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Germination characteristics of *Balanites aegyptiaca* (l.) Del. seeds under varying light intensity and sowing orientations in a Sudano-Sahelian zone of Nigeria

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ABSTRACT

Balanites aegyptiaca tree has multiple benefits in the arid/semi-arid regions of Nigeria. However, despite its importance, information on its silvicultural requirements is still scanty. This study was therefore conducted to determine the optimum light requirement and best sowing orientation of *Balanites aegyptiaca* seeds that would enhance its germination. The experiment was laid out in a 4×3 factorial in a Completely Randomized Design (CRD). Factor A (light) has four levels: 100% (L_1), 75% (L_2), 50% (L_3) and 25% (L_4) light intensities. Factor B (sowing orientation) has 3 levels: seeds sown vertically with stalk upward (SO_1), seeds sown vertically with stalk downward (SO_2) and seeds sown horizontally (SO_3). Germination percentage (GP), mean germination time (MGT), and germination speed (GS) were the variables assessed. The results show that light intensity and the interaction between light intensity and sowing orientation did not significantly influence the germination characteristics assessed. However, exposure to 100% light resulted in better GP (13.81±7.18%) and GS (2.85±1.84). Sowing orientation was also found not to affect GP and MGT significantly. However, it affects GS significantly. Sowing seed vertically with stalk upward gave better GP (15.79±6.02%) but early completion of germination (11.29±7.17 days) was observed when seeds were sown horizontally. Seeds sown vertically with stalk upward germinate faster (3.44±1.85). Sowing of *Balanites aegyptiaca* seeds should in a vertical position with their stalk upward and under moderate light exposure is recommended.

Keywords: *Balanites aegyptiaca*, Desert date, Light intensity, Germination percentage, Mean germination time.

INTRODUCTION

Balanites aegyptiaca is a desert or arid/semi-arid specie, it is distributed widely across the Sahel region of Africa, some parts of the Middle East, and Asia (Orwa et al., 2009). It is popularly referred to as desert date because of its similarities with date fruit. It is known as Ádúúwàà in the Northern part of Nigeria where it is common. Identified by its multiple branches and spines, the stem is dark brown or grey colour, while the leaf is green or dark green. It has a height of 10 m and a diameter at breast height of 40 cm at its best (Varshney and Anis, 2014). Various part of the tree is utilized; the fruit and leaf are edible, providing several essential nutrients (Kubmarawa et al., 2008, NRC 2008, Okia et al., 2013). It also has many medicinal benefits (Ojo et al., 2006; Orwa et al., 2009; Morsya et al., 2010; Ya'u et al., 2011; Al-Maliki et al., 2016). The stem is used in constructing farm tools and local slate which is used for writing and reading. The wood of *Balanites aegyptiaca* provides good calorific value when used as fuelwood (Orwa et al., 2009).

Light is one of the most important environmental factors required for seed germination, plant growth, and development (Fankhauser and Chory, 1997; Pons, 2000). According to Menegaes et al, (2018), there are three categories that all seeds belong to: positively photoblastic, negatively photoblastic, and neutral photoblastic. Positively photoblastic seeds germinate in the presence of light, which means they are light-dependent. For example, *Musanga leoerrerae* seeds had the highest germination rate in the presence of light according to Muhanguzi et al. (2002). Negatively photoblastic seeds are inhibited by light, while neutral photoblastic seeds are indifferent to light, for example, species of *Funtumia africana*, *Oxyansus speciosus*, *Funtumia gummifera, Celosia argentea,* and *Celosia cristata* did well under neutral light (Muhanguzi et al., 2002; Menegaes et al., 2018). Germination in the seeds of *Cassia fistula*, *Enterolobium saman,* and *Delonix regia* species were found to be significantly affected by light intensity (Aref, 2014). Muhanguzi et al, (2002) also reported a significant difference in the germination response of some selected species. Similarly, Onyekwelu et al. (2012) found a significant difference in the germination of *Chrysophyllum albidum* when exposed to different light intensities. While light intensity was found to affect germination significantly as mentioned earlier, in some species different light regime was found not to affect germination significantly. For example, Onyekwelu et al. (2012) reported that seeds of *Irvingia gabonensis* were not significantly affected by different light treatments. Likewise, Akinyemi and Sakpere (2015) observed that the germination of Moringa seeds was not significantly different between light and dark conditions.

