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MORPHOLOGICAL RESPONSES *OF Balanities eagyptica* (Linnaeus) Del. SEEDLINGS: UNVEILING THE INTERPLAY BETWEEN PHYSICAL FACTORS AND SEEDLINGS ARCHITECTURE

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ABSTRACT

*B. aegyptiaca*is an extremely important tree species in the development of the rural economy in Northern Nigeria and no specific study has been carried out to establish its productivity potentials and conservation strategies of *B. aegyptiaca.* Therefore, the study was conducted to investigate the morphological responses of *Balanities eagyptiaca*as influenced by soil forms, watering regime and light intensity on the early growth performance of *Balanites aegyptiaca* A total of one hundred and ninety nine seeds (199) were sown in 1m by 1m seed bed after pre-treatment with cold water for seventy-two hours. The experiment was arranged in 3 x 3 x 3 factorial in Completely Randomized Design (CRD) with twenty-seven treatments combination and three replicates. The experiment was carried out for sixteen (16) weeks and five growth parameters were measured. Data collected were subjected to Analysis of Variance (ANOVA and descriptive statistics. Treatment combination of C3T1W3 (Sandy x 50% of light x watering three times in a week) showed the highest performance followed by C1T3W3 (Clay x 100% of light intensity x watering three times in a week). Light intensity had significant different on shoot height and leaf production while watering regime had significant differences on leaf area and stem diameter at 0.05 probability level. Also, sandy soil had significance differences on leaf area at 0.05 probability level. Watering three times in a week and light intensity between 50 to 100 % are required for the growth of the species. Sandy soil supported the growth of the species and there must be application of specific insecticide at early stage.

Keywords: Impact, Soil Forms, Light and Water regime, Morphological Attributes, and *Balanities eagyptiaca,*

INTRODUCTION

Balanites aegyptiaca is a species of tree, classified as a member of the *Balanitaceae*. This tree is native to much of Africa and parts of the Middle East. There are many common names for this plant; in English the fruit is called "Desert date", soap berry tree, Thron tree, while in Egypt the tree is called Egyptian myrobalan and Egyptian balsam. The fruit is called lalob, hidjihi, inteishit, and heglig (hijlij) in Arabic Plant List, 2016 while in Hausa it is called aduwa, in Tamasheq, the Tuareg language taboraq, in Swahili mchunju and in Amharic bedena. The generic part of the binomial Balanites derives from the Greek word for an acorn and refers to the fruit, this name was coined by (Delile, 2016). The specific name aegyptiaca was applied by Carl Linnaeus as the species was initially described from specimens collected in Egypt. The species is found in the Sahel-Savannah region across Africa. It can be found in much kind of habitats, tolerating a wide variety of soil types, from sand to heavy clay, and climatic moisture levels, from arid to sub-humid. It is relatively tolerant of flooding, livestock activity, and wildfire. The *Balanites aegyptiaca* tree (**Plate 1)** reaches 10m (33ft) in height with a generally narrow form (Salami, 2019). The branches have long, straight green spines arranged in spirals. The dark green compound leaves grow out of the base of the spines and are made up of two leaflets which are variable in size and shape. The fluted trunk has grayish-brown, ragged bark with yellow-green patches where it is shed (Delile, 2016). Effective propagation and seedling establishment are the basic requirements for sustainable management of rare species. However, initial stages of plant life cycle, including seed germination and seedling establishment are most susceptible to environmental disturbances, and hence associated with high mortality rates (Moles and Westby, 2004). Seed germination in tree species is sometimes difficult due to hard seed coat and dormant embryos (Jaiswal and Chaudhary, 2005) and the seeds often fail to germinate even under favorable moisture, oxygen and soil conditions. To overcome this problem, several methods including mechanical scarification, soaking in water and acids (Patane and Gresta, 2006), chilling and heating (Beigh *et al.*, 2002; Iavoglou and Radoglou, 2015) and irradiation (Jan and Jan, 2012) are used for treating seeds prior to sowing.

