International Journal of Advanced Research in Biological Sciences
ISSN : 2348-8069
www.ijarbs.com

Research Article

Influence of different potting media on the growth of pod mahogany (*Afzelia quanzensis*) seedlings

Thembinkosi Mathowa[1*], Kebafentse Hababa[1], Christopher Mpofu[1], Gabatshele M. Legwaila and Witness Mojeremane[1]

[1]Department of Crop Science and Production, Botswana College of Agriculture, Private Bag 0027, Gaborone, Botswana

*Corresponding author: *tmathowa@yahoo.com*

Abstract

A pot experiment was set up in the net-shade at Botswana College of Agriculture from January to May 2014 to evaluate the growth response of *Afzelia quanzensis* potted seedlings to different growth media. The experiment was laid out in a completely randomized design (CRD) with four treatments each replicated four times as follows; top garden soil (TGS), top forest soil (TFS), commercial compost (CC) and a mixture of the three (TGS+TFS+CC) being treatments 1−4, respectively. The results indicates that the growth response of seedlings to potting media with regards to plant height was significant ($p<0.05$) in the top garden soil in the first 6 weeks when compared with the rest of the treatments. Potting media had no effect ($p>0.05$)on plant leaf number, collar diameter, total (roots + shoots) fresh and dry weights for the entire study period. *A. quanzensis* seedlings tolerate different potting media. However, the top garden soil is recommended to tree growers because it increased plant height slightly.

Keywords: *Afzelia quanzensis,* potting media, completely randomized design, tree nursery

Introduction

The survival of containerized seedlings in a nursery depends on suitable environmental factors. Potting media is one of the most important factors required for the survival and production of containerized seedlings because it is not only the growing place for seedlings but also provides them with moisture and mineral nutrients (Kiran *et al.*, 2007; Indriyani *et al.,* 2011). A suitable potting media used in containerized seedlings should anchor or support them, provides nutrients and water and allow the diffusion of oxygen to the roots (Argo, 1998; Abad *et al.*, 2002). The potting media influences seed germination (Bhardwaj, 2014), seedling quality (Wilson *et al.*, 2001; Agbo and Omaliko, 2006) and their subsequent survival as well as performance in the field. A suitable potting media should drain-well with a good water holding capacity to reduce the frequency of watering. A balanced media with adequate nutrient supply is critical in producing healthy and vigorous seedlings with a well-developed and balanced root/shoot ratio. The presence of organic matter in a potting media is important because it has a significant impact on soil physical, chemical and biological properties (Bell *et al.,* 1998; Brussoard, 1998; Jonge *et al.,* 1999; Six *et al.,* 2000; Carter, 2002). Organic matter performs numerous functions in soil, it supplies essential nutrients required by plants (Khan *et al*., 2006), improves the water holding capacity (Tisdale and Oades, 1982; Jonge *et al.*, 1999; Carter, 2002; Osaigbovo and Orhue, 2012), reduces crusting, improves aggregation, prevents erosion, and prevents compaction (Carter, 2002).

A. quanzensis Welw. (Family Caesalphiaceae) known as Afzelia, African Afzelia, mahogany bean, pod mahogany, Rhodesian mahogany in English speaking

African countries, occurs from southern DR Congo and Somalia, and south to Angloa, Botswana, Zimbabwe and northern South Africa (Palmer and Pitman, 1972; Pullinger and Kitchin, 1982; Storrs, 1995; Palgreave, 2002; Brummitt *et al.*, 2007; Gerard and Louppe, 2011) up to 1350−1800 m above sea level (Brummitt *et al.,* 2007; Gerard and Louppe, 2011). It is a medium to large spreading deciduous tree attaining 24–35 m height (Mulofwa *et al*., 1994; Storrs, 1995; Van Wyk and Van Wyk, 2000; Gerard and Louppe, 2011) and 1−1.6 m diameter breast height (Van Wyk and Van Wyk, 2000; Gerard and Louppe, 2011). *A. quanzensis* is a valuable multipurpose African tree species. Leaves are cooked together with potash and eaten in a mixture with other vegetables (Gerard and Louppe, 2011) and its various parts such as roots, leaves and bark are used in traditional medicine to treat different ailments (Palgreave, 2002; Gerard and Louppe, 2011; Mtambalika *et al.*, 2014). The foliage is browsed by livestock, mainly towards the end of the dry season when little fodder is available (Gerard and Louppe, 2011).

