	100.00^{b}±00.00
a_2b_1	7	100.00^{bc}±00.00
a_3b_1	7	100.00^{b}±00.00
a_0b_2	8	100.00^{b}±00.00
a_1b_2	8	66.66^{a}±16.66
a_2b_2	8	83.33^{a}±16.66
a_3b_2	8	83.33^{a}±16.66

Note: TC=Treatment Combination, SER=Seedling Emergence Rate, DAP = Day After Planting, a0=Washed River Sand, a1= Clay Soil, a2=Sandy Soil, a3= Sandy Loam, b0= Control, b1= Concentrated sulphuric Acid, b2= hot Water. Values with different alphabets as superscript were significantly different (P≤0.05) while those with two different alphabets as superscript (xab) were different but not at significantly level. The values with the same alphabet as superscript were not significantly different (at P≤0.05)

Table 4. Extract from statistical analysis on plant height of seedlings showing the treatment combinations, mean values and standard error

TC	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Total	Mean
a_0b_0	6.43^{a} ±1.54	6.5^{a} ±1.55	7.06^{a} ±1.32	7.60^{a} ±1.34	8.23^{a} ±1.48	8.83^{a} ±1.21	9.60^{a} ±1.15	54.25±9.59	7.75±1.37
a_1b_0	10.23^{a}±0.63	10.6^{b} ±0.69	11.70^{b}±0.10	12.70^{a}±0.35	14.03^{a} ±0.35	14.36^{a} ±0.27	15.06^{a} ±0.08	88.68±2.47	12.6±0.35
a_2b_0	7.56^{ab}±2.05	8.9^{ab} ±1.59	9.80^{b} ±1.87	9.03^{ab}±4.39	12.10^{bc}±3.05	13.20^{bc}±3.62	14.26^{bc} ±4.01	74.85±20.58	10.6±2.94
a_3b_0	7.80^{a} ±0.87	8.2^{a}±0.70	8.53^{a} ±0.73	9.96^{a} ±0.95	12.2^{a} ±2.04	13.26^{a}±2.18	14.63^{a} ±1.94	74.58±9.41	10.6±1.34
a_0b_1	8.06^{a} ±1.09	8.56^{a} ±1.60	8.96^{a}±1.47	10.5^{a} ±1.02	11.16^{a} ±0.8	11.66^{a}±0.70	12.73^{a}±0.73	71.63±7.41	10.23±1.05
a_1b_1	8.70^{a} ±0.30	9.06^{a} ±0.28	11.1^{ab}±0.43	12.3^{a} ±0.18	13.50^{a}±0.55	13.80^{a}±0.41	14.70^{a}±0.62	83.16±2.77	11.88±0.39
a_2b_1	9.03^{b} ±1.23	9.46^{b} ±1.17	10.70^{b}±1.11	11.7^{b} ±0.43	13.70^{c} ±0.36	14.56^{c} ±0.12	15.30^{c}±0.20	84.45±4.62	12.06±0.66
a_3b_1	10.4^{b} ±1.04	10.7^{a} ±1.04	12.06^{b}±1.16	15.90^{b}±0.22	17.3^{b} ±1.55	18.93^{b} ±1.37	19.76^{b}±1.28	105±7.66	15.00±1.09
a_0b_2	7.23^{a} ±1.50	8.00^{a} ±1.45	8.40^{a}±1.40	9.00^{a} ±1.27	9.80^{a} ±1.17	10.10^{a} ±1.17	10.50^{a}±1.02	63.03±8.98	9.00±1.28
a_1b_2	6.10^{a} ±0.51	7.10^{a} ±0.17	8.00^{a} ±0.11	9.23^{a} ±0.63	11.23^{a} ±1.04	11.83^{a} ±0.78	12.76^{a}±0.97	66.25±4.21	9.46±0.60
a_2b_2	5.83^{a} ±0.20	6.33^{a} ±0.38	6.63^{a} ±0.46	7.00^{a} ±0.56	7.60^{a}±0.66	8.76^{a} ±0.69	9.60^{a}±0.62	51.75±3.57	7.39±0.51
a_3b_2	7.93^{a} ±1.36	8.40^{a} ±1.41	8.80^{a} ±1.51	9.50^{a} ±1.56	10.23^{a}±1.53	10.73^{a}±1.46	11.10^{a}±1.49	66.69±10.23	9.52±1.46

Note: TC=Treatment Combination, a_0=Washed River Sand, a_1= Clay Soil, a_2=Sandy Soil, a_3= Sandy Loam, b_0= Control, b_1= Concentrated sulphuric Acid, b_2= hot Water. Values with different alphabets as superscript were significantly different (P≤0.05) while those with two different alphabets as superscript (x^{ab}) were different but not at significantly level. The values with the same alphabet as superscript were not significantly different (at P≤0.05)

