

Response of seedling growth attributes to seed size variation of *Albizia lebbeck*

ABSTRACT

Aims: To investigate the influence of seed size variation on seedling growth attributes of *Albizia lebbeck* in the nursery.

Place and Duration of Study: The experiment was conducted at Malawi College of Forestry and Wildlife nursery between March and September 2014.

Methodology: Seeds were categorized into four groups in regard to their length and weight: large ($\geq 0.80\text{cm}$) and ($\geq 0.20\text{g}$); medium ($0.51\text{-}0.79\text{cm}$) and ($0.11\text{-}0.19\text{g}$); small ($\leq 0.50\text{cm}$) and ($\leq 0.10\text{g}$) and a mixture of large, medium and small seeds (acted as a control). The treatments were completely randomized into four replications. A total of 800 seeds were used with each treatment having 50 seeds. In order to improve germination of seed, mechanical nicking using secateurs was applied.

Results: There were significantly ($P < .001$) differences in seedling growth attributes and survival percentage between seed size categories, with large seeds having the highest seedling growth attributes values and survival percentage while small seeds had the lowest values. This was attributed to differences in the food reserves. The differences on growth attributes between mean values of large and small seeds; large and medium; large and control, ranged from 99% to 197%; 34% to 95%; and 41% to 107% respectively. This confirms merits of grading seed to enhance transplant quality. There were no significant ($P > .05$) differences between small seeds and control on dry weight and survival percentage. Even though control had slightly higher dry weight (5.9g) and survival percentage (53%) compared to 5.1g (dry weight) and 46% (survival percentage) of small seeds. There was a strong positive significant ($P = .05$) relationship ($r > .80$) between seed size and seedling growth attributes. This indicate that seed size could be used as parameter for predicting seedling growth rates in the nursery.

Conclusion: It is recommended to use large sized seeds for production of high quality transplants of *Albizia lebbeck* in the nursery.

Key words: shoot length; root collar diameter; root length; leaf area; number of leaves; dry weight; survival.

31 1. INTRODUCTION

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

36

37 The influence of seed size on seedling emergence and growth in various tree species have been studied
38 by many researchers [1, 2, 3 – 9]. However, these results varied widely between species. Most researchers
39 have reported that seeds of larger size produced vigour seedlings when compared to that of smaller ones.
40 Higher seedling growth attributes with increased seed size were observed in *Mammea suriga*[2] and in
41 *Azela quanzensis*[9]. These results showed that the higher seedling growth attributes that occurred in
42 larger seeds is due to the larger food reserves in these seeds [1]. In contrast, there were no significant
43 differences in seedling growth of *Bauhinia thonningii* due to seed size [8].

44

45 *Albizia lebbeck* L. Benth. is an important multipurpose tree species belonging to the family of *Leguminosae*
46 [10]. The tree species is well distributed in all regions of Malawi and it has been prioritized as one of the
47 species for conservation in Malawi to enhance its contribution to livelihood of communities. The
48 morphological description, its uses and application in Malawi has been well explained by [11]. Most of the
49 studies on *Albizia lebbeck* and other species in Malawi have concentrated on germination [8, 11]. In both
50 studies, it was reported that seed size had no influence on seed germination of *Albizia lebbeck* and
51 *Bauhinia thonningii*. There is no information on effect of seed size on seedling growth attributes of *Albizia*
52 *lebbeck*. *Albizia lebbeck* seeds collected from natural population are of different sizes, ranging from 0.3cm
53 to 1.1cm long and 0.2cm to 0.9cm broad and the weight ranges from 0.06g to 0.2g [12]. To fill the
54 knowledge gap, this study was conducted to investigate the influence of seed size variation on seedling
55 growth attributes of *Albizia lebbeck* in the nursery.

56

57 2. MATERIAL AND METHODS

58 2.1 Seed Acquisition and Study site

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

65

66 2.2 Experimental design and treatments

67 Seeds were categorised into four treatments; large, medium, small and control (mixture of large, medium
68 and small) in terms of length and weight (Table1). The treatments were completely randomized in four
69 replicates. Each treatment had 50 seeds making a total of 800 seeds that were used for the whole
70 experiment. In order to improve germination of seed, mechanical nicking of seeds using secateurs was
71 applied. This technique was applied because in most studies in Malawi it has proved to be effective[8, 11,
72 13].

