FULL LENGTH RESEARCH ARTICLE

STUDIES ON THE SEEDLING GROWTH OF *Adansonia digitata* AL.

*CHIA, A. M.; IORTSUUN, D.N. & CARTHAGE, B. A.

Department of Biological Sciences, Ahmadu Bello University
Zaria, Nigeria
*(Corresponding author)
chia28us@yahoo.com

ABSTRACT
The germination and growth of seedlings of *Adansonia digitata* were investigated at the Biological garden of ABU Zaria, Nigeria (07°38' and 11°11'N) at different planting depths and soil types. The seeds were planted at different planting depths of 1.0 cm, 2.0 cm, 4.0 cm and 6.0 cm in nursery bags and kept in a screen house and watered regularly. Results shows that as the planting depth increased, there was an increase in percentage germination, seedling height, number of leaves produced and leaf area index. The case was reverse in terms of percentage survival as increased planting depth resulted in a decrease survival. Number of days before emergence increased with increased planting depth. The highest percentage germination was recorded in sandy soil (75 %), followed by humus soil (32.7 %) while clay soil had no germination. The highest number of days before emergence was recorded in humus soil. Sandy soil had seedlings that produced leaves with Leaf Area Index (LAI) of 18.04 cm^2, Humus 9.24 cm^2 and loamy soil 7.26 cm^2. All seedlings from all soil types produced between 8-15 leaves. Germinated seedlings from clay soil did not survive 60 days post planting. Significant correlation values were observed between planting depth and seedling height, number of days before emergence, number of leaves produced and seedling survival. Both the depth of planting and soil type affected seed germination and seedling performance of *Adansonia digitata.*

Keywords: Planting depth, soil type, seed, germination, seedling, *Adansonia digitat*

INTRODUCTION
The depth of planting is a determinant of germination because it has great influence on moisture, temperature, oxygen and light that can reach the seed (Roberts & Feast 1972). Some seeds need to be planted deeper than others for best emergence and subsequent desirable growth because they do not need light for germination (Grundy *et al.* 1996). It has been shown that the depth of planting of the Russian wildrye (*Elymus junsceus* Fisch) influenced the seedling growth during the seedling year in field planting over 4 years at two locations (McGinnes, 1974). Similarly, Grundy *et al.* 1996 reported that *Chenopodium album* showed superior seedling performance for seeds planted close to the soil surface except for number of days to emergence. McGinnes (1973) observed that height difference between the range grasses planted at different depths apparently resulted from some form of seedling selection at greater depths. Growth habit, and number of tillers produced are influenced by the planting depth in several grasses and cereal grains (McGinnes 1974), with those planted at depths of 2.5cm-3.8 cm planting depth growing significantly taller than those at 1.3 cm depth (McGinnes 1973).

Soils differ greatly in texture, chemical composition, colour e.t.c. depending upon the particle size of the mineral component and organic matter (Kitajima 1996; Froelich *et al.* 2001). The physical condition of soil is crucial to the survival of seeds because it determines the amount of water, air (aeration) and light that get to the seed. In compacted soils, soil strength and limited aeration affect plant growth (Froelich *et al.* 2001). Mechanical impedance decreases the rates of plant cell division and length in root meristems (Bengough & Mullins 1996).

Adansonia digitata is a highly exploited economic tree with a wide spectrum of importance. Both humans and livestock eat the leaves, stem, roots and fruits. The tree has great potential for Agro-forestry, serving as wind break, fodder for animals, food and aesthetics e.t.c. The increase in the demand of some major parts of the plant by man has encouraged the cultivation of *A. digitata* in homes, gardens, estates or large parks. Therefore, its presence could be said to be indicative of human habitation because only very few are still found growing in the wild. However, wherever it is found, it is so highly exploited that it sometimes fails to form fruits or disperse them leading to scarcity of its seedlings. Despite the immense importance of this plant, not much is known on the effect of planting depth and soil type on the germination and seedling establishment considered crucial for optimum germination, seedling establishment and subsequent development of the plants.

This research was carried out to determine the effects of planting depth and soil type on seed germination and seedling growth of *A. digitata.*

MATERIALS AND METHODS
Experimental Site: The experiment was conducted at the Biological Science Garden, Ahmadu Bello University, Zaria Nigeria (07°38'E and 11°11'N).
Experimental Design: The experimental design was Completely Randomized Design (CRD) with two replications per treatment and four bags per replication.