Table 5. Extract from statistical analysis on collar girth of seedlings showing the treatment combinations, mean values and standard error

TC	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Total	Mean
a_0b_0	0.78^{a}±0.03	0.74^{a} ±0.15	0.90^{a} ±0.18	1.03^{a} ±0.19	1.13^{a} ±0.18	1.13^{a} ±0.18	1.30^{a} ±0.14	6.96±1.06	0.99±0.15
a_1b_0	0.88^{a}±0.03	1.22^{a} ±0.17	1.20^{a} ±0.09	1.20^{a} ±0.09	1.25^{a} ±0.06	1.28^{a} ±0.05	1.32^{a} ±0.54	8.27±1.07	1.18±0.15
a_2b_0	0.76^{a}±0.11	0.98^{a} ±0.24	1.12^{a} ±0.24	1.42^{a} ±0.12	1.47^{a} ±0.12	1.52^{a} ±0.11	1.62^{a} ±0.10	8.89±1.28	1.27±0.18
a_3b_0	0.83^{a}±0.23	0.80^{a} ±0.18	0.95^{a} ±0.22	1.29^{a} ±0.19	1.46^{a} ±0.21	1.59^{a} ±0.31	1.70^{a} ±0.33	8.62±1.67	1.23±0.23
a_0b_1	0.50^{a}±0.15	0.83^{a} ±0.23	0.95^{a} ±0.22	1.11^{a} ±0.22	1.18^{a} ±0.18	1.57^{a} ±0.17	1.68^{a} ±0.21	7.82±1.38	1.11±0.19
a_1b_1	0.69^{a}±0.03	0.99^{a} ±0.07	1.20^{a} ±0.34	1.35^{a} ±0.04	1.40^{a} ±0.02	1.42^{a} ±0.03	1.46^{a} ±0.21	8.51±0.74	1.21±0.10
a_2b_1	0.73^{a}±0.05	0.86^{a} ±0.16	1.01^{a} ±0.10	1.44^{a} ±0.14	1.54^{a} ±0.14	1.59^{a} ±0.14	1.65^{a} ±0.15	8.82±0.88	1.26±0.12
a_3b_1	0.71^{a}±0.10	1.37^{a} ±0.23	1.60^{b} ±0.17	1.85^{b} ±0.20	1.97^{b} ±0.22	2.15^{a} ±0.23	2.26^{a} ±0.24	11.91±1.39	1.70±0.19
a_0b_2	0.61^{a}±0.19	0.62^{a} ±0.11	0.94^{a} ±0.18	1.20^{a} ±0.16	1.41^{a} ±0.13	1.48^{a} ±0.11	1.55^{a} ±0.89	7.81±1.29	1.11±0.18
a_1b_2	0.66^{a}±0.12	0.85^{a} ±0.06	1.11^{a} ±0.54	1.28^{a} ±0.11	1.33^{a} ±0.13	1.41^{a} ±0.12	1.49^{a} ±0.14	8.13±1.22	1.16±0.17
a_2b_2	0.76^{a}±0.09	0.84^{a} ±0.06	1.08^{a} ±0.08	1.28^{a} ±0.66	1.37^{a} ±0.09	1.48^{a} ±0.08	1.58^{a} ±0.12	8.39±1.18	1.19±0.16
a_3b_2	0.54^{a}±0.13	0.84^{a} ±0.07	1.15^{a} ±0.04	1.62^{b} ±0.24	1.72^{ab} ±0.25	1.87^{ab} ±0.27	1.97^{ab}±0.25	9.71±1.25	1.38±0.17

Note: TC = Treatment Combination, a_0 = Washed River Sand, a_1 = Clay Soil, a_2=Sandy Soil, a_3= Sandy Loam, b_0= Control, b_1= Concentrated sulphuric Acid, b_2= hot Water. Values with different alphabets as superscript were significantly different (P≤0.05) while those with two different alphabets as superscript (x^{ab}) were different but not at significantly level. The values with the same alphabet as superscript were not significantly different (at P≤0.05)

Table 6. Extract from statistical analysis on number of leaves of seedlings showing the treatment combinations, mean values and standard error