73

74 Seed were sown on 31st March 2014 in 10 cm black polythene tubes filled with soil collected from natural
75 woodland (*Brachystegia* stand) to ensure availability of nutrients for growth. One seed was sown per tube
76 at a depth of 2cm, as recommended by [14]. Regular watering was done as per requirement to maintain
77 adequate moisture necessary for germination and seedling growth.

78

79 **Table 1** Seed size categories in terms of length and weight

80

Seed size category	Range of length (cm)	Average length (cm)	Range of seed weight (g)	Average weight (g) of 100 seeds
Small	≤ 0.50	0.32	≤ 0.10	0.09
Medium	0.51 – 0.79	0.64	0.11 – 0.19	0.13
Large	≥ 0.80	0.98	≥ 0.20	0.22
Control	0.20 – 1.10	0.67	0.06 – 0.25	0.17

81

82

83 2.3 Data collection and analysis

84 Germination was recorded daily for 30 days until germinated seeds occurred no more. The seed was
85 considered germinated by a visible protrusion of split seed coat with the cotyledons, hypocotyls, and
86 epicotyl on the surface of the soil. Daily germination percentages were summed up to obtain cumulative

germination for each treatment. After the completion of seed germination experiment, seedling growth attributes were monitored for 150 days to assess the seed size variation effect on growth. All the seedlings were measured for total shoot height and root collar diameter once for every 30 days. Survival of the seedlings was also assessed at the same interval. 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. The number of seedlings that survived was also counted in each and every treatment unit. At the termination of the experiment root length, number of leafs, leaf area and dry weight of the seedlings were determined.

95

Germination percentage was calculated by dividing the total number of seeds that germinated in each treatment by the number of seeds sown (excluding dead seeds) and multiplied by 100. Survival percentage of seedlings that survived was also calculated based on the seed germinated. Data on germination percentage, seedling height, root collar diameter, survival percentage, root length, number of leaves, leaf area and dry weight were subjected to Kolmogorov-Smirnov D and normal probability plot tests using Statistical Analysis of Systems software version 9.1.3[15]. This was done in order to check the normality of the data. After that the data was subjected to analysis of variance (ANOVA) using the same Statistical Analysis of Systems software version 9.1.3. Differences between treatment means were separated using Fischer's least significant difference (LSD) at the 0.05 level. Pearson's correlation coefficients (r) were calculated to determine the relationship that existed between seed size and the parameters studied.

107

3. RESULTS AND DISCUSSION

3.1 Germination

The results for cumulative germination percentage are given in Table 2. The results shows that there were no significant ($P>.05$) differences in cumulative germination percentage between the seed size variation, although large seeds had a slightly higher (3.7% - 4.9%) cumulative germination percentage than the other seed size variation. This could mean that all the four seed size categories can germinate provided that high physiological quality seeds are used [9]. According to [16] some of the desirable seed physiological qualities include plumpness, high purity, freedom from pests and diseases, and being dried to a right

moisture content. The present results are consistent with the previous study [11] and also in agreement with those reported by [8, 9].

3.2 Seedling growth attributes

There were significant ($P < .001$) differences between the seed size variation in all the seedling growth attributes studied (Tables 2 and 3). The results indicate that large seeds produced higher values while small seeds had lowest values. The findings of the present study are in agreement with those in literature [1, 2, 17, 18]. Large seed produced robust seedlings due to greater amount of carbohydrates in their endosperm or cotyledons than medium, smaller and mixture seeds, ensuring early development to produce faster growing plants [2, 19]. On the other hand, Mwase and Mvula [8], Agboola [20], Malavasi and Malavasi [21] 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 [22]. Therefore the present study has shown that for production of better seedling in terms of seedling vigour, large seeds of *Albizia lebbbeck* should be encouraged in the nursery.