The amount or intensity of light required by the seed during germination is often neglected even though it is an already established fact that the seed of different species responds to light differently during germination (Muhanguzi et al., 2002; Onyekwelu et al., 2012; Aref, 2014; Menegaes et al., 2018). However, the light requirement of several species, especially tropical tree species is yet to be established. It is therefore important to understand the response of specie to light to achieve optimum germination.

Other factors such as sowing orientation or position can also affect germination. Seeds must be placed in a position that allowed the uptake of water and other environmental variables required for germination (Bowers and Hayden 1972). In some instances the effect of sowing orientation on seed germination was reported to be significant (Elfeel, 2012; Zhang et al., 2015) while in another instance it was reported to be non-significant (Kelvin et al., 2015). This implies that the seed of different species responds differently during germination to the position of sowing. The position of the seed during sowing can be vertical or horizontal, depending on the type of seed. For example, in *Balanites aegyptiaca* seeds, better germination was achieved when seeds were sown vertically with stalk downward (Hall and Walker 1991; Sayda 2002; Elfeel, 2012). However, poor germination was reported when seeds of the same *Balanites aegyptiaca* specie were laid in the same position (vertically) according to El Nour and Kalislo (1995) in another study. In *Litchi chinensis* placement of seeds vertically with their radicle downward results in better germination compared to sowing with radicle upward (Zhang et al., 2015). Sowing seeds of *Lagenaria siceraria* in a horizontal position resulted in better germination (Kelvin et al., 2015). In peanut seeds, the highest germination rate was recorded when seeds were sown vertically with hypocotyls end down, while the least germination was observed when the hypocotyls end was up (Ahn et al., 2016). This means that the appropriate position of seed placement during sowing is dependent on the type of species.

Though the effect of sowing orientation on germination of *Balanites aegyptiaca* was studied by Hall and Walker (1991), El Nour and Kalislo (1995), Sayda (2002), and Elfeel (2012), there seem to be contradictions in their findings. Therefore more studies are needed to establish the best sowing position that would lead to rapid and synchronized. The aim of this study therefore was to determine the optimum light requirement and the best sowing position of *Balanites aegyptiaca* seeds that would lead to rapid and synchronized germination which is an essential requirement for raising seedlings for plantation establishment and domestication programme.

METHODOLOGY

Study area

The study was carried out at the Seedlings Nursery of the Department of Forestry and Wildlife Management, Federal University Gashua, Yobe State, Nigeria. Gashua town is located between Latitude 12°51'.723"- 12°54'.723" N and longitude 11°00'.024" - 11°03'.475" E. The climate is divided into rain (June – September) and dry seasons (end of September – May). Average annual rainfall ranged between 500 to 1000 mm. The minimum temperature ranged from 23 to 28°C, while the maximum temperature ranges from 38 - to 40°C (Field Survey 2021).

Seeds collections

Ten (10) kg of mature fruits of *Balanites aegyptiaca* that are of good quality, free from pest or insect attack were collected from tree stands within the Federal University Gashua. The fruits were bulked and separated into different sizes; the larger fruits were selected for the experiment.

Experimental procedure

Selected fruits of *Balanites aegyptiaca* were de-pulped by soaking and washing in water to obtain the seeds. The viability of the seeds was tested using the floatation test (Wakawa and Akinyele 2016). 2,000 viable seeds were selected for the experiment. Seeds of *Balanites aegyptiaca* were randomly sampled from the bulk of viable seeds and sown at three different orientations (vertically with stalk upward (SO_1), vertically with stalk downward (SO_2), and horizontally (SO_3)) in germination trays filled with sterilized river sand. Light chambers were locally constructed with a wooden frame covered with 1 mm green mesh netting. Seeds sown in germination trays without a light chamber served as control (100% light intensity). Seeds sown in germination trays covered with one (1), two (2) and three (3) layers of green mesh nets represent 75% (L_2), 50% (L_3), and 25% (L_3) light penetration respectively (Akinyele, 2007). The germination trays were watered twice a day (morning and evening) while the experiment lasted. Germination count stopped after no new germination was observed for one (1) week. The experiment lasted for five weeks (35 days).