A. quanzensis produce quality valuable timber (Mtambalika *et al.,* 2014). The wood is characterised by excellent stability with little susceptibility to variations in humidity, small shrinkage rates during drying and good natural durability (Gerard and Louppe, 2011). The wood is also termite resistant and hence used for making bridges, plywood, boats, flooring, doors and furniture (Van Wyk and Van Wyk, 2000; Palgrave, 2002). The tree fixes atmospheric nitrogen and is known to improve soil fertility in many African countries and hence used in agroforestry practices (Young, 1989). It is planted as an ornamental tree in parks and gardens in some places because of its beautiful appearance (Orwa *et al.*, 2009; Gerard and Louppe, 2011). *A. quanzensis* is widespread, but recent studies show that it is locally threatened by the high rate of exploitation or valuable timber (Gerard and Louppe, 2011; Mtambalika *et al.*, 2014), wildfires, habitat degradations and factors related to climate change (Botsheleng *et al*., 2014). The low growth rates of the tree limits its prospects as a commercial plantation timber species (Gerard and Louppe, 2011). However, its valuable wood makes it economically interesting and warrants its propagation and introduction in plantation and agroforestry systems.

The use of indigenous tree species in plantation, parks, streets and agroforestry planting programmes in arid and semi-arid areas received significant attention in recent years. Nowadays efforts are directed towards planting multipurpose indigenous tree species that can cope with harsh environment conditions prevalent in arid and semi-arid areas (Rasebeka *et al.,* 2013). The main problem encountered in propagating seedlings of indigenous tree species in arid and semi-arid areas is poor germination related to seed dormancy (Demel, 1996; Walters *et al*., 2004; Botsheleng *et al.*, 2014) and poor potting media. Low seedling propagation rates can be attributed to inadequate knowledge of their requirements including appropriate potting media that can be adopted to enhance their growth at the nursery. Knowing the nursery requirements of *A. quanzensis* is important in producing quality seedlings that are capable of surviving harsh conditions when planted out in the field. This study was therefore carried out to determine the influence of different potting media on the development of *A. quanzensis* seedlings in Botswana.

Materials and Methods

Experimental site

The study was conducted at the tree nursery of Botswana College of Agriculture (BCA). The College is situated in Sebele content farm, Gaborone city. Sebele is located between latitude 24°33'S and longitude 25°54'E at an elevation of 994 m above sea level, 10 km from Gaborone, along Gaborone-Francistown highway. Seeds used in this study were obtained from Botswana National Tree Seed Centre, Department of Forestry and Range Resources, Ministry of Environment, Wildlife and Tourism, Gaborone. Analysis of potting media physical and chemical properties was conducted at the Department of Crop Science and Production, Soil Science Laboratory, Botswana College of Agriculture.

Seedling pre-treatment and germination

Seeds were scarified manually by cutting 1 mm of the seed coat at the opposite site of hilum using a scissor and were then soaked in distilled water overnight a method described by Botsheleng *et al*. (2014). The seeds were then germinated in a seedbed measuring 2 m × 5 m filled with a layer of sand and compost (leaf mould). The seedbed was watered twice a day when required. Weeds were carefully hand removed whenever they appeared to avoid pulling out seedlings. After germination and development of true leaves, seedlings were transplanted into black polyethylene pots filled with different potting media (inside diameter 25 cm).

Determination of potting media physical and chemical properties

Potting media pH was measured from a soil-water suspension (1:1, v/v) by a pH meter (model: Hannah HI 110). Cation exchange capacity (CEC) was determined by the ammonium acetate saturation method (Schollenberger and Simon, 1945). Total nitrogen (N) content was determined by Kjeldahl method (Bremner, 1965) and measured on a distillation unit (model: Buchi K-350). Available phosphorus (P) was determined by the Bray II method (Bray and Kurt, 1945) and measured on an inductively coupled plasma - optical emission spectrophotometer (model: Perkinelmer DV 2100). Exchangeable potassium (K^+) was measured by flame photometer (model: Sherwood 410) after extraction with 1 N ammonium acetate pH 7.0.

