

Research Article

Effect of Seed Size of *Afzelia quanzensis* on Germination and Seedling Growth

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Afzelia quanzensis Welw is a valuable timber producing tree species in Africa. A study was conducted to evaluate the influence of seed size on seed germination and seedlings quality of *Afzelia quanzensis*. Seed was categorized into three groups in regard to their length, small (<1.5 cm), medium ($\geq 1.5 \leq 2.5$ cm), and large (>2.5 cm). The treatments were completely randomized into four replications. Germination percentage was not significantly ($P > 0.05$) different between the treatments, although large seeds had the highest germination percentage of 94.9%. There were significant ($P < 0.05$) differences in seedling height and root collar diameter among the different seed sizes, with large seeds having the highest seedlings height and largest root collar diameter. This was attributed to differences in the food reserves. Survival of transplants from shoot dieback was significantly ($P < 0.05$) different such that seedlings from large seed attained the highest survival of 92%. It is therefore recommended that, for production of high quality transplants in the nursery, large seeds should be used.

1. Introduction

Africa has a wide range of valuable Miombo tree species. *Afzelia quanzensis* Welw is one of the tree species that produce quality valuable timber. *Afzelia quanzensis* Welw (pod mahogany) locally known as Msambamfumu in Malawi is typically a fast growing indigenous tree species that reaches 24–35 m tall and 1–1.6 m in diameter at breast height [1]. The predominant natural vegetation over most range of *Afzelia quanzensis* is Miombo woodland [2]. The tree has a wide distribution range in the west, east, and central Africa, specifically in countries such as Somalia, Angola, Botswana, Kenya, Mozambique, Swaziland, Tanzania, Namibia, Zambia, and Malawi [3].

Afzelia quanzensis is a multipurpose tree species and basically the use depends on its strength, durability, stability, and good appearance [4]. Besides these properties, *Afzelia quanzensis* wood is termite resistant and hence is best used for making bridges, plywoods, boats, flooring, doors, and furniture [1, 2]. Other parts of this tree, such as root, leaves, and bark, are used as traditional medicine to treat different

ailments, for instance, chest pain. According to [5] *Afzelia quanzensis* is also nitrogen fixing leguminous species that is known to improve the soil fertility in many African countries and hence used in agroforestry practices. Orwa et al. [6] also describe *Afzelia quanzensis* as one of the best indigenous species for ornamental purposes because of its pleasing appearance such that it is planted in gardens and parks. The multipurpose functional potential of this specie is renowned to improve livelihoods of rural people of Malawi. Hence, the species is presently promoted for reforestation programmes to enhance its contribution to health and livelihood of local communities [7].

In Malawi, *Afzelia quanzensis* occurs in areas with mean annual rainfall ranging from 700 mm to 1200 mm and mean annual temperature from 17 to 30°C and altitude from 0 to 1300 m above the sea level [8]. The tree is widely distributed country wide predominantly in savanna woodland on well-drained reddish soils [3].

Despite its importance, *Afzelia quanzensis* is threatened by an increasing rate of exploitation. Hence, to ensure the continuity in the benefit supply of *Afzelia quanzensis* tree

TABLE 1: Seed size categories in terms of weight and length.

Seed size categories	Range of seed weight (g)	Average weight (g) of 100 seeds	Range of length (cm)	Average length (cm)
Small	<3.0	1.2	<1.5	0.9
Medium	3.1–5.9	3.4	1.5–2.5	2.0
Large	>6.0	10.6	>2.5	3.3

species, nursery operations are done in various forestry activities to raise seedlings. However, *Azelia quanzenis* seed collected from the natural population are of different sizes, ranging from 0.8 cm to 4 cm long and 0.4 cm to 1.7 cm wide and the weight ranges from 0.8 g to 22 g [8–11]. Choe et al. [12] reported that seed size influenced germination and early seedling growth of *Syzygium cumini* Miombo tree species. Therefore, knowledge of grading seed of *Azelia quanzenis* to raise quality seedlings in the nursery is essential in order to obtain high germination and quality transplants. From this point of view, a study was carried out to determine the influence of different seed size on seed germination and early seedling development of *Azelia quanzenis*.