Table 2 Effect of seed size variation on germination percentage, root length, shoot length, seedling length and shoot root ratio with standard errors in parenthesis of *Albizia lebbbeck* at nursery

Seed size	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Shoot root 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
Control	96.2(1.3) ^a	18.8(1.2) ^b	40.5(1.5) ^b	59.3(1.3) ^b	0.46(0.03) ^b
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 with standard errors in parenthesis of *Albizia lebbbeck* at nursery

Seed size	Root collar diameter (mm)	Number of leafs	Leaf area (cm ² plant ⁻¹)	Dry weight (g plant ⁻¹)	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) ^d	5.1(0.3) ^c	46.1(2.4) ^c
Control	3.97(0.02) ^b	5.82(0.02) ^b	195.5(3.2) ^c	5.9(1.1) ^c	52.9(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 ($P < .001$)

Shoot length and root collar growth trend of *Albizia lebbeck* for the period of 150 days are presented in Figures 1 and 2 respectively. The shoot length and root collar growth of *Albizia 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 (Figure 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.

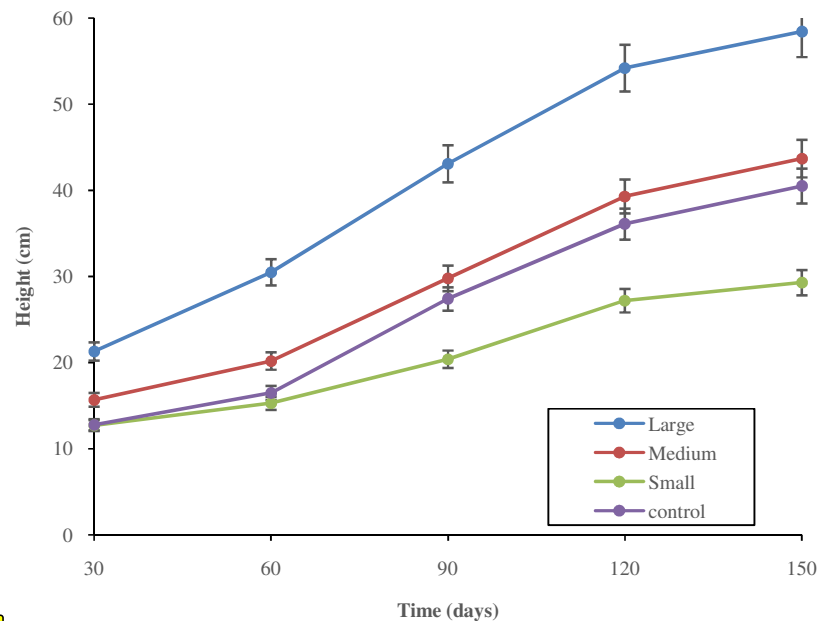


Figure 1 seedling height growth of *Albizia lebbeck* from different seed size categories

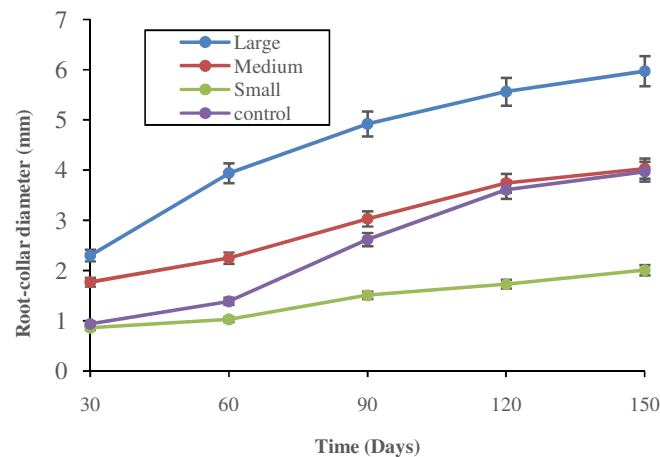


Figure 2 Seedling root collar growth of *Albizia lebbeck* from different seed size categories

3.3 Seedling survival

A log survival percentage against time was constructed (Figure 3). Survivorship curves of seedlings from all the four seed size variation were close to Deevy Type II curve with more or less constant mortality rate. However, survivorship curves for medium, small and mixture seeds were steeper than that for large seeds. There were no significant ($P > .05$) differences between curves of small seeds and mixture seeds. The results are in conformity with other researchers [23, 24]. 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 [24].