According to Beigh *et al.*, 2002) the species as an indigenous tree species is highly preferred and utilized throughout the year most especially during the 5 month pangs of hunger for food (leaves for vegetables) medicine, live fences, fodders and fuel wood for subsistence living in this area. Despite the fact that *B. aegyptiaca*is an extremely important tree species in the development of the subsistence rural economy in Northern Nigeria, its potential use is not yet entirely known. Apart from some initiatives in northern Nigeria by (Okia *et al.*, 2011) and (Egweru *et al*., 2014), there is no specific study has been carried out in Nigeria to establish its productivity potentials and conservation strategies of *B. aegyptiaca.*

According to (Hartmann *et al.,* 2007), seed germination is influenced by the type of substrate used and environmental factors such as oxygen, water, temperature and for some species may be affected by light. Previous years ago, combination of soil types with different ratios of nutrients have been tested for their suitability towards seed germination (Selivanovskaya and Latypova, 2006). Because of its excessive exploitation for a variety of purposes, this species falls in the category of endangered plants species (Elfeel, 2012) which has necessitated conservation of this wild growing tree, and hence action plan for its maintenance and sustainable development has become indispensable.

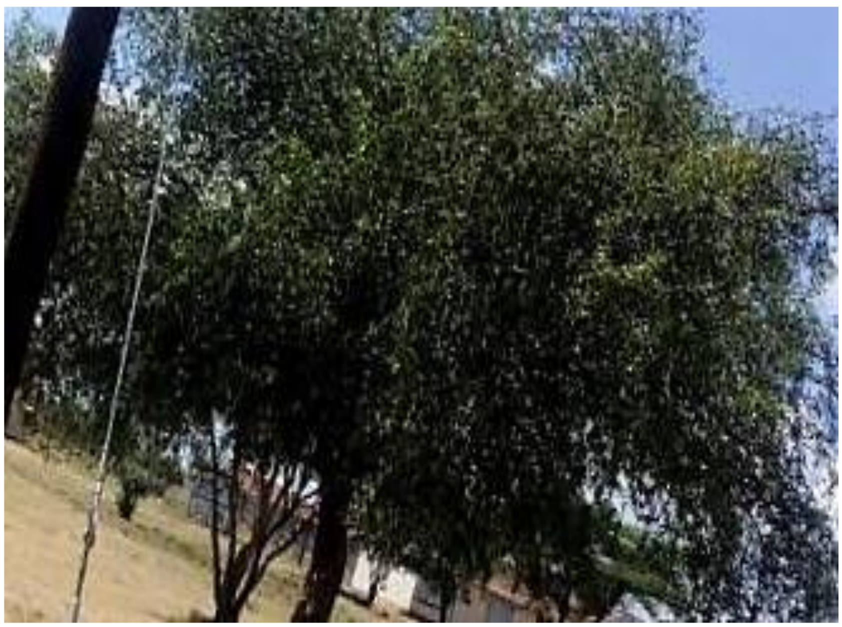

Plate 1: Typical stand of *B. aegyptiaca* at maturity stage

MATERIALS AND METHOD

Description of the area

The study was carried out at Federal University Dutse Jigawa state nursery at 11.00°N to 13.00°N and longitudes 8.00°E to 10.15°E there is little rainfall throughout the year precipitation of 734mm falls annually the average temperature is 26·5ºC (NPC, 2006). Soil are well known to be fertile ranging from sandy–loamy, ph ranges from 6.07-6.72, nitrogen content ranges from 0.63 to 1.64g/kg, phosphorus 6.25 to 12.04mgkg^{-1} and potassium ranges from 0.18 to 0.63 cmolkg^{-1} respectively. Sunshine hours showed that the town enjoys 10-11 hours of sunshine depending on the season (Salami and Lawal, 2018).