2. Materials and Methods

2.1. Seed Acquisition and Study Site. *Azelia quanzenis* seed of Mtaja provenance (11°52'S, 33°37'E, and 1384 m above sea level) was supplied by Forestry Research Institution of Malawi (FRIM) in December 2010. The study was conducted in Malawi located in Southern Africa in the tropical savannah region at Mzuzu University green house. According to Hardcastle [13], Mzuzu University is in silvicultural zone M lying at altitude 1270 m above sea level, located at latitude 11°28'S and longitude 34°01'E. The mean annual temperature ranges from 13.5°C to 24°C, with mean annual rainfall of 1150 mm. It is situated about 360 km north of Lilongwe the capital.

2.2. Experimental Design and Treatments. Seeds were categorized into small, medium, and large seed in terms of weight and length (Table 1).

The experiment was laid out in a completely randomized design (CRD). This was done because all the experimental units were placed under relatively homogenous conditions in a green house. Each treatment had a total of 100 seeds which were replicated four times with 25 seeds each. In order to improve the germination of seed, mechanical nicking of seeds using secateurs was applied.

Seed were sown on December 26, 2010, in black polythene tubes filled with soil collected from natural woodland (*Brachystegia* stand). One seed was sown per tube at a depth of 2 cm, as recommended by Abideen et al. [4]. The tubes were then labelled according to the replicates and treatments assigned. Plants were watered twice a day to maintain adequate moisture necessary for germination and seedling growth.

2.3. Data Collection and Analysis. Germination was recorded daily for 30 days until germinated seeds occurred no more. The seed was considered germinated by a visible protrusion

of split seed coat with the cotyledons, hypocotyls, and 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, the growth performance of the seedlings was monitored for 8 weeks (56 days) to assess the seed size treatment effect on growth. All the seedlings were measured for total shoot height and collar diameter at 37 days, 65 days, and 86 days after sowing. 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 microcaliper 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.

Germination percentage (G%) was calculated by dividing the total number of seeds that germinated in each treatment by the number of seeds sown and multiplied by 100 [14]. Survival percentage (SV%) of seedlings that survived also was calculated. Data on germination was transformed using the Arcsine in order to normalize the data [15]. Analysis of Variance (ANOVA) was then performed on the transformed germination percentages, plant height, and root collar diameter and survival percentage using GenStat for Windows version 13 [16]. Multiple comparison tests were done using Fisher's least significant difference (LSD). Pearson's correlation coefficients (r) were calculated to determine the relationship that existed between seed size, germination percentage, seedling height, root collar diameter, and survival percentage.

3. Results

3.1. Germination Percentage. Germination percentages for small, medium, and large seed of *Azelia quanzenis*, 30 days after sowing, are presented in Figure 1. Statistically, there were no significant ($P > 0.05$) differences between germination of all the three treatments, although large seeds had a higher (94.9%) cumulative germination percentage than the other treatments.

3.2. Plant Height and Root Collar Diameter. The mean height and root collar growth of the seedlings at 37, 65, and 86 days after sowing are presented in Table 2. The results indicate that there were significant ($P < 0.05$) differences in seedling height and root collar diameter among the different seed sizes, with large seeds having the tallest seedlings height and largest root collar diameter than the other two treatments. Small seeds had the lowest seedling height and root collar diameter. However, there were no significant ($P > 0.05$)

TABLE 2: Mean seedling height and root collar diameter growth with standard errors in parenthesis at 37, 65, and 86 days after sowing.

Treatment	37 days after sowing		65 days after sowing		86 days after sowing	
	Height (cm)	Root collar diameter (mm)	Height (cm)	Root collar diameter (mm)	Height (cm)	Root collar diameter (mm)
Small seeds	13.15 (0.53) ^c	0.3 (0.03) ^c	13.85 (0.18) ^c	0.5 (0.03) ^b	14.53 (0.52) ^c	0.5 (0.01) ^c
Medium seeds	15.22 (0.42) ^b	0.4 (0.01) ^b	16.75 (0.40) ^b	0.5 (0.01) ^b	17.30 (0.44) ^b	0.6 (0.02) ^b
Large seeds	16.77 (0.37) ^a	0.5 (0.01) ^a	19.38 (0.45) ^a	0.6 (0.03) ^a	22.95 (0.60) ^a	0.8 (0.02) ^a
LSD	0.30	0.02	0.41	0.03	0.60	0.03
CV%	6.7	6.9	6.2	6.8	5.2	5.1

Note. Means with different letters within a column differ ($P < 0.05$).