Experimental design

The experiment was laid out in a completely randomized design (CRD) with four treatments (potting media) each replicated four times. The four treatments were as follows: top garden soil (TGS), top forest soil (TFS), commercial compost (CC) and mixture of TGS+CC+TFS (1:1:1, v/v) being treatments 1−4, respectively. There were 10 black polythene pots each with a seedling per replicate which were randomly located in the nursery (Fig. 1), giving a total of one hundred and sixty (160) pots. The experiment was conducted under a 60% green net-shade to minimize loss of water. Seedlings were watered twice a day, in the morning and in the afternoon when necessary throughout the duration of the experiment. Weeds were removed manually by hands whenever they occurred. No fertilizer was supplied to the seedlings.

Growth parameters

The experiment was monitored for twelve (12) weeks after transplanting (WAT) and the growth parameters measured were: plant height, number of leaves, collar diameter and total (roots + shoots) fresh and dry weight. Measurements were taken bi-weekly after transplanting except for fresh and dry weights which were taken at the end of the study. Plant height (cm) was measured using a meter ruler from the soil level to the terminal bud. The number of leaves was measured quantitatively by counting. The collar diameter (mm) was measured at about 2.5 cm above the soil level using a calibrated digital caliper (0−150 mm). A destructive method was used to determine both fresh and dry weights (g) which were measured at week 12 and 5 seedlings were used per replicate. The average was then taken to represent the replicate. The seedlings were uprooted from the polyethylene pots and placed into weighing paper bags. The fresh samples were taken to the laboratory and measured using a bench top electric balance (PGW 4502e). The samples were then oven dried to constant weight at 80^{o}C using a hot air oven (Scientific Series 2000) and dry weight was recorded

Data analysis

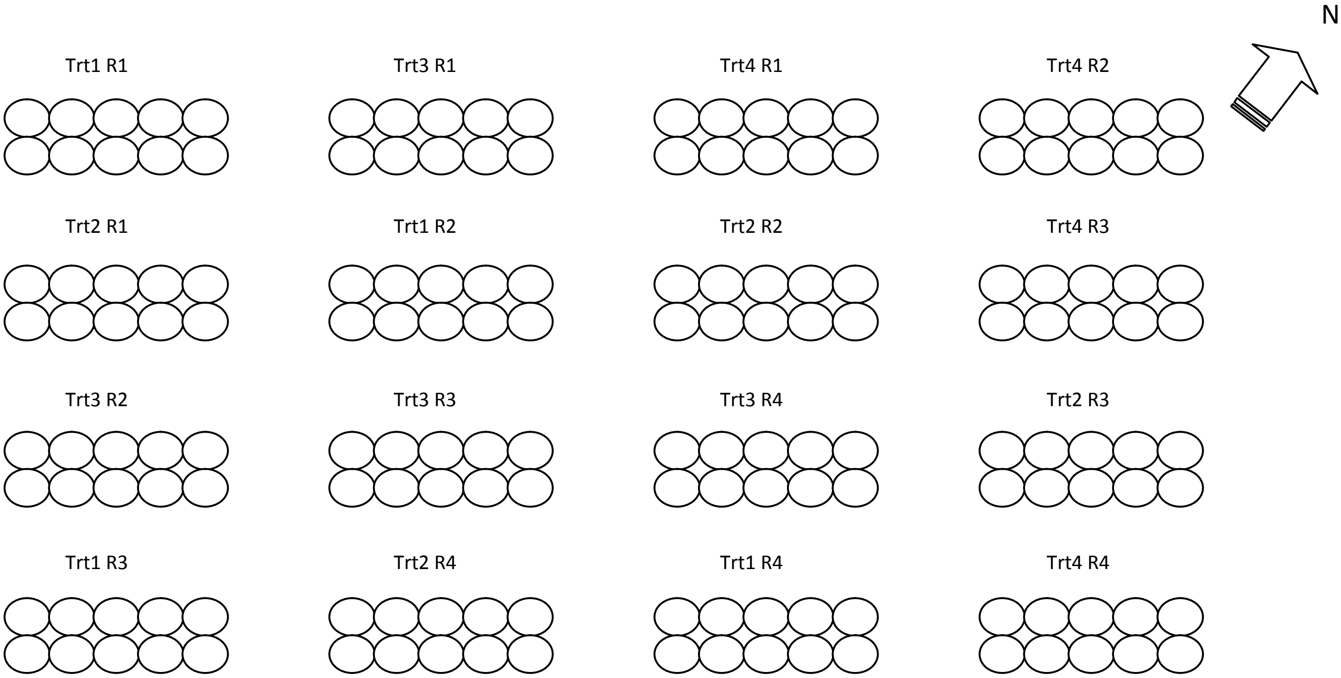
The data collected was subjected to analysis of variance (ANOVA) using the STATISTIX-8 program. Where a significant F-test was observed and means comparison test were carried out using Least Significant Difference (LSD) at $p \leq 0.05$ to separate treatment means.