Experimental design

The experiment was arranged in a 4×3 factorial in a completely randomized design (CRD). The treatment combinations are shown in Table 1 below. Each treatment combination was made up of 12 germination trays, which translated to a total of 48 germination trays.

Table 1: Treatments Combination of 4×3 factorial

	Light intensity			
Seeds shape	L_1	L_2	L_3	L_4
SO_1	L_1SO_1	L_2SO_1	L_3SO_1	L_4SO_1
SO_2	L_1SO_2	L_2SO_2	L_3SO_2	L_4SO_2
SO_3	L_1SO_3	L_2SO_3	L_3SO_3	L_4SO_3

L_1:100% Light intensity, **L_2:**75% Light intensity, **L_3:**50% Light intensity, **L_4:**25% Light intensity, **SO_1:** Seeds sowed vertically with stalk upward, **SO_2:** Seeds sowed vertically with stalk downward, **SO_3:** Seeds sowed horizontally

Germination characteristics assessed

Germination percentage (GP)

Germination percentage was calculated based on the formulae adopted by International Seed Testing Association (ISTA) (1999) as shown below:

$$GP = \frac{Number\ of\ seeds\ germinatd}{Total\ number\ of\ seeds\ sown} \times 100$$

Mean germination time (MGT days)

Mean germination time (MGT) was determined according to Soltani et al, (2015) formulae given below:

MGT= $\sum(n.t)/\sum n$

t is the time from the beginning of the germination test in terms of days

n is the number of newly germinated seeds at Time *t*.

Germination speed (GS)

Germination speed (GS) was calculated using the equation of Maguire (1962), given as

$$GS = \frac{No.of\ germinated}{Days\ of\ first\ count} + - - + \frac{No.of\ seeds\ germinated}{days\ of\ final\ count}$$

Data analysis

Data collected were subjected to two ways Analysis of Variance (ANOVA) using STATISTICA Version 12. Mean separation where applicable was done using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Germination percentage

Light variation did not affect the germination percentage of *Balanites aegyptiaca* seeds significantly (Table 2). This implies that the germination of *Balanites aegyptiaca* seeds is not dependent on the amount of light exposed to. However, seeds exposed to 100% light intensity (control) had better performance (13.81±7.18%). According to Menegaes et al (2018), seed germination of some species is indifferent to light (neutral photoblastic), collaborating with our finding. In *Irvingia gabonensis* seeds, Onyekwelu et al. (2012) reported similar results when it was subjected to varying light exposure. A lack of significant difference in germination percentage of Moringa seeds exposed to light and darkness was also reported by Sakpere (2015). However, in other species, such as *Cassia fistula*, *Enterolobium saman*, *Delonix regia*, and *Chrysophyllum albidum*, exposure to different light significantly influenced germination. Seeds of different species respond differently under varying light intensity as observed by Menegaes et al (2018). Overall germination percentage recorded for all the light regimes was poor which we attributed to the dormancy effect of the seed as a result of the hard seed coat. We also suspect the low temperature observed during the experiment to have played a part in hindering germination. The study was conducted during the harmattan season when the temperature was low. Temperature is one of the environmental factors that can affect germination. The temperature in both extremes can decrease seed viability thereby reducing germination (Corbineau et al., 1986; Eberle et al., 2014).