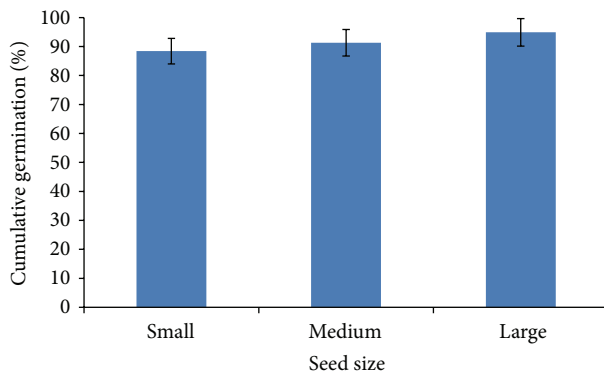


FIGURE 1: Cumulative germination percentage for small, medium, and large seeds of *Afzelia quanzenensis* at 30 days after sowing.

differences between small seeds and medium seeds for root collar diameter at 65 days after sowing.

3.3. Seedling Survival. Seedling mortality caused by shoot dieback was first noticed 40 days after sowing the seed. The survival percentages of the seedlings after 86 days of sowing are shown in Figure 2. There were significant ($P < 0.05$) differences in survival percentage between the seed sizes, with the highest (92%) attained by seedlings from large seed and the lowest (68%) by those from small seed.

3.4. Correlation between Parameters. Germination capacity of *Afzelia quanzenensis* was weakly correlated ($r = 0.089$, $P \geq 0.784$) with seed size. However, there were strong positive relationships between seed size with height growth ($r = 0.935$, $P \leq 0.001$), root collar diameter ($r = 0.921$, $P \leq 0.001$), and survival percentage ($r = 0.672$, $P \leq 0.017$) and between height and root collar diameter ($r = 0.901$, $P \leq 0.001$) and root collar diameter with survival percentage ($r = 0.776$, $P \leq 0.003$).

4. Discussion

4.1. Germination Performance. Germination is an event which denotes transition from seed being dependent on food sources from the mother plant to an independent plant

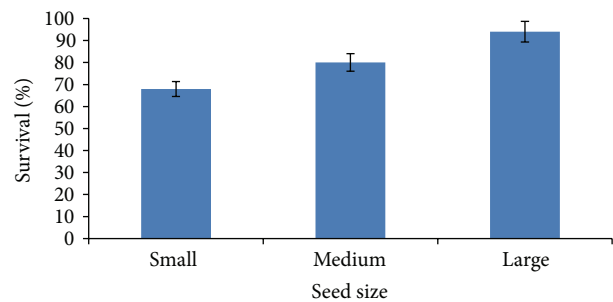


FIGURE 2: Mean survival percentage at 86 days after sowing.

capable of taking up nutrients and growing independently [17]. Inconsiderable germination percentage difference (2%, 4.5%, and 6.5% between large and medium, medium and small, and large and small seed, resp.) might imply that germination was not influenced by seed of *Afzelia quanzenensis* tree species. This could mean that all the three seed sizes can germinate provided that the condition is optimal for germination. The results in the present study are in agreement with [18] which reported that seed size did not have an effect on germination percentage of *Pinus roxburghii* seedlings. A similar result was also reported by [19, 20] on *Virola koschny* and *Albizia lebbek*, respectively. However, the findings of the present study do not agree with the findings of [21] cited by [22] which reported that germination percentage was strongly influenced by seed size of loblolly pine (*Pinus taeda*), such that germination percentage difference was reported to be considerable between large, medium, and small seed.

The present results could be an indication that grading seed of *Afzelia quanzenensis* with the aim of enhancing germination is not important. On the other hand, the silvicultural practice that could be applicable in this species is to consider the use of high physiological quality seed for the enhancement of germination. According to [17] some of the desirable seed physiological qualities include plumpness, high purity, freedom from pests and diseases, and being dried to a right moisture content. Schimdt [17] further reported that high physiological quality is necessary for obtaining high germination capacity and vigour, which subsequently could result in well-established, vigorous, and uniform transplants in the nursery.