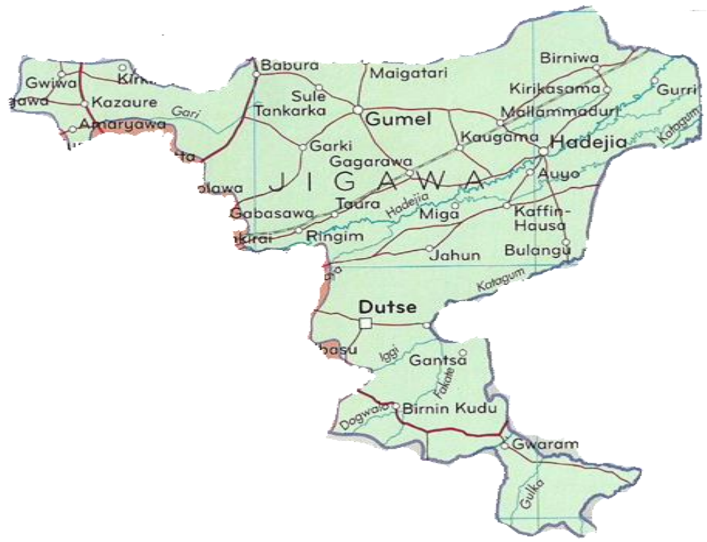

Figure 1: showing the map of Dutse

Adapted: Salami *et al*, (2020).

Seed and soil collection

Mature seed of *Balanities eagyptiaca* was be purchased from Sabon Kasuwa market, Dutse Jigawa state seed was extracted from the fruits and soak for seven two hours in cold water (Salami *et al.*, 2019). Loamy, sandy and clay soil was collected at Forestry Nursery, Federal University Dutse Jigawa state. Sample of soil textural classes (Loamy, sandy and clay) was collected from the upper level of the earth crust which was determined by using feel method (Presley and Thien 2008). The soil samples was taken to the soil science laboratory soil science department Federal University Dutse for particle seize analysis using Bouyoucos (hydrometer) method (Bouyoucos, 1951) to confirm its actual textural class.

Methods

Procedure

A total of 199 seeds were sown in1meter by 1 meter seed bed after pre-treatment with cold water for seventy-two hours. Eighty-one best samples of seedlings were chosen from the population for transplanting to the polythene pot for growth study. Two (2) light chambers constructed with wooden frame covered with one and two layers of green net representing 50% and 75% of natural sunlight respectively and open space (control) each treatment combination. Transplanted seedlings were watered once daily for a week for the seedlings to establish after they were subjected to vary light intensity and different watering regime. The seedlings were watered daily, once a week, twice a week depending on the treatment combination over 16 weeks of study (Wakawa and Akinyele, 2017).

Experimental design

The experiment was arranged in 3 x 3 x 3 factorial in Completely Randomized Design (CRD) with twenty-seven treatments combination and three replicates respectively. The factors were: soil textural class (loamy, sandy, clay soil) watering regime (watered daily, once a week, twice a week) and light intensity (50%, 75% and 100%).

$$Y_{ij} = \mu + (A_i + B_j) + (AB)_{ij} + e_{ijk}$$

where:

ij= individual observation
μ= overall mean or general mean
A_i= effect of factor A (Soil forms)
B_i=effect of factor B (Light forms)
$(AB)_{ijk}$= effect of interaction between AB (Soil forms and Light variations)
e_{ijk} =experimental error

Experimental layout

	W1	W2	W3
C1T1	C1T1W1	C1T1W2	C1T1W3
C2T1	C2T1W1	C2T1W2	C2T1W3
C3T1	C3T1W1	C3T1W2	C3T1W3
C1T2	C1T2W1	C1T2W2	C1T2W3
C2T2	C2T2W1	C2T2W2	C2T2W3
C3T2	C3T2W1	C3T2W2	C3T2W3
C1T3	C1T3W1	C1T3W2	C1T3W3
C2T3	C2T3W1	C2T3W2	C2T3W3
C3T3	C3T3W1	C3T3W2	C3T3W3

NOTE: C 1= clay, C 2= Loamy, C3= sandy, W1= Once per day, W2= Twice per day, W3= three time in a week, T1 =50%, T2= 70% and T3=100 %

Data analysis

Data collected was subjected to inferential and descriptive statistics two ways Analysis of Variance) based on the data obtained from morphological characteristics with the aid of statistical package for social sciences (SPSS) version 19

