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Survival and Growth Response of Seedlings to Seed Size Variation of *Albizia lebbeck* (L.) Benth

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Authors' contributions

This work was carried out in collaboration between both authors. Authors EM and CM designed the study. Author EM performed the statistical analysis. Authors EM and CM performed the experiment and wrote the first draft of the manuscript. Author EM managed the literature searches, addressed subsequent reviewer comments and suggestions for improvement. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To investigate the influence of seed size variation on seedling growth height, root collar diameter, root length, seedling length, root shoot ratio, number of leafs, leaf area, dry weight and survival of *Albizia lebbeck* in the nursery.
Place and Duration of Study: The experiment was conducted in the nursery at Malawi College of Forestry and Wildlife between March and September 2014.
Methodology: Seeds were categorized into three groups in regard to their length and weight: large (0.98±0.05 cm) and (0.22±0.02 g); medium (0.64±0.04 cm) and (0.13±0.02 g); and small (0.32±0.05 cm) and (0.09±0.01 g).The treatments were completely randomized into four replications. A total of 600 seeds were used with each treatment having 50 seeds. To improve germination, seeds were mechanically nicked with secateurs.
Results: Seedling height, root collar diameter, root length, seedling length, root shoot ratio, number of leafs, leaf area, dry weight and percentage survival were significantly (P<.001) affected by seed size variation. Large seeds produced higher seedling height (58.4 cm), root collar diameter

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(5.97 mm), root length (29.7 cm), seedling length (88.1 cm), root shoot ratio (0.51), number of leafs (8.21), leaf area (405.0 cm^2 $plant^-$), dry weight (11.3 g $plant^-$) and percentage survival (89.6%) compared to seedling height (43.7 cm), root collar diameter (4.03 mm), root length (20.2 cm), seedling length (63.8 cm), root shoot ratio (0.46), number of leafs (5.93), leaf area (207.3 cm^2 $plant^-$), dry weight (7.8 g $plant^-$) and percentage survival (65.2%) of medium seeds and seedling height (29.3 cm), root collar diameter (2.01 mm), root length (12.6 cm), seedling length (41.9 cm), root shoot ratio (0.43), number of leafs (3.66), leaf area (136.8 cm^2 $plant^-$), dry weight (5.1 g $plant^-$) and percentage survival (46.1%) of small seeds.There was a significant correlation between seed size and seedling height (*P*=.05, r=.92), root length (*P*=.05, r=.93), root collar diameter (*P*=.05, r=.95), number of leafs (*P*=.05, r=.95), leaf area (*P*=.05, r=.90), dry weight (*P*=.05, r=.81), and percentage survival (*P*=.05, r=.82). This indicates that seed size could be used as parameter for predicting seedling growth rates in the nursery.

Conclusion: The present study has demonstrated the merits of grading seeds and that use of large size seeds for production of high quality transplants of *Albizia lebbeck* in the nursery is recommended.

Keywords: Shoot length; root collar diameter; root length; leaf area; number of leafs; dry weight; survival.

1. INTRODUCTION

Seed plays an important role in transfer of genetic characters and improvement of qualitative and quantitative traits of production. One of the most important aspects in maximizing crop yield is planting high quality seed [1]. Seed size is an important parameter of seed quality that influences the germination, growth and biomass of the nursery seedlings and that trend correlates to the future crop [2].

The influence of seed size on seedling emergence and growth in various tree species have been studied by many researchers [1–9], but there is no consistent trend between seed size and seedling growth and survival. For example, large seeds produced more vigorous seedlings than small seeds in *Mammea suriga* and in *Afzelia quanzensis* [2,9], because of higher food reserves stored in large seeds [1]. On contrast, there were no significant differences in seedling growth of *Bauhinia thonningii* due to seed size [8].

Albizia lebbeck L. Benth. is an important multipurpose tree species belonging to the family of *Leguminosae* [10]. The tree species is well distributed in all regions of Malawi and it has been prioritized as one of the species for conservation in Malawi to enhance its contribution to livelihood of communities. The morphological description, its uses and application in Malawi has been well explained by [11]. Seeds sizes of *A. lebbeck* vary widely [12], however no attempt has been made to investigate the effect of seed size on seedling growth and survival of *A. lebbeck*. It is considered necessary to know the effect of seed size on seedling growth and survival so as to get healthy seedlings of plant species for a purpose of transportation in the field [13]. To fill the knowledge gap, this study was conducted to investigate the influence of seed size variation on seedling growth, biomass production and survival of *A. Lebbeck* in the nursery.