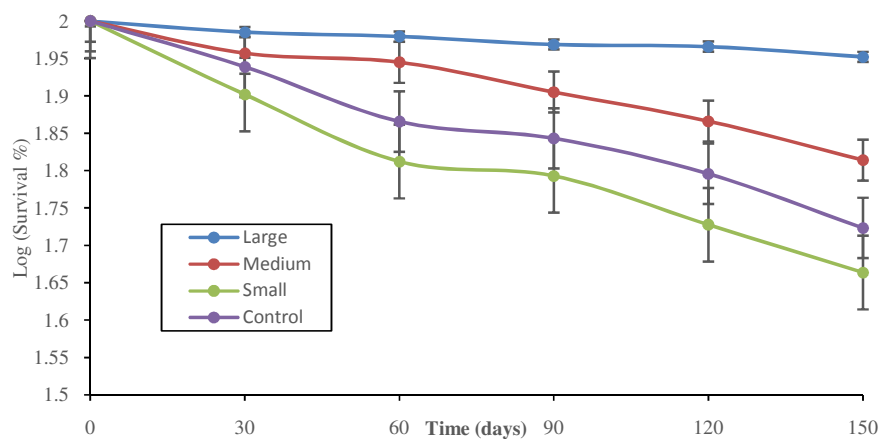


Figure 3 Survival trend of *Albizia lebbeck* seedlings from different seed size categories

3.4 Correlation of seed size with seedling growth attributes

Correlation and regressions equations results between seed size and seedling growth attributes are presented in Table 4. The results shows that there was a strong positive significant ($P=.05$) relationship ($r>.80$) between seed size and seedling growth attributes. 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 attributes (height and root collar diameter growth) of *Afzelia quanzensis*.

Table 4 Regression equations between seed size and seedling growth attributes of *Albizia lebbeck*

Shoot length (cm)	Root length (cm)	Root collar diameter (mm)	Number of leafs	Leaf area (cm ² plant ⁻¹)	Dry weight (g plant ⁻¹)	Survival (%)
$Y=197.98X+12.78$	$Y=117.71X+2.37$	$Y=27.62X-0.22$	$Y=31.68X+1.07$	$Y=1891.6X-52.32$	$Y=40.08X+1.41$	$Y=283.07X+20.28$
$r=.918$	$r=.926$	$r=.950$	$r=.948$	$r=.901$	$r=.808$	$r=.822$
$P=.022$	$P=.021$	$P=.013$	$P=.016$	$P=.031$	$P=.050$	$P=.046$

4. CONCLUSION

The current study has revealed that seed size has a clear effect on seedling growth attributes and survival of *Albizia lebbeck* in the nursery. Larger seeds produced high quality seedlings and high survival rate. This confirms merits of grading seed to enhance transplant quality. There was a strong positive significant relationship between seed size and seedling growth attributes. This indicate 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 *Albizia lebbeck* in the nursery.

REFERENCES

1. Zareian A, Hamidi A, Sadeghi H, Jazaeri MR. Effect of Seed Size on Some Germination Characteristics, Seedling Emergence Percentage and Yield of Three Wheat (*Triticum aestivum* L.) Cultivars in Laboratory and Field. Middle-East Journal of Scientific Research. 2013; 13(8):1126 – 1131.
2. Gunaga RP, Doddabasava D, Vasudeva R. Influence of seed size on germination and seedling growth in *Mammea suriga*. Karnataka Journal of Agriculture and Science. 2011; 24(3):415 – 416.