RESULTS

From the result at 50% light intensity, there is increase in the morphological response of when the watering regime was increase from once per day to three times per day. The twice per day watering regime showed low morphological response. This implies that the light intensity and or the soil type may be the cause of the low response. The leaf number and leaf area at 50% light intensity showed low response when the watering regime was once per day for all the morphological variables. There is increase in the value across the soil types. Sandy soil at 50% light intensity showed low morphological response across the watering regime except for the stem diameter and leaf area that showed increased value at watering regime of three times per week. At 75% light intensity, the morphological response was higher across the watering regimes except for the leaf area that showed the lowest value. Clay soil showed low morphological response across the watering regime at 75% watering regime. Likewise, the loamy soil showed low morphological responses except for the watering regime at three times per week which showed increase in all the morphological responses.The morphological responses of clay soil at 100% light intensity showed high response across the watering regime. For loamy soil, there is low response while for sandy soil, there is high response in the morphological response across the watering regime.

Table 1: Mean separation for Impact of Soil Forms, Light and Water regime on the early growth performance of *Balanities aegyptiaca* at maturity period (12 weeks), Mean ± standard error

SN	Treatment codes	Leaf number	Shoot height (cm)	Spine number	Stem diameter (cm)	Leaf area (cm^2)
1	C1T1W1	27±0.19^{bc}	10±0.5^{c}	18.5±0.28^{c}	2.48±1.21^{c}	12.12±0.41^{c}
2	C1T1W2	15±0.33^{c}	7.5±0.67^{d}	16±0.31^{c}	2.71±1.1^{b}	11.85±0.43^{c}
3	C1T1W3	38.5±0.13^{b}	18±0.28^{b}	27.5±0.18^{ab}	2.92±1.03^{a}	14.85±0.34^{c}
4	C2T1W1	20±0.25^{c}	16.5±0.30^{b}	18.5±0.28^{c}	2.66±1.13^{b}	8.35±0.60^{d}
5	C2T1W2	31.5±0.16^{bc}	17.5±0.29^{b}	17.5±0.29^{c}	2.68±1.13^{b}	10.56±0.5^{c}
6	C2T1W3	29±0.17^{bc}	15.5±0.32^{c}	14±0.36^{d}	2.16±1.39^{c}	7.79±0.64^{d}
7	C3T1W1	10±0.5^{d}	12±0.42^{c}	13.5±0.36^{d}	2.99±1.00^{a}	5.79±0.87^{d}
8	C3T1W2	18.5±0.27^{c}	10.5±0.4^{c}	14±0.36^{d}	2.36±1.27^{c}	15.34±0.32^{b}
9	C3T1W3	47±0.11^{a}	26±0.19^{a}	24±0.21^{ab}	2.99±1.00^{a}	10.01±0.5^{c}
10	C1T2W1	31.5±0.16^{bc}	14±0.36^{c}	16.5±0.31^{c}	2.21±1.36^{c}	12.79±0.43^{c}
11	C1T2W2	27.5±0.18^{bc}	20.5±0.25^{ab}	25±0.2^{ab}	1.99±1.51^{d}	7.79±0.64^{d}
12	C1T2W3	18.5±027^{c}	18±0.28^{b}	19±0.26^{c}	2.15±1.40^{c}	5.52±0.91^{d}
13	C2T2W1	30±0.17^{bc}	20±0.25^{ab}	27±0.19^{ab}	2.02±1.49^{c}	13.90±0.38^{c}
14	C2T2W2	20±0.25^{c}	18±0.28^{b}	15±0.33^{d}	1.97±1.52^{d}	5.52±0.91^{d}
15	C2T2W3	27.5±0.18^{bc}	20±0.25^{ab}	34±0.15^{a}	2.33±1.29^{c}	9.13±0.55
16	C3T2W1	15.5±0.32^{c}	11.5±0.43^{c}	16±0.31c	2.30±1.30^{c}	10.57±0.5^{c}
17	C3T2W2	14.5±0.35^{d}	17±0.29^{b}	21.5±0.23	2.31±1.30^{c}	24.17±0.21^{ab}
18	C3T2W3	29±0.17^{bc}	18.5±0.27^{b}	27±0.18^{ab}	2.41±1.25^{c}	10.18±0.5^{c}
19	C1T3W1	21.5±0.23^{c}	15±0.33^{c}	20±0.25^{c}	1.61±1.86^{d}	10.85±0.6^{c}
20	C1T3W2	28±0.17^{bc}	23±0.21^{a}	19±0.26^{d}	2.63±2.63^{b}	7.27±0.69^{d}
21	C1T3W3	38.5±0.13^{b}	19±0.26^{b}	25±0.22^{ab}	1.51±1.99^{d}	22.78±0.22^{ab}
22	C2T3W1	32.5±0.16^{bc}	21.5±0.23^{ab}	22.5±0.22^{ab}	2.31±0.13^{c}	13.44±0.38^{c}
23	C2T3W2	21±0.23^{c}	16.5±0.32^{b}	16±0.31^{c}	2.83±1.06^{b}	16.13±0.31^{b}
24	C2T3W3	9±0.55^{d}	16.5±0.32^{b}	15±0.33^{d}	2.12±1.42^{c}	12.01±0.43^{c}
25	C3T3W1	20±0.25^{c}	16±0.31^{b}	14±0.36^{d}	2.4±1.24^{c}	10.55±0.5^{c}
26	C3T3W2	22±0.22^{c}	20±0.25^{ab}	18.5±0.28^{c}	2.46±1.21^{c}	11.56±0.43^{c}
27	C3T3W3	13±0.38^{d}	21.5±0.23^{ab}	22±0.25^{ab}	2.08±1.44^{c}	33.32±0.15^{a}