2. MATERIALS AND METHODS

2.1 Seed Acquisition and Study Site

Albizia lebbeck seed from Salima (13°53'S, 34°26'E, and about 540 m above sea level), was supplied by Forestry Research Institute of Malawi (FRIM) in March 2014. This study was conducted at Malawi College of Forestry and Wildlife (MCFW) nursery (14°19'S, 34°17'E, and 1591 m above sea level) which is located in Malawi near the tropical savannah region in Southern Africa. Mean annual rainfall at MCFW is 1200 mm to 1800 mm, with annual temperature range of 7°C to 25°C. It is situated about 85 km south east of Lilongwe the capital.

2.2 Experimental Design and Treatments

Seeds were categorised into three treatments; large, medium and small according to both seed length and weight (Table 1). The treatments were completely randomized in four replicates. Each treatment had 50 seeds making a total of 600 seeds that were used for the whole experiment. All experimental seeds were mechanically nicked with secateurs to improve germination as the technique has been effective in other studies [8, 11,14].

Seed were sown on 31st March 2014 in 10 cm black polythene tubes filled with soil collected from a natural *Brachystegia* woodland stand which contain adequate nutrients for seedling growth [9]. One seed was sown per tube at a depth of 2 cm, as previously recommended [15]. All pots were watered regularly to maintain adequate moisture necessary for germination and seedling growth.

Table 1. Mean seed length and weight of large, medium and small seeds used in the experiment

Seed size category	Average length (cm)	Average weight (g)
Large	0.98±0.05	0.22±0.02
Medium	0.64±0.04	0.13±0.02
Small	0.32±0.05	0.09±0.01

2.3 Data Collection and Analysis

Seeds germination was recorded daily and the experiment concluded after 30 days when no more germination occurred. A seed was considered germinated when there was visible protrusion of split seed coat with the cotyledons, hypocotyls and epicotyl on the soil surface. Daily germination percentages were summed up to obtain cumulative germination for each treatment. After the completion of seed germination experiment, shoot height, root collar diameter and survival of seedlings were monitored for 150 days. All the seedlings were measured for total shoot height and root collar diameter at 30 days interval and seedling survival was recorded simultaneously. Total shoot height was measured by using a 30 cm ruler and collar diameter by using a microcalliper to the nearest 0.01 mm. The measurements were taken just below the cotyledons. At the termination of the experiment root length, number of leafs, leaf area and dry weight of the seedlings were determined.

Germination percentage was calculated by dividing the total number of seeds that germinated in each treatment by the number of seeds sown and multiplied by 100. Survival percentage of seedlings that survived was also calculated based on the seeds that germinated. Data on seedling length and root shoot ratio were obtained by adding root length to shoot length and dividing root length by shoot length for each seedling respectively. Germination percentage, seedling height, seedling length, root shoot ration, root collar diameter, survival percentage, root length, number of leafs, leaf area and dry weight data were tested for normality and homogeneity with Kolmogorov-Smirnov D and normal probability plot tests using Statistical Analysis of Systems software version 9.1.3 [16]. After the two criteria were met the data were subjected to analysis of variance (ANOVA) using the same Statistical Analysis of Systems software and means separated with Fischer's least significant difference (LSD) at the 0.05 level. Regression analysis was used to determine the relationship between seed size and the parameters studied.

3. RESULTS AND DISCUSSION

3.1 Germination

There was no significant (P>.05) differences in cumulative germination percentage among the three seed size variation (Table 2). Results of present study are consistent with the previous studies [8,9,11]. This could mean that all the three seed size categories can germinate provided that high physiological quality seeds are used [9]. According to [17] some of the desirable seed physiological qualities include plumpness, high purity, freedom from pests and diseases, and being dried to right moisture content.

3.2 Seedling Growth

There were significant (P<.001) differences in seedling height, root collar diameter, root length, seedling length, root shoot ratio, number of leafs, leaf area and dry weight among the three seed sizes studied (Tables 2 and 3). Large seeds produced seedlings with higher height, root collar diameter, root length, root shoot ratio, number of leafs, leaf area and dry weight than medium and small seeds, while medium seeds produced seedlings with medium height, root collar diameter, root length, seedling length, root shoot ratio, number of leafs, leaf area and dry weight than small seeds. The findings of the present study are in agreement with previous studies [1,2,18,19]. Production of superior seedlings by large seeds has been attributed to growth enhancement by higher carbohydrates reserves in their endosperm when compared to medium and small seeds [2,20]. On the other hand, [8,21,22] reported no significant influence of seed size on seedling growth in a few tropical tree species, while [2] reported that medium sized seeds produced better seedling growth than those of smaller and larger ones. These differences may be due to the fact that seedling growth is highly controlled by many intrinsic and extrinsic factors and is species specific [23]. Although seedling growth is not always correlated to seed size [21,22], the present study has shown that large seeds should be used for production of superior seedling in terms of seedling vigour, in *A. lebbeck*.