Planting Material: The seeds of *A. digitata* were collected from the wild in Zaria and its environs. They were obtained by cracking the fruits open and washing away the dry powdery coating and dried for 4 hrs under sunlight and preserved in polythene bags at room temperature until planting time. The seeds were scarified mechanically by scribing the seed case with a knife and soaked in hot water for 2-6 hrs (Odetola 1987).

Planting Depth Experiment: Polythene bags (785 cm^3 capacity) were also used as the medium of germination for the seeds. Four different planting depths were 1.0 cm, 2.0 cm, 4.0 cm and 6.0 cm with each planting depth having two replications with four bags per replication. A total number of 32 bags were used for this experiment. The bags were filled to the top with sandy soil collected from the garden after analysis of soil. The bags were then watered and labeled according to each planting depth using masking tape. A meter rule was used to measure each planting depth. This was done by inserting the ruler to the bottom of the soil and measuring from the surface of the soil in wards. These bags were watered regularly.

Soil Type Experiment: The planting media were the 4 different soil types, classified according to physical characteristics (Bengough & Mullins 1996) as sandy, loamy, clay and humus. The soils were placed into polythene bags (785cm^3 capacity) were perforated on the underside to allow for draining of water from the soil. A total of 32 bags were used for this experiment involving 4 bags per replication and two replications per treatment.

Data Collection: Data was collected on Germination percentage, Seedling emergence, Seedling height, Leaf Area Index (LAI), Number of leaves produced and seedling survival.

Data Analysis: Data obtained was subjected to One-way Analysis of Variance (ANOVA) to test for significant difference. Least Significant Difference (LSD) was used to separate significantly different means at $P \le 0.05$. Relationship between observed parameters was determined using Pearson Correlation Coefficient.

RESULTS

Percentage Germination: Percentage germination decreased as planting depth increased (Table 1). 2.0 cm planting depth had the highest average percentage germination of 78.13 % while the least was observed at 6.0 cm with mean germination percentage of 21.88 %. At 6.0 cm planting depth, there were cases where no seed germinated at all, indicating the severity of planting depth on germination. Although, 78.13 % germination percentage was observed at 2.0 cm planting depth, it was not significantly different with 53.13 % germination percent recorded at 1.0 cm planting depth. Mean percentage germination obtained at 4.0 cm (30.63 %) and 6.0 cm (21.88 %) were also not significantly different $P \le 0.05$ (Table 1 and 2). Percentage germination varied between the different soil types; with average percentage germination of 65.63 % for sandy soil, 31.75 % for humus soil, 25 % for loamy and the least in clay soil with 6.25 % (Table 4). Mean germination for the different soil types differed significantly ($P<0.05$) (Table 2).

TABLE 1. PARAMETERS OBSERVED FROM SEEDS OF *Adansonia digitata* GERMINATING AT DIFFERENT PLANTING DEPTHS

Planting Depth	Germination Percentage (%)	Emergence (days)	Seedling Height (41 days after planting)	Seedling Height (60 days after planting	Leaf Area Index(LAI)cm^3	Number leaves	Survival Percentage (%)
1.00cm	53.13 ± 5.66^{b}	8.25 ± 0.41^{a}	13.70 ± 0.77^{c}	15.68 ± 0.73^{b}	30.83 ± 4.39^{b}	13.38 ± 0.63^{c}	53.13 ± 0.22^{b}
2.00cm	78.13 ± 7.38^{c}	9.25 ± 0.37^{a}	10.23 ± 0.80^{b}	12.44 ± 0.87^{b}	18.77 ± 2.73^{a}	8.25 ± 0.77^{b}	75.00 ± 0.33^{b}
4.00cm	30.63 ± 7.93^{a}	11.00 ± 0.60^{b}	8.93 ± 0.38^{a}	9.88 ± 1.49^{a}	13.00 ± 2.36^{a}	7.63 ± 0.68^{a}	34.375 ± 0.32^{a}
6.00cm	21.88 ± 5.66^{a}	14.25 ± 0.86^{c}	6.50 ± 0.93^{a}	7.05 ± 1.25^{a}	9.61 ± 2.31^{a}	4.63 ± 0.91^{a}	21.875 ± 0.23^{a}

Note: Means with same alphabets along the columns are not significantly different at $P<0.05$

TABLE 2. MEAN SQUARE VALUES FOR PARAMETERS OBSERVED

Source of Variation	Df	Germination percentage	Emergence	Seedling height (41 days)	Seedling height (60 days)	Leaf Area Index	Number of leaves	Percentage survival
Planting Depth	3	5069.79*	52.13*	72.19*	108.06*	694.98*	195.61*	6.86*
Error	28	362.95	2.80	4.49	10.16	75.33	4.54	0.63
Soil Types	3	6790.37*	110.67*	204.45*	287.39*	440.76*	119.36*	12.38*
Error	28	655.69	8.41	8.63	11.71	22.07	24	1.03

Note: * Significant at $P \le 0.05$

Number of days before emergence: Data collected showed that the least number of days to emergence was observed for seeds planted at 1.0cm depth, with an average of 8 days. The highest number of days it takes seedlings to emerge was observed in seeds planted at 6.0cm depth, with an average of 14 days (Table 3).