Results and Discussion

Physical and chemical properties of the potting media

The physical and chemical properties of potting media data presented in Table 1 shows that the pH ranged from 5.0 to 7.1, slightly acidic to neutral. Soil pH is an important chemical property of any soil or potting media that influences essential mineral nutrients availability (Roberts, 2006). Potting media with a higher pH can be deficient in iron and phosphorus, whereas acidic media lack calcium and magnesium (Kramer and Kozlowski, 1979). The CEC ranged from 0.80 to 1.63 cmol kg^{-1} and was high in the TGS and the TGS+TFS+CC. Total N ranged from 0.52−1.01% and was high in the TGS+TFS+CC followed by TGS and CC, respectively. Values for available P ranged from 7.0 to 98.0 ppm and the highest was recorded in the CC and lowest in the TGS. Exchangeable K^+ ranged from 1.61 to 2.98% and the highest was recorded in the CC and the lowest in the TGS

Fig (1). Sketch map of the experimental design.



treatment. Results presented in Table 1 shows that, overall, the potting media are sandy loam, slightly acidic to neutral, with good aeration, high permeability, and low water holding capacity, low in nitrogen content, phosphorus and potassium.

Plant height

Different potting media have significant effect on the growth of plant seedlings (Vendrame *et al.*, 2005). The composition of potting media is among many factors that affects the growth of trees (Tinus *et al.*, 1979).Results in Table 2 show that from week 2 to 6 plant height in the TGS was significantly ($p<0.05$) higher than in other treatments. Similar results were observed in *Cassia abbreviate* seedlings (Sekepe *et al.*, 2013). The taller seedlings observed in TGS soil could probably have been enhanced by high water holding capacity of the soil and nutrient availability which accelerated the early growth of the seedlings in the first six weeks. Potting media with suitable texture and adequate nutrients was shown to determine the allocation of biomass in seedlings and hence their growth and survival rates (Gower, 1987). Studies conducted on other plant species elsewhere recorded taller seedlings in the top garden soil than other potting media (Isirimal *et al*., 2003; Agbogidi *et al*., 2007, Agbogidi and Avwevughware, 2011).

There was no significant difference in plant height between the TGS and CC from week 8 to 10. A similar trend occurred between the CC and TGS+TFS+CC. Plants grown in the TFS were significantly ($p<0.01$) shorter than those grown in the TGS+TFS+CC between weeks 8 and 10. Plant height increased weekly throughout the study, but no significant ($p>0.05$) difference was observed across TGS, CC and TGS+TFS+CC at the end of study (Table 2). This suggests that the TGS accelerated early seedling height growth which disappeared with time. Plant height in the TGS, CC and TGS+TFS+CC was significantly ($p<0.01$) higher than in the TFS from week 8 to 10 and significant ($p<0.05$) in week 12. Mean height values in Table 2 shows that at week 12, the TGS seedlings were slightly taller (11.15cm) than in the CC (10.17 cm) and TGS+TFS+CC (10.24 cm) potting media. At week 12, seedlings in the TFS potting medium were significant ($p<0.05$) shorter (8.86 cm) than their counterparts in other treatments probably due to the textural class which was sandy loam with more silt and less sand (Table 1).