TC	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Total	Mean
a0b0	1.00a±0.00	1.66a±0.33	1.66a±0.33	2.33a±0.33	2.00a±0.57	2.00a±0.57	2.66a±0.66	13.31±2.79	1.90±0.9
a1b0	1.00a±0.00	2.00a±0.57	2.33a±0.33	3.66a±0.66	3.66a±0.66	4.33a±0.88	4.66a±0.66	21.64±4.53	3.09±0.4
a2b0	1.00a±0.00	2.00bc±0.7	2.33a±0.66	3.33b±0.88	3.66a±0.66	4.33b±0.88	5.33b±0.88	21.96±4.53	3.13±0.64
a3b0	1.00a±0.00	1.66ab±0.33	2.66a±0.66	3.33a±0.88	4.66a±1.20	5.33b±1.45	5.33b±1.45	23.97±5.97	3.42±0.5
a0b1	1.00a±0.00	1.33a±0.33	2.00a±0.57	2.66a±0.66	3.33a±0.88	3.66a±0.88	3.66a±0.88	17.64±4.2	2.52±0.6
a1b1	1.00a±0.00	2.00a±0.57	2.66a±0.33	3.66a±0.66	4.33a±0.33	5.00a±.57	5.00a±0.57	23.65±3.03	3.37±0.3
a2b1	2.00b±0.57	2.33c±0.33	2.33a±0.33	3.00ab±0.57	3.00a±0.57	3.66a±0.66	4.00a±0.57	20.32±3.6	2.90±0.1
a3b1	1.66b±0.33	3.33b±0.33	4.00b±0.57	6.00b±0.00	7.00b±0.57	8.00b±0.00	8.33b±0.33	38.32±2.13	5.47±0.0
a0b2	1.66b±0.33	1.66a±0.33	2.33a±0.33	2.66a±0.33	3.00a±0.00	3.33a±0.33	3.66a±0.33	18.3±1.98	2.61±0.8
a1b2	1.00a±0.00	1.66a±0.33	2.00a±0.57	2.66a±0.03	3.00a±0.57	4.00a±0.00	4.00a±0.00	18.32±1.5	2.61±0.1
a2b2	1.00a±0.00	1.00a±0.00	1.66a±0.33	1.66a±0.33	2.66a±0.33	2.66a±0.33	3.00a±0.57	13.64±1.89	1.94±0.7
a3b2	1.00a±0.00	1.33a±0.33	2.00a±0.57	2.33a±0.33	3.00a±0.00	3.00a±0.00	3.33a±0.33	15.99±1.56	2.28±0.2

Note: TC=Treatment Combination, a_0 = Washed River Sand, a_1 = Clay Soil, a_2 = Sandy Soil, a_3 = Sandy Loam, b_0= Control, b_1 = Concentrated sulphuric Acid, b_2 = hot Water. Values with different alphabets as superscript were significantly different (P≤0.05) while those with two different alphabets as superscript (x^{ab}) were different but not at significantly level. The values with the same alphabet as superscript were not significantly different (at P≤0.05)

Table 7. Extract from statistical analysis on leaf area (cm^2) of seedlings from treatment combinations, mean values and standard error

TC	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Total	Mean
a_0b_0	0.80^{a}±0.66	0.67^{a}±0.13	0.69^{a}±0.30	0.98^{a}±0.28	1.11^{a}±0.64	1.71^{a}±0.51	2.01^{a}±0.54	7.97±3.06	1.13±0.43
a_1b_0	1.38^{a}±0.60	1.39^{ab}±0.28	2.20^{a}±0.42	2.59^{a}±0.50	4.04^{a}±0.80	3.93^{a}±0.46	4.60^{a}±0.65	20.13±3.71	2.87±0.53
a_2b_0	0.47^{a}±0.04	1.34^{a}±0.59	1.68^{a}±0.53	2.90^{a}±1.14	4.48^{b}±2.03	4.92^{b}±2.21	5.39^{a}±1.88	21.18±8.42	3.02±1.20
a_3b_0	1.77^{bc}±0.73	1.05^{a}±0.83	1.52^{a}±0.66	2.05^{a}±0.47	4.68^{ab}±2.59	5.17^{bc}±2.68	5.01^{bc}±3.02	21.25±10.96	3.03±1.56
a_0b_1	0.75^{a}±0.16	1.25^{a}±0.42	1.40^{a}±0.60	1.53^{a}±0.62	1.78^{a}±0.77	2.29^{a}±1.01	2.64^{a}±0.57	11.64±4.15	1.66±0.59
a_1b_1	1.96^{a}±0.82	2.39^{b}±1.20	2.15^{a}±0.23	2.68^{a}±0.40	3.61^{a}±0.54	3.27^{a}±0.36	3.70^{a}±0.38	19.76±3.93	2.82±0.56
a_2b_1	1.62^{a}±0.32	0.74^{a}±0.16	1.60^{a}±0.53	1.29^{a}±0.80	3.28^{ab}±1.89	3.55^{ab}±1.78	4.46^{a}±1.75	16.54±7.23	2.36±1.03
a_3b_1	2.72^{c}±0.32	3.20^{b}±0.23	2.33^{a}±0.50	4.64^{a}±0.69	6.28^{b}±0.69	7.04^{c}±0.92	7.59^{c}±0.86	33.8±4.21	4.82±0.60
a_0b_2	0.72^{a}±0.19	0.46^{a}±0.09	2.29^{a}±0.63	1.72^{a}±0.81	2.39^{a}±0.12	2.15^{a}±0.51	2.28^{a}±0.60	12.01±2.95	1.71±0.42
a_1b_2	0.44^{a}±0.16	0.67^{a}±0.14	0.84^{a}±0.32	1.03^{a}±0.33	1.76^{a}±0.64	1.62^{a}±0.42	2.27^{a}±0.47	8.63±2.48	1.23±0.35
a_2b_2	1.04^{a}±0.38	1.72^{a}±1.23	1.74^{a}±1.22	1.31^{a}±0.04	1.35^{a}±0.50	1.56^{a}±0.55	2.84^{a}±0.19	11.56±4.11	1.65±0.58
a_3b_2	0.55^{a}±0.06	1.30^{a}±0.62	1.96^{a}±0.22	2.42^{ab}±0.52	2.73^{a}±0.37	1.09^{a}±0.43	0.87^{a}±0.67	10.92±2.89	1.56±0.41