The highest duration to emergence was observed in clay soils with 13 days and the least in sandy soil with 7 days. The earliest seedlings to emerge were recorded in sandy soil. The results obtained indicated that there was no significant difference between the number of days to emergence of seeds planted in loamy, humus and sandy soils ($P>0.05$), except in clay soils while the rate of emergence at the different planting depths varied significantly (Table 4).

Seedling Height: Measurements taken after 41 and 60 days post planting showed a steady decrease in seedling height as planting depth increased. Seeds planted at 1.0 cm depth had the highest average seedling height of 13.7 cm. At day 61 days, the tallest seedlings were those planted at 1.0 cm depth and shortest those planted 6.0 cm. The height of seedlings at 1.0 cm planting depth was significantly higher

TABLE 3. CORRELATION COEFFICIENTS FOR DIFFERENT PARAMETERS

Parameter	Planting Depth
Percentage Germination	-0.8006**
Seedling Height	-0.9826**
Number of days to emergence	0.9828**
Leaf Area Index (LAI)	-0.9139**
Number of leaves produced	-0.9532**
Seedling survival	-0.8266**

Note: ** Highly significantly correlated at P≤0.05

TABLE 4. PARAMETERS OBSERVED FROM SEEDS OF *Adansonia digitata* GERMINATING IN DIFFERENT SOIL TYPES

Planting Depth	Germination Percentage (%)	Emergence (days)	Seedling Height (41 days after planting)	Seedling Height (60 days after planting)	Leaf Area Index (LAI)cm3	Number leaves	Survival Percentage (%)
Clay	6.25±4.09[a]	12.88±1.88[b]	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]
Loamy	25.00±9.45[b]	9.88±0.55[a]	4.66±1.41[b]	5.73±1.71[b]	7.26±2.27[b]	6.75±2.04[a]	34.00±0.40[a]
Humus	31.25±13.31[b]	11.38±0.50[a]	5.88±1.32[b]	6.88±1.55[b]	9.24±2.17[b]	8.13±2.04[b]	40.75±0.53[b]
Sandy	65.63±6.68[c]	7.38±0.32[a]	12.26±0.76[c]	14.58±0.72[c]	18.04±1.08[c]	8.00±1.99[b]	75.00±0.27[c]

Note: Means with same alphabets along the columns are not significantly different at P<0.05

than the height recorded for other planting depths. The mean seedling height recorded at 4.0 cm was not significantly different from those obtained at 6.0 cm depth (Table 1).

Sandy soil had the highest average seedling height of 12.26 cm and 14.58 cm, while the lowest seedling height was recorded in loamy soil with 4.66 cm and 5.76 cm at 41and 60 days post planting respectively. No significant difference in height between the seeds that emerged from humus and loamy soils at day 41 and 60 after planting. No seedling height was recorded for clay soil as germinated seedling did not survive (Table 4).

Leaf Area Index (LAI): Planting depth significantly correlated with Leaf Area Index (Table 3) because as plant height increased there was a corresponding decrease in LAI. The planting depth of 1.0 cm had the highest LAI of about 30.83 cm^2 while 6.0 cm had the least LAI of 9.61 cm^2 (Table 1). Performance of seedlings in terms of LAI indicated that most seed planted from 1.0-2.0 cm planting depth had leaves with significantly larger areas than those planted from 4.0-6.0 cm. Sandy soil recorded the highest LAI of 18.04 cm^2 followed by humus soil (9.24 cm^2) and loamy soil (7.26 cm^2). Mean LAI of seedling that emerged from loamy and humus soils were not significantly different (Table 4).