- 195 3. Dar FA, Gera M, Gera N. Effect of seed grading on germination pattern of some multi-purpose tree
196 species of Jammu region. *Indian Forester*. 2002; 128:509 – 512.
- 197 4. Larsen SU, Andreassen C. Light and heavy seeds differ in germination percentage and mean
198 germination thermal time. *Crop Science*. 2004; 44:1710 – 1720.
- 199 5. Willenborg CJ, Wildeman JC, Miller AK, Rossnaged BG, Shirliffe SJ. Oat Germination
200 Characteristics Differ among Genotypes, Seed Sizes and Osmotic Potentials. *Crop Science*. 2005;
201 45:2023 – 2029.
- 202 6. Baraloto C, Forget PM. Seed size, seedling morphology, and response to deep shade and
203 damage in Neotropical rain forest trees. *The American Journal of Botany*. 2007; 94(6):901–911.
- 204 7. Kaydan D, Ya mur M. Germination, seedling growth and relative water content of shoot in different
205 seed sizes of triticale under osmotic stress of water and NaCl. *African Journal of Biotechnology*.
206 2008; 7:2862 – 2868.
- 207 8. Mwase WF, Mvula T. Effect of seed size and pre-treatment methods of *Bauhinia thonningii*
208 Schum. on germination and seedling growth. *African Journal of Biotechnology*. 2011; 10(13): 5143
209 – 5148.
- 210 9. Mtambalika K, Munthali C, Gondwe D, Missanjo E. Effect of Seed Size of *Afzelia quanzensis* on
211 Germination and Seedling Growth. *International Journal of Forestry Research*. 2014;
212 doi.org/10.1155/2014/384565.
- 213 10. Bhat GS, Chauhan PS. Provenance variation in seed and seedling traits of *Albizia lebbeck* Benth.
214 *Journal of Tree Science*. 2002; 21:52–57.
- 215 11. Missanjo E, Maya C, Kapira D, Banda H, Kamanga-Thole G. Effect of Seed Size and Pre-
216 treatment Methods on Germination of *Albizia lebbeck*. *ISRN Botany*. 2013;
217 doi:10.1155/2013/969026.
- 218 12. Uddin MB, Mukul SA, Khan MASA, Hossain MK. Effects of phosphorous fertilizer on seedlings
219 growth and nodulation capabilities of some popular agroforestry tree species of Bangladesh.
220 *Journal of Forestry Research*. 2007; 18: 283 – 286.
- 221 13. Likoswe MG, Njoloma JP, Mwase WF, Chilima CZ. Effect of seed collection times and pre-
222 treatment methods on germination of *Terminalia sericea* Burch. *African Journal of Biotechnology*.
223 2008; 7(16):2840 – 2846.

- 224 14. Abideen MZ, Gopikumar K, Jamaludheen V. Effect of Seed Character and its Nutrient content on
225 vigour of Seedlings in *Pongamia pinnata* and *Tamarindas indica*. My Forest Journal. 1993; 29:225
226 – 230.
- 227 15. SAS9.1.3. Qualification Tools User's Guide. SAS Institute Inc., Cary, NC, USA, 2004.
- 228 16. Schimdt L. Dormancy and Pre-Treatment:Guide to Handling of Tropical and Subtropical Forest
229 Seeds. Danida Forest Seed Center, Denmark. 2000.
- 230 17. Manonmani V, Vanangamudi K, Rai RSV. Effect of seed size on seed germination and vigour in
231 *Pongamia pinnata*. Journal of Tropical Forestry and Science. 1996; 9:1 – 5.
- 232 18. Ebofin AO, Agboola DA, Ayodele M, Aduradola AM. Effect of seed sizes and seedling growth of
233 some Savanna Tree legumes. ASSET Journal. 2003; 3(2):109–113.
- 234 19. Hewitt N. Seed-size and shade tolerance: a comparative analysis of North American temperate
235 trees. Oecologia. 1998; 114:432 – 440.
- 236 20. Agboola DA. The effect of seed size on germination and seedling growth of three tropical tree
237 species. Journal of Tropical Forestry and Science. 1996; 9:44 – 51.
- 238 21. Malavasi M, Malavasi UC. Effect of seed size on seedling growth of a shade-tolerant tropical tree
239 (*Hymanea stilbocarpa* Haynes). Tree Planting Notices. 1996; 46:130 – 133.
- 240 22. Murali KS. Patterns of seed size, germination and seed viability of tropical tree species in Southern
241 India. Biological Tropical. 1997; 29:271 – 279.
- 242 23. Khurana E, Singh JS. Germination and seedling growth of five tree species from tropical dry forest
243 in relation to water stress: impact of seed size. Journal of Tropical Ecology. 2004; 20:385 – 396.
- 244 24. Mwitwa JP, Munthali CRY, van Wyk G. Half-sib family Variations in shoot and root Traits of
245 Seedlings of *Pterocarpus angolensis* (family: Fabaceae, syn. papilionaceae). Southern
246 Hemisphere Forestry Journal. 2007; 69:91 – 94.
- 247