DISCUSSION

This study demonstrates that specific treatment combinations significantly enhance leaf production, vertical growth, spine formation, and stem thickness in *Balanites aegyptiaca*, highlighting the importance of optimized environmental conditions for plant resilience and adaptability in arid environments. The findings imply that water availability, stem diameter, and leaf area are critical factors influencing plant growth and survival, with thicker stems and larger leaf areas contributing to mechanical strength and photosynthetic efficiency. The ability of *Balanites aegyptiaca* to adjust leaf area in response to different treatments indicates a critical survival strategy in fluctuating environments. These results have practical applications in agricultural management, conservation efforts, and ecosystem resilience, and suggest future research directions exploring molecular mechanisms, long-term implications, and scalability to inform effective strategies for cultivating and conserving this valuable plant species. The table provides data on the effects of various treatments on several morphological attributes of *Balanites aegyptiaca*. Leaf number varies significantly across treatments, with the highest leaf number observed in treatment C3T1W3 (47±0.11) and the lowest in C2T3W3 (9±0.55). The data suggest that certain combinations of treatments significantly enhance leaf production in *Balanites aegyptiaca*. Shoot height shows a broad range, with the maximum height recorded in C3T1W3 (26±0.19 cm) and the minimum in C1T1W2 (7.5±0.67 cm). This variation in shoot height across treatments suggests that some treatments are more conducive to vertical growth than others. Spine number also varies considerably, with the highest number found in C2T2W3 (34±0.15) and the lowest in several treatments, such as C1T1W3 (14±0.36), indicating that the conditions provided by some treatments may be more favourable for spine formation. Stem diameter is another critical parameter, with the highest stem diameter observed in C1T1W3 and C3T1W1 (2.99±1.00 cm each). In contrast, the lowest stem diameter is recorded in C1T3W3