Sowing orientation has no significant effect on the germination percentage of *Balanites aegyptiaca* seeds but seeds sown vertically with their stalk upward perform marginally better than other orientations (15.79±6.02%). Our result was contrary to that of Elfeel (2012) who reported sowing orientation to significantly affect the germination percentage of *Balanites aegyptiaca* seeds. According to Elfeel (2012) sowing *Balanites aegyptiaca* seeds in a vertical position with the stalk downward and horizontally gave better germination and differed significantly with seeds sown vertically with the stalk upward. Our result indicated that sowing seeds vertically with stalk upward gave better germination compared with those sown vertically with stalk downward and horizontally though the difference was not significant. The contradiction between our work and that of Elfeel (2012) is surprising since the species used are the same. Reports from other studies concerning the effect of sowing orientation on the germination percentage of *Balanites aegyptiaca* seeds such as that of Hall and Walker (1991) and Sayda (2002) all affirmed the superiority of sowing seeds vertically with stalk downward. However, El Nour and Kalislo (1995) reported poor germination when *Balanites aegyptiaca* seeds were sown vertically with stalk downward. This implies that there is an intra-specific variation in germination response among *Balanites aegyptiaca* seeds. Variation in germination response of seeds of different species when placed in a different position during sowing is common (Elfeel, 2012; Kelvin et al, 2015; Zhang et al, 2015) but variation among similar species is not common. Variation in seed characteristics among *Balanites aegyptiaca* species has been reported by Aviara et al. (2005). This could be one of the reasons responsible for the observed difference since the characteristics of seeds used in our study and that of Elfeel (2012) were not taken into consideration. Seed characteristics such as size, weight, etc affect germination (Egli and Rucker, 2012; Souza and Fagundes 2014; Tabakovic et al 2020).

Interaction between light intensity and sowing orientation did not significantly affect the germination percentage of *Balanites aegyptiaca* seeds. However, seeds exposed to 75% light and sown vertically with stalk upward gave a better germination percentage of 16.49±8.17 (Table 3). Sowing orientation seems to contribute more to this relationship than light intensity.

Mean germination time

The different light intensities had no significant effects on MGT, seeds sown under full light (control) took a longer period (15.50±2.87 days) before completing germination, while seeds exposed to 50% light intensity completed germination within the shortest possible time (11.99±6.36 days) (Table 2). Unlike in GP where exposure of *Balanites aegyptiaca* seeds to high light intensity resulted in higher GP, in MGT, low light intensity leads to early completion of germination. MGT is used to determine the number of days it takes for germination to start and conclude. The fewer the days spent to complete germination the better. Therefore exposing *Balanites aegyptiaca* seeds to 50% light intensity is better because it shortens the number of days required to complete germination. The number of days taken to complete germination in the seeds of some tropical forest species was reported to vary under different light conditions according to Borthwick (1957), this is similar to our observation though the variation was not significant.

Sowing seeds of *Balanites aegyptiaca* in different orientations did not affect MGT significantly. Seeds sown vertically with stalk upward require 15.17±2.84 days to complete germination, while seeds sown horizontally took fewer days (11.29±7.17) to complete germination. Our result is contrary to that of Kelvin et al. (2015) who reported MGT to vary significantly in seeds of *Lagenaria siceraria* when sown in a different position. This may be attributed to the difference in species and/or environmental factors from which the mother tree used for the collection of seeds was grown. The interaction between light intensity and sowing orientation on MGT was not significant, seeds sown vertically with stalk downward and exposed to 100% light intensity gave higher MGT (16.98±3.46 days), while those sown vertically with stalk downward and exposed to 75% light intensity had the least MGT of 7.83±13.57 days. This implies that sowing *Balanites aegyptiaca* seed vertically with the stalk downward and exposed to 75% light intensity will reduce the time taken to complete germination.

Germination speed

The germination speed of *Balanites aegyptiaca* was not affected by exposure to different light intensities. Seeds sown under 100% light intensity germinated faster (2.85±1.84) in comparison with other light treatments (Table 2). Seeds exposed to 75% light intensity had the slowest germination speed (1.95±1.90). This means sowing *Balanites aegyptiaca* seeds in high light intensity could lead to rapid germination. Rapidity during seed germination is very important. Seeds that germinate faster and in large numbers during germination are generally preferred because it is an indication of a favourable germination condition

(Sarvas, 1950). Contrary to our result, the germination rate in the seeds of four tropical species was found to vary significantly (Borthwick 1957). Since the species are different, we assumed individual species difference was responsible for variation in behaviour.