Table (1): Physical and chemical properties of potting media

Potting media	pH (H_2O)	CEC (cmol kg^{-1})	Total N (%)	Available P (ppm)	Exchangeable K^+ (%)	Textural class		
						Sand (%)	Clay (%)	Silt (%)
Top garden soil (TGS)	6.3^c	1.61^a	0.87^{ab}	7.00^c	1.78^c	87	7	6
Top forest soil (TFS)	7.1^a	0.80^b	0.52^c	11.00^c	1.61^c	75	9	16
Commercial compost (CC)	5.0^d	-	0.74^b	98.00^a	2.98^a	-	-	-
Mixture (TGS+TFS+CC)	6.7^b	1.63^a	1.01^a	41.00^b	2.37^b	87	7	6
Significance	**	**	**	**	**	-	-	-
LSD 0.05	0.40	0.33	0.18	8.83	0.36	-	-	-
CV (%)	3.38	12.31	11.98	11.95	8.64	-	-	-

** Highly significant at $p<0.01$. Means separated by Least Significance Difference (LSD) Test at $p\leq0.05$, means within columns followed by the same letters are not significantly different, ppm denotes parts per million.

Table (2): *A. quanzensis* seedling height (cm)

Growth media	Week 2	Week 4	Week 6	Week 8	Week 10	Week 12
Top garden soil (TGS)	10.32^a	10.35^a	10.38^a	10.61^a	10.78^a	11.15^a
Top forest soil (TFS)	7.94^b	7.98^b	8.00^b	8.04^c	8.35^c	8.86^b
Commercial compost (CC)	8.98^b	9.00^b	9.03^b	9.87^{ab}	10.01^{ab}	10.17^a
Mixture (TGS+TFS+CC)	8.80^b	8.82^b	8.84^b	9.38^b	9.77^b	10.24^a
Significance	*	*	*	**	**	*
LSD 0.05	1.27	1.27	1.27	1.11	0.97	1.27
CV (%)	9.15	9.10	9.08	7.64	6.45	8.14

** Highly significant at $p<0.01$, * significantly at $p<0.05$. Means separated by Least Significance Difference (LSD) Test at $p\leq0.05$, means within columns followed by the same letters are not significantly different. Where week 2 to week 12 are dates from 20-02-2014 to 29-05-2014 respectively.

Collar diameter

Results in Table 3 shows that collar diameter was not affected ($p>0.05$) by potting media. This is consistent with results of studies conducted on other plant species here (Sekepe *et al.*, 2013) and elsewhere (Egharevba *et al.*, 2005). Plant collar diameter increased slowly with time. There was not much variation observed among the collar diameter values of *A. quanzensis* seedlings. Our results suggest that *A. quanzensis* seedlings can be propagated on a wide range of soils but requires good drainage due to water-logging intolerance (Gerard and Louppe, 2011). At week 6, collar diameter values were as follows: TGS (3.19 mm), TFS (3.21 mm), CC (3.21 mm) and TGS+TFS+CC (3.38 mm). At week 12, the highest collar diameter value of 4.50 mm and the lowest value of 4.22 mm were measured in the TFS and TGS treatments, respectively (Table 3).

Leaf number

The number of *A.quanzensis* seedling leaves was not affected by potting media (Table 4).The leaves increased in all treatments from week 2 to 8. The number of leaves recorded in the various potting media from week 8 to 12 is as follows: top garden soil (2.30), top forest soil (2.40), commercial compost (2.43) and mixture (2.40). Similar results have been reported on other plants in studies conducted here (Sekepe *et al.,* 2013) and elsewhere (Okunomo *et al.*, 2004, 2009; Dolor, 2011). Sekepe *et al*. (2013) used similar potting media in *Cassia abbreviata* and found no significant differences in leaf number across

Table (3):*A.quanzensis* seedling collar diameter (mm)

Growth media	Week 2	Week 4	Week 6	Week 8	Week 10	Week 12
Top garden soil (TGS)	2.40	2.70	3.19	3.37	3.45	4.22
Top forest soil (TFS)	2.26	2.68	3.21	3.49	3.56	4.50
Commercial compost (CC)	2.34	2.89	3.21	3.41	3.53	4.40
Mixture (TGS+TFS+CC)	2.30	2.68	3.38	3.65	3.72	4.47
Significance	ns	ns	ns	ns	ns	ns
LSD 0.05	ns	ns	ns	ns	ns	ns
CV (%)	6.52	6.37	5.33	5.47	5.78	6.14

^{ns} non-significant at p>0.05. Where week 2 to week 12 are dates from 20-02-2014 to 29-05-2014 respectively.