(1.51±1.99 cm), which may reflect how different treatments impact the thickness of the plant's stem. Leaf area demonstrates a significant range across treatments, with the largest leaf area in C3T3W3 (33.32±0.15 cm²) and the smallest in C3T1W1 (5.79±0.87 cm²). The findings from this study align closely with existing research that highlights the significance of environmental factors in influencing the growth of *Balanites aegyptiaca* and other species adapted to arid conditions. For instance, Daws *et al*. (2002) emphasize the crucial role of water availability in determining the growth and survival of seedlings in arid environments. Water stress is a common challenge in arid regions, and adequate water supply is vital for the early growth stages of many plants, including *Balanites aegyptiaca*. The higher leaf number and shoot height observed in treatments with optimized water conditions in this study are consistent with Daws' findings. This suggests that water availability not only supports seedling survival but also significantly enhances vegetative growth, which is critical for the establishment of *Balanites aegyptiaca* in harsh environments. Similarly, the influence of stem diameter on plant stability is well-documented in the literature. Niklas (1992) explored the mechanical stability of plants and found that thicker stems are generally associated with greater structural integrity, which helps plants withstand environmental stresses such as wind and herbivory. The significant variation in stem diameter across the different treatments in this study reinforces the idea that environmental conditions can be managed to enhance stem growth. A thicker stem provides better support and contributes to the plant's overall resilience, making it better suited to survive in challenging environments. Studies have also researched the impact of stem architecture on plant resilience. For example, Poorter *et al*. (2010) conducted a comprehensive analysis of plant functional traits and concluded that stem diameter is a key determinant of a plant's mechanical strength and longevity. This supports the findings of the current study, where certain treatments led to increased stem diameter, likely resulting in a more robust plant structure capable of enduring arid conditions. Reich *et al*. (1997) explored the relationship between leaf area and photosynthetic efficiency and found that larger leaf areas generally correlate with higher photosynthetic rates, which in turn lead to improved growth and productivity. The findings from the current study, which demonstrate significant variations in leaf area based on treatment, support the notion that optimizing environmental conditions to increase leaf area can enhance the growth and productivity of *Balanites aegyptiaca*. The larger leaf areas observed in certain treatments suggest that these conditions may maximize the plant's ability to capture light and perform photosynthesis, which is particularly important in arid environments where resource acquisition is limited. Further supporting this, Valladares *et al*. (2016) emphasized the importance of plasticity in leaf traits for plants growing in variable environments. The ability of *Balanites aegyptiaca* to adjust leaf area in response to different treatments, as observed in this study, indicates a level of adaptability that could be critical for its survival in fluctuating environmental conditions. This adaptability might explain why certain treatments result in larger leaf areas, as the plant adjusts its morphology to optimize resource use under different conditions

CONCLUSION

This study investigated the effects of various treatments on the morphological attributes of *Balanites aegyptiaca*, a plant species adapted to arid conditions. The results demonstrate significant variations in leaf number, shoot height, spine number, stem diameter, and leaf area across different treatments. These findings suggest that specific treatment combinations can enhance leaf production, vertical growth, spine formation, and stem thickness, ultimately contributing to the plant's resilience and adaptability in harsh environments. The study's results align with existing research emphasizing the crucial role of environmental factors, particularly water availability, in influencing the growth and survival of *Balanites aegyptiaca*. Optimized water conditions led to increased leaf number and shoot height, while variations in stem diameter and leaf area reflected the plant's adaptability to different environmental conditions. The significance of stem diameter in plant stability and resilience is reinforced by the study's findings. Thicker stems, resulting from certain treatments, likely contribute to greater structural integrity and better support for the plant. Moreover, the observed variations in leaf area suggest that optimizing environmental conditions can enhance photosynthetic efficiency and growth productivity. The plant's adaptability, demonstrated by its ability to adjust leaf area in response to different treatments, is critical for its survival in fluctuating environmental conditions. This adaptability enables *Balanites aegyptiaca* to optimize resource use under various conditions, highlighting the importance of plasticity in leaf traits.

In conclusion, this study underscores the importance of carefully managed environmental conditions in enhancing the growth, productivity, and resilience of *Balanites aegyptiaca*. The findings provide valuable insights into the plant's morphological responses to different treatments, informing strategies for optimal cultivation and conservation in arid regions. By understanding how environmental factors influence the growth and adaptability of *Balanites aegyptiaca*, researchers and practitioners can develop more effective approaches to promoting the sustainable development of this valuable plant species. Future research should focus on exploring the molecular mechanisms underlying the observed morphological responses and investigating the long-term implications of these findings for ecosystem resilience and biodiversity conservation. By integrating these insights with existing knowledge, scientists can develop more comprehensive strategies for managing and conserving plant species in arid environments, ultimately contributing to a more sustainable future.

RECOMMENDATIONS

The study recommended that moderate light intensity and water frequency had more response to the morphological attributes of *Balanites aegyptiaca* and they must be put into consideration for the better growth yield and development of *Balanites aegyptiaca*. More also, any forms of soil could be used for planting this species most especially sandy soil.

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