Note: TC= Treatment combination, a_0 = River sand, a_1 = Clay soil, a_2 = Sandy soil, a_3 = Loamy soil, b_0 = Control, b_1= Concentrated sulphuric acid, b_2 = Hot-water. Values with different alphabets as superscript were significantly (p≤0.05) different. Also values that had two different alphabets as superscript (x^{ab}) were different but not significantly different. The values with the same alphabet as superscript were not significantly (P ≤0.05) different

Table 8. Post experimental analysis of the soil types on values of P^H, OC and TN at week 8

Parameters	Washed river-sand	Clayey soil	Sandy soil	Sandy loam
P^H	07.12	07.40	06.98	06.88
Organic carbon (%)	18.40	15.30	17.20	22.60
Total nitrogen (%)	01.92	08.24	03.59	08.95

or and abrasion paper and hot water treatment, concentrated acid treatment [16,6] reported that seeds with impermeable seed coat were reported to germinate well after pre-sowing treatments, but dormancy in seeds varies, so it is imperative to know which method is suitable cost saving for pre-treating hard coated seeds so as to improve seedling emergence as well as the soil type that is suitable for the optimal growth. The result from this study revealed that pretreatment methods with concentrated sulphuric acid significantly influenced the seedling emergence rate of *Acacia auriculiformis* irrespective of the soil types probably sequel to the fast action the acid on the seed coat thereby breaking the dormancy(paving way for water imbibition, biochemical activities and emergence of the plumule or gemmule). The maximum mean value of plant height (15.00 cm) was recorded from treatment combination a_3b_1 (the treatment combination in which seeds were pretreated with conc. sulphuric acid and planted/sowed in sandy loam) this was probably due to the higher nutrient status in sandy loamas opposed to other soil types used. The maximum mean value of collar girth (1.70 cm) was recorded from treatment combination a_3b_1, (seeds pretreated with conc. H_2S0_4 and sowed in sandy loam). This was probably due to the high nutrient status / fertility level of the loamy soil [17]. *Acacia auriculiformis* seeds pretreated with conc. sulphuric acid and sown in sandy loam had the maximum growth in all the parameters considered which was followed by clayey soil, sandy and river sand due to the high nutrient status in sandy loam.

4. CONCLUSION

Based on the results obtained, pretreatment method with concentrated sulphuric acid (H_2SO_4) from which 100% seedling emergence was achieved was the best method of breaking dormancy and improving seedling emergence rate of this species. It could therefore be inferred that pretreatment with concentrated sulphuric acid (H_2S0_4) and sowing in sandy loam was the best among the treatment methods employed for breaking the dormancy of *Acacia auriculiformis* (A. Cunn. ex Benth) seeds and ensuring reasonably enhanced growth rate of the seedlings. Similarly, the hot water treatment and sowing in clay soil could also be employed for breaking the dormancy in the seeds and enhancing the growth rate since it was the next treatment method that had reasonable seedlings' emergence (100%) and growth in addition to its being cost saving or inexpensive. Conclusively, this *Acacia* species being a nitrogen fixing plant had increased the nitrogen content of the soil type (a_3) which had the highest percentage increment in nitrogen content, from initial value of 5.45% to 8.95%) and soil type (a_2) sandy soil in which the nitrogen content also increased from 3.55% to 3.59%.

5. RECOMMENDATIONS

Based on the results from this study, it is hereby recommended that:

- Dormancy in *Acacia auriculiformis* seeds can be best removed by pre-treating the seeds with concentrated sulphuric acid for higher seedling emergence percentage or stirring of the seeds in hot water at 80ºC for 20 minutes which is more economical.
- Sandy loam is the most suitable growth medium for the production of *Acacia auriculiformis* seedlings in order to achieve maximum growth and development.
- Large scale cultivation of this species should be embarked upon owing to the numerous benefits derivable from it.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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