Table (4):*A.quanzensis* seedling leaf number

Growth media	Week 2	Week 4	Week 6	Week 8	Week 10	Week 12
Top garden soil (TGS)	2.20	2.20	2.20	2.30	2.30	2.30
Top forest soil (TFS)	2.27	2.28	2.30	2.40	2.40	2.40
Commercial compost (CC)	2.30	2.30	2.30	2.43	2.43	2.43
Mixture (TGS+TFS+CC)	2.25	2.25	2.25	2.40	2.40	2.40
Significance	ns	ns	ns	ns	ns	ns
LSD 0.05	ns	ns	ns	ns	ns	ns
CV (%)	6.74	6.74	6.63	6.37	6.37	6.37

^{ns} non-significant at p>0.05. Where week 2 to week 12 are dates from 20-02-2014 to 29-05-2014 respectively.

Table (5):*A.quanzensis* seedlings fresh and dry matter (g)

Growth media	Fresh weight (g)	Dry weight (g)
Top garden soil (TGS)	114.47	58.37
Top forest soil (TFS)	113.81	54.67
Commercial compost (CC)	93.05	47.12
Mixture (TGS+TFS+CC)	114.32	57.95
Significance	ns	ns
LSD 0.05	27.18	11.27
CV (%)	16.20	13.47

^{ns} non-significant at p>0.05

treatments. Plant leaves are an important parameter in agronomical and ecological processes, such as photosynthesis, transpiration and field energy balance (Awal *et al.,* 2004). Plant leaf area is also an important parameter used to model tree growth and the tree's physiological processes (Diao *et al.,* 2010). The no significant effect of potting media on the number of leaves probably suggests the parameter is not influenced by media at seedling stage as suggested by Sekepe *et al*. (2013).

Total plant fresh and dry matter (roots and shoots)

The results in Table 5 shows that fresh and dry weights of *A.quanzensis* seedlings determined 12 weeks after transplanting was unaffected by potting media (p>0 05). These results are supported by findings of other plants studies conducted here (Sekepe *et al.*, 2013) and elsewhere (Dolor, 2011). Sekepe *et al*. (2013) subjected *Cassia abbreviata* to similar potting media and reported a slightly higher(but insignificant) plant dry matter in the top garden soil which is consistent with our results. The highest (58.37 g) insignificant total plant dry matter at the end of study (week 12) was recorded in the TGS followed by TGS+TFS+CC (57.95 g) and TFS (54.67 g), and the least in CC (47.12 g) (Table 5). This could be attributed to high phosphorus and potassium available in CC on the expense of nitrogen and low pH (5.0) which did not enhance plant growth (Table 1).

Conclusion and recommendation

The present study indicates that *A. quanzensis* seedlings are slow growing. Potting media did not affect measured parameters except for plant height which was significantly increased by top garden soil in the early stages. *A. quanzensis* seedlings tolerate different potting media. However, the top garden soil is recommended to tree growers because it slightly increased plant height.

Acknowledgment

Kebafentse Hababa was funded by the Ministry of Education Skills and Development undergraduate scholarship. The authors express their appreciation to Botswana College of Agriculture for providing resources (tree nursery and laboratory facilities) and the National TreeSeed Centre, Ministry of Environment, Wildlife and Tourism for providing seeds

References

Abad, M., Noguera, P., Puchades, R., Maquieira, A. and Noguera, V. 2002. Physico-chemical and chemical properties of some cocoanut dusts for use as peat substitute for containerised ornamental plants. Bioresour Tech. 8(3): 241−245.

Agbo, C. U. and Omaliko, C. M. 2006. Initiation and growth of shoots of *Gongronema latifolia* Benth stem cuttings in different rooting media. Afr. J. Biotech.5(5): 425−428.

Agbogidi, O. M. and Avwevughware O. I. 2011. Growth response of *Afzelia africana* (SM. EX PERS.) seedlings to different potting mixtures. Int. J. Agric. Sci.1(1): 017−019.

Agbogidi, O.M., Okonta B. C. and Okechukwu E. M. 2007. Performance of teak (*Tectona grandis* Linn.) seedlings under different planting media. Res. J. For.1(2): 91−94.

Argo, W. R.1998. Root medium chemical properties. HortTech. 8(4): 846−894.