Shoot length and root collar growth trend of *A. Lebbeck* for the period of 150 days are presented in Figs. 1 and 2 respectively. The shoot length and root collar growth of *A. lebbeck* was significantly ($P<.001$) higher in large seeds than in other seed size variations. Large seeds gave the highest seedling height growth which increased rapidly between 30 and 120 days, then increased at the decreasing rate between 120 and 150 days. A similar trend was also observed for the other seed size variations and for the root collar diameter growth (Fig. 2). According to [6], the higher growth rate of large seeds could be due to the reason that large-seeded species are predicted to be better adapted to the catastrophic events encountered by seedlings because they can compensate for damage using seed reserves.The growth increased at an increasing rate between 60 and 120 days because the seedlings were using the photosynthesized food for growth, as the food reserves were being invested in the tap root of the plants. This was indicated by the plants changing of cotyledons colour from brown yellowish to right green in the nursery.

3.3 Seedling Survival

A log survival percentage against time was constructed (Fig. 3). Survivorship curves of seedlings from all the three seed size variation were close to Deevy Type II curve with more or less constant mortality rate. However, survivorship curves for medium and small seeds were steeper than that for large seeds. The results are in conformity with other researchers [24,25]. Survival of seedlings is dependent on the amount of the reserves at the time of re-growth, such that those with greater amount of food reserves are able to regenerate new shoots [25].

3.4 Correlation among Seed Size, Seedling Growth and Percentage Survival

Correlation and regressions equations results among seed size, shoot length, root length, root collar diameter, number of leafs, leaf area, dry weight and percentage survival are presented in Table 4. The results shows that there was a strong positive significant ($P=.05$) relationship ($r>.80$) between seed size and shoot length, root length, root collar diameter, number of leafs, leaf area, dry weight and percentage survival. This imply that seed size could be used as parameter for predicting seedling growth rates in the nursery. The present results are in agreement with the results of [9] who reported a strong relationship between seed size and seedling growth height and root collar diameter growth of *Afzelia quanzensis*.

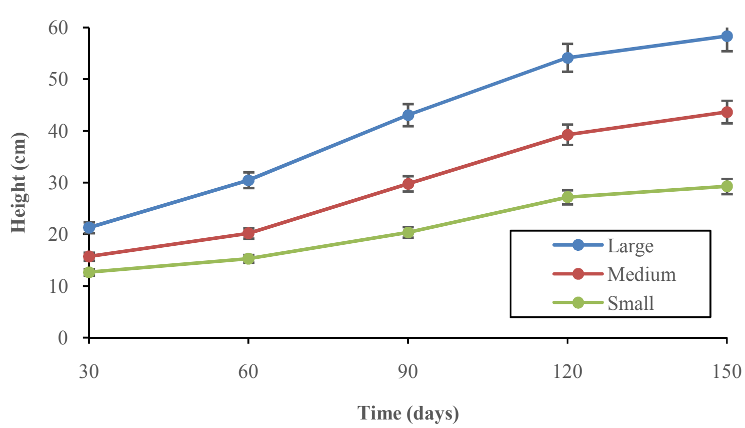

Fig. 1. Seedling height growth of *Albizia lebbeck* from different seed size categories

Table 2. Effect of seed size variation on germination percentage, root length, shoot length, seedling length and root shoot ratio of *Albizia lebbeck* at nursery

Seed size	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Root shoot ratio
Large	100.0±0.0[a]	29.7±1.5[a]	58.4±1.4[a]	88.1±1.5[a]	0.51±0.01[a]
Medium	96.3±1.5[a]	20.2±1.3[b]	43.7±2.7[b]	63.8±1.9[b]	0.46±0.03[b]
Small	95.1±1.6[a]	12.6±1.3[c]	29.3±1.3[c]	41.9±1.3[c]	0.43±0.03[c]
CV%	5.2	4.6	7.3	8.9	6.3

Note:[a,b,c]means with different subscript within a column significantly differ (P<.001)

Table 3. Effect of seed size variation on root collar diameter, number of leafs, leaf area, dry weight and survival percentage of *Albizia lebbeck* at nursery

Seed size	Root collar diameter (mm)	Number of leafs	Leaf area (cm^2 $plant^-$)	Dry weight (g $plant^-$)	Survival (%)
Large	5.97±0.01[a]	8.21±0.04[a]	405.0±2.4[a]	11.3±0.6[a]	89.6±2.5[a]
Medium	4.03±0.02[b]	5.93±0.03[b]	207.3±3.2[b]	7.8±0.3[b]	65.2±2.3[b]
Small	2.01±0.02[c]	3.66±0.03[c]	136.8±2.2[c]	5.1±0.3[c]	46.1±2.4[c]
CV%	5.3	4.6	6.8	8.9	7.2

Note:[a,b,c]means with different subscript within a column significantly differ (P<.001)