4.2. Height and Root Collar Diameter Growth. Substantial height growth percentage difference (22%) between seedlings from large and small at 37 days could be attributed to differences in food reserves. This is supported by [23] which reported that larger seed store greater amounts of carbohydrate in their endosperm than small seed. It could also be that large and medium seed had reserves that were not much different than with small seed resulting in lower differences of 9% compared to the latter. 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 [24–26].

The pattern of growth continued at 65 days with increased height growth difference (28%, 17%, and 13% between seedlings from large and small, medium and small, and large and medium, resp.). At this stage, this could indicate that plants were using the photosynthesized food for growth, as the food reserves were being invested in the tap root of the plants. This was also indicated by the plants changing of cotyledons colour from brown yellowish to right green in the nursery. Roy et al. [27] reported that, during early growth of a seedling, food reserves are transported to the growing axis such as root or photosynthetic tissue in order to maintain a positive net energy balance as seedling reaches higher light intensity.

The trend continued at 86 days for seedlings developed from large and medium seed, such that there was an increased height percentage difference in *Azalia quanzensis* transplants (36% and 25% between large and small, large and medium, resp.) with time. However, a slight decrease in height percentage difference (16%) between medium and small with time could mean that seedlings from small seed could also achieve faster growth with time, since they fully use photosynthesized food for growth. Ebofin et al. [28] support that, while the plant is growing and developing additional leaves, food reserves diminish with increased rate of photosynthesis. This could also imply that *Azalia quanzensis* seedlings from small seed may be slow starters, such that with time they can attain fast growth rate regardless of having initial small amount of seed reserves. The present results are in agreement with the observation in the relative growth of *Bauhinia thonningii* [29], *Pinus elliotti* [30], and *Pinus strobus* [31] where the height growth and root collar diameter growth at the end of first year were influenced by the weight of the seed. Present results have shown that, for production of better seedlings in terms of seedling vigour, large and medium seed should be promoted in the nursery. On the other hand, seedling from small seed should not be discarded as their growth improves following active photosynthesis and hence field study should assess their performance in the field.

4.3. Seedling Mortality. Seedling mortality in the nursery was largely attributed to the occurrence of shoot dieback (dying back to about 3 cm below the ground). Low mortality in seedlings developed from large seed could be due to its ability to develop a new shoot after dying back by drawing from the large amount of energy reserves contained in the tap root. Munthali [32] reported that there is a positive

correlation between shoot dieback and the sizes of the shoot and root in *Pterocarpus angolensis* seedlings. The present results are in line with [33] which reported that survival of a *Pterocarpus angolensis* seedling is dependent on the amount of the reserves at the time of regrowth, such that those with greater amount of food reserves were able to regenerate a new shoot. The present study has indicated that survival percentage difference between seedlings from large and medium (6%) was small in degree; however, it was considerable between large and small (15%). This implies that large and medium seeds of *Azalia quanzensis* should be promoted for sowing because of its low mortality rate.

4.4. Correlation of Seed Size with Seedling Parameters. Weak correlation between seed size and germination could imply that as long as seed is of high physiological quality it will germinate irrespective of size. However, in the current study there was a strong relationship between seed size, seedling height, and root collar diameter and survival percentage. This could imply that seed size could be used as a parameter for predicting seedling growth rates in the nursery. The results of the present study are in line with [34] which reported strong relationships between seed weight and growth factors such as height and root collar diameter growth of *Pinus oocarpa*.

5. Conclusion

The study has demonstrated that seed size does not affect germination. Therefore, use of only high physiological quality seed could enhance germination of this species. Seedling vigour and survival were influenced by the weight of the seed. Positive relationship between seed size and early seedling growth and survival percentage confirms merits of grading seed to enhance transplant quality. Therefore, in raising *Azalia quanzensis*, nursery managers, foresters, and local communities are recommended to use large and medium seed for production of high quality transplants.

Conflict of Interests

The authors declare that there is no conflict of interests in any form regarding the publication of this paper.

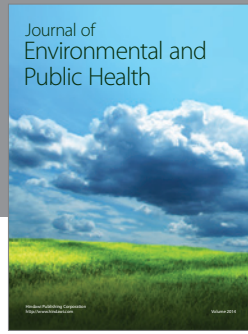
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