Number of leaves Produced: Seeds planted at shorter depths produced seedlings with the highest seedling height which also possessed the highest leaf numbers. At 1.0 cm the highest number of leaves recorded was 13 while 6.0 cm planting depth produced seedlings with the least number of leaves (5) per plant. The number of leaves produced at 4.0 cm and 6.0 cm planting depths were not significantly different at P<0.05 (Table 3). Most seedlings that emerged from these planting depths (4.0 cm and 6.0 cm) had between two (2) to ten (10) leaves. The seedlings that emerged from the lesser planting depths (1.0 cm and 2.0 cm) had significantly different performances in terms of total leaf numbers per seedling from each treatments (Table 1).

Loamy soil produced the fewest number of leaves per plant (7 leaves) while humus and sandy soils had an average of 8 leaves per plant. On a general note, 8-14 leaves were produced per time by all seedlings from all soil types.

Seedling Survival: The peak number of seedlings that survived at the end of the experiment was recorded in seeds planted at 2.0 cm planting depth (75 % seedlings) while the least was at the 6.0 cm planting depth (25 % seedling). The highest recorded percentage survival for 4.0 cm and 6.0 cm planting depth was 50 %, though there were cases where no germination occurred (Table 1). Survival percentage for 1.0 cm-2.0 cm and 4.0 cm-6.0 cm planting depths were significantly different. The number of seedlings that survived at the end of the experiment was highest in sandy soil with an average seedling survival of 75 %; followed by humus soil having 40.75 %; loamy soil 34 % and no seedling survival for clay soil 60 days after planting (Table 4).

DISCUSSION

The results from this study demonstrate clearly that planting depth affects seed germination and seedling growth/performance of *Adansonia digitata.* When planting depth is varied, *A. digitata* seedlings show distinct variations in their characteristics which increase or decrease depending on the depth of planting. Significant negative correlation coefficient values for all (except for number of days to emergence) growth parameters recorded in the current findings indicate that increasing the depth of planting for this plant will result in plants with poor growth attributes. For example as planting depth was decreased, there was a corresponding increase in plant height. The variations also may have been due to the type of germination exhibited by this plant, size of seed and soil (Barnes *et al*. 1998). The findings of this research conform to that of Grundy *et al.* (1996) and Abeyo (2000) who reported better performance of seedlings that emerged from seeds planted at shorter planting depths but contrary to that of McGinnies (1973).

The alteration of any factor during germination could become limiting to the seed/seedling, resulting in a negative feedback by the plant as growth progresses. This is because these alterations could result in profound changes in other physiological factors which could be to the advantage or disadvantage of the plant. Factors that affect the initial germination of seeds may also affect the later growth of the species. The current findings brings this to limelight because germinated seeds that emerged from different planting depths showed characteristics that were significantly varied from one treatment to the other. This is supported by the fact that percentage germination and seedling survival was found to be highest at planting depth of 2.0 cm, agreeing with Koger *et al.* (2004) who observed that Texasweed seedlings emerged from soil as deep as 7.5 cm (7% emergence), but greater percentage germination and emergence (87 %) and subsequent development of seedlings occurring at 2.0 cm planting depth. Chachalis & Reddy (2000) recorded higher emergence rates of *Campsis radicans* seedlings at lesser planting depths, although in terms of seedling growth, parameters like height, leaf area index (LAI), and number of leaves produced, the seeds planted at 1.0cm planting depth performed better than those planted much deeper into the soil. The depth of planting determines the amount of water, light and oxygen that will reach *A. digitata* seed. So the change in one factor (planting depth) affects a host of other factors (light, oxygen and water) that in the long run result in the negative or positive response of the seed, seedling or plant (Abeyo 2000). The result from this work is not in agreement with the observations by Abeyo (2000) who studied Winter wheat.

Soil composition or physical condition which does not support growth as observed in clay soil was responsible for very low percentage germination, growth and development of *A. digitata.* Sandy soil supported seed germination and seedling establishment better than all the other soil types as was expressed by increased seedling height, number of leaves produced and LAI. In terms of the number of leaves produced, humus soil surpassed the other soil types. This is further supported by the fact that when seeds are subjected to excess water as in the case of soils with high water retention capacity, it is prone to decay, therefore not likely to germinate and establish itself. This could explain why sandy soil had better performance than all the other soils types as it has the poorest water retention capacity. The first stem can force a passage through sandy soils more easily than clay soil (Michael & Peter 2000).

This research clearly demonstrates that planting depth and soil type affect seed germination and seedling establishment or performance of *A. digitata.* It is concluded that 2.0cm planting depth is the best for optimal growth, seedlings performance and establishment. Sandy soil is the best for optimum performance of *A. digitata* though in areas where loamy and humus soils are found the plant can still survive. Clay soil does not support the germination and seedling establishment of this plant.

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