Sowing orientation significantly affects the germination speed of *Balanites aegyptiaca* seeds. Seeds sown vertically with stalk upward germinate faster (3.44±1.85) and differed significantly from those sown vertically with stalk downward which had 1.13±1.18. Our result agreed with that of Kelvin et al (2015) who reported a significant difference in GS of *Lagenaria siceraria* sown in a different orientation. Ahn et al. (2017) also reported that sowing orientation significantly affects the GS of peanut seeds. The interaction between light intensity and sowing orientation was not significant. Seeds sown vertically with stalk upward and exposed to 25% light intensity had a faster germination rate (3.99±3.06S2), while those sown vertically with stalk downward and exposed to 75% light intensity had the lowest germination speed (0.47±0.81)

Table 2: Effects of light intensity and sowing orientation on germination characteristics of *Balanites aegyptiaca*

Treatments	GP	MGT (days)	GS
L1	13.81±7.18	15.50±2.87	2.85±1.84
L2	10.52±9.67	10.96±9.10	1.95±1.90
L3	11.27±7.54	11.99±6.36	2.46±1.83
L4	12.54±11.06	12.11±8.52	2.70±2.65
S1	15.79±6.02	15.17±2.84	3.44±1.85^{a}
S2	7.03±7.25	11.46±9.39	1.13±1.18^{b}
S3	13.29±10.38	11.29±7.17	2.90±2.24^{ab}

Note: Mean carrying the same alphabet did not vary significantly p≤ 0.05. Means values are followed by standard deviation. L1=100% Light Intensity, L2=75% Light Intensity, L3=50% Light Intensity, L4=25% Light Intensity, S1= Seed sown vertically with stalk upward, S2= Seed sown vertically with stalk downward, S3= Seed sown horizontally

Table 3: Effect of interaction between light intensity and sowing orientation on germination characteristics of *Balanites aegyptiaca*

Treatments		GP	MGT	GS
L1	S1	15.24±3.59	15.22±2.45	3.14±1.30
L1	S2	10.48±7.87	16.98±3.46	1.90±1.61
L1	S3	15.71±10.30	14.31±3.09	3.51±2.67
L2	S1	16.49±8.17	15.17±4.80	3.17±1.93
L2	S2	3.81±6.60	7.83±13.57	0.47±0.81
L2	S3	11.25±11.91	9.89±9.02	2.20±2.12
L3	S1	15.71±6.22	14.78±3.75	3.46±1.82
L3	S2	7.15±6.55	11.97±7.76	1.26±1.01
L3	S3	10.95±9.51	9.22±8.01	2.67±2.32
L4	S1	15.72±8.92	15.52±0.90	3.99±3.06
L4	S2	6.67±10.33	9.07±12.40	0.89±1.34
L4	S3	15.24±15.00	11.73±10.20	3.22±3.02

Note: Mean carrying the same alphabet did not vary significantly p≤ 0.05. Means values are followed by standard deviation.

L1=100% Light Intensity, L2=75% Light Intensity, L3=50% Light Intensity, L4=25% Light Intensity, S1= Seed sown vertically with stalk upward, S2= Seed sown vertically with stalk downward, S3= Seed sown horizontally, L×S= Interaction between light intensity and sowing orientation

CONCLUSION

Germination characteristics of *Balanites aegyptiaca* seeds were not affected by the intensity of light. This is an indication of the ability of the seeds to germinate irrespective of the intensity of light. Sowing *Balanites aegyptiaca* seeds vertically with the stalk upward gave better germination characteristics even though the difference from other sowing orientations was not significant. Sowing of *Balanites aegyptiaca* seeds in a vertical position with their stalk upward under moderate light exposure is therefore recommended.

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