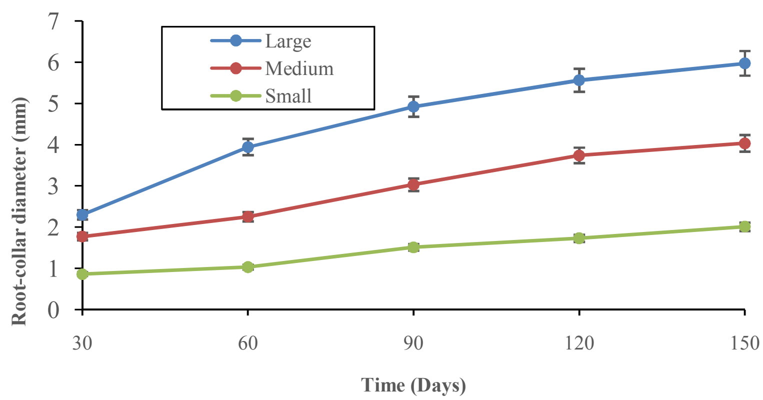

Fig. 2. Seedling root collar growth of *Albizia lebbeck* from different seed size categories

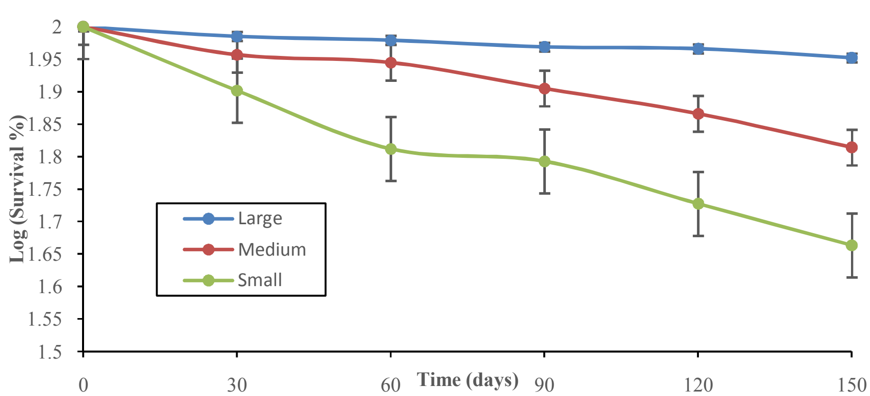

Fig. 3. Survival trend of *Albizia lebbeck* seedlings from different seed size categories

Table 4. Regression equations (above diagonal) and correlations (below diagonal) among seed size, shoot length, root length, root collar diameter, number of leafs, leaf area, dry weight and percentage survival of *Albizia lebbeck*

Parameter	Seed size	Shoot length (cm)	Root length (cm)	RCD (mm)	Number of leafs	Leaf area (cm^2 $plant^-$)	Dry weight (g $plant^-$)	Survival (%)
Seed size	-	Y=198X+13	Y=118X+2.4	Y=28X-0.22	Y=32X+1.1	Y=1892X-52	Y=40X+1.4	Y=283X+20
Shoot length (cm)	r=.92*	-	Y=0.59X-5.0	Y=0.13X-1.8	Y=0.15X-0.7	Y=9.4X-166	Y=0.22X-2.0	Y=1.55X-3.1
Root length (cm)	r=.93*	r=.99**	-	Y=0.23X-0.6	Y=0.26X+0.6	Y=16.1X-91	Y=0.38X-0.2	Y=2.6X+9.9
RCD (mm)	r=.95*	r=.99**	r=.99**	-	Y=1.15X+1.3	Y=67.7X-34	Y=1.57X+1.2	Y=11X+19.4
Number of leafs	r=.95*	r=.99**	r=.99**	r=.99**	-	Y=59X-114	Y=1.38X-0.6	Y=9.7X+6.4
Leaf area (cm^2 $plant^-$)	r=.90*	r=.96*	r=.98*	r=.94*	r=.95*	-	Y=0.02X+2.1	Y=0.16X+26
Dry weight (g $plant^-$)	r=.81*	r=.96*	r=.97*	r=.92*	r=.93*	r=.97*	-	Y=6.93X+11
Survival (%)	r=.82*	r=.97*	r=.97*	r=.93*	r=.94*	r=.97*	r=.99**	-

Note:*Highly significant (P<0.001), *significant at (P<0.05), RCD: Root collar diameter*

4. CONCLUSION

The current study has revealed that seed size has a clear effect on seedling growth and percentage survival of *A. lebbeck* in the nursery. Larger seeds produced high quality seedlings that had a higher high survival rates than medium and small seeds. This confirms merits of grading seed to enhance transplant quality. There was a strong positive significant relationship between seed size andseedling growth and percentage survival. This indicates that seed size could be used as parameter for predicting seedling growth rates in the nursery. Therefore, it is recommended to use large sized seeds for production of high quality transplants of *A. lebbeck* in the nursery.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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