Awal, M. A., Ishak W., Endan J. and Haniff, M. 2004. Determination of specific leaf area and leaf area-leaf mass relationship in oil palm plantation. Asian J. Plant Sci. 3(3):264−268.

Bell, M. J., Moody, D. W., Connolly, R. D. and Bridge, B.J. 1998. The role of active fractions of soil organic matter in physical and chemical fertility of fernasols. Aust. J. Soil Res. 36(5): 809–820.

Bhardwaj, R. L. 2014. Effect on seed germination and seedling growth of papaya ‘cv’ Red lady. Afr. J. Plant Sci. 8(4): 178−184.

Botsheleng, B., Mathowa, T. and Mojeremane, W. 2014. Effects of pre-treatments methods on the germination of Pod mahogany (*Afzelia quanzensis*) and Mukusi (*Baikiaea plurijuga)* seeds. Int. J. Innov. Res. Sci. Eng.Tech. 3(1): 8108−8113.

Bray, R. H. and Kurt, L. T. 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Sci. 59(1): 39−46.

Bremner, J. M. 1965. Isotope ratio analyses of nitrogen-15 traces investigations. Methods of soil analysis. American Society of Agronomy, Madison, Wisconsin, 1256−1286.

Brummitt, R. K., Chikuni, A. C.,Lock, J. M. and Polhill R. M. 2007. Leguminosae Flora Zambesica. 3(2). http://apps.kew.org/efloras/namedetail.do?flora=fz&taxon=10823&nameid=27583

Brussoard, L. 1998. Soil fauna, guilds, functional groups and ecosystem process. Appl. Soil Ecol. 9(1-3): 123–135.

Carter, M. R. 2002. Soil quality for sustainable land management. Agron. J. 94(1): 38–47.

Demel, T. 1996. Germination ecology of twelve indigenous and eight exotic multipurpose leguminous species from Ethiopia. For. Ecol. Manage. 80: 209−223.

Diao, J., Lei, X-d., Hong, L-x., Rong, J-t. and Shi, Q. 2010. Single leaf area estimation models based on leaf weight of eucalyptus in southern China. J. For. Res. 21(1): 73−76.

Dolor, D. 2011. Effect of propagation media on the germination and seedling performance of *Irvingia wombolu* (Vermoesen). Am. J. Biotech. Mol. Sci.1(2): 51−56.

Egharevba, R. K., Ikhatua, M.I. and Kalu, C. 2005. The Influence of seed treatments and growing media on seedling growth and development of African walnut, *Plukenetia conophorum.* Afr. J. Biotech. 4(8): 808−811.

Gerard, J. and Louppe, D. 2011. *Afzelia quanzensis* Welw. In: Lemmens, R.H.M.J., Louppe, D. and Oteng-Amoako, A. A. (Editors). Timbers 2. Plant Resources of Tropical Africa, 7 (2). Wageningen, Netherlands. pp. 41−45.

Grower, S. T. 1987. Relations between mineral nutrient availability and fine root biomass in two Costa Rican tropical wet forests, hypothesis. Biotropica, 19: 171-175.

Indriyani, N. L. P., Hadiati, S. and Soemargono, A. 2011. The effect of planting medium on the growth of pineapple seedlings. ARPN J. Agric. Biol. Sci.6(2): 43−48.

Isirimah, N. O., Dickson A. A. and Igwe, C. 2003. Introductory soil chemistry and biology for agriculture and biotechnology. Osia Publishers Ltd., Diobu, Port Harcourt, Nigeria.

Jonge, L. W., Jajobsen, O. H. and Moldrup, D. 1999. Soil water repellency: effects of water content, temperature, and particle size. Soil Sci. Soc. Am. J. 63(3): 437–442.

Khan, M. M., Khan, M. A., Mazhai, A., Muhammad, J. M. A. and Abbas, H. 2006. Evaluation of potting media for the production of rough lemon nursery stock. Pak. J. Bot. 38(3): 623−629.

Kiran, M. K., Jalal-ud-Din, B., Waseem, K., Jilani, M. S. and Khan, M. Q. 2007. Effect of different growing media on the growth and development of Dahlia (*Dahlia pinnata*) under the agro-climatic condition of Dera Ismail Khan. Pak. J. Biol. Sci. 10(22): 4140−4143.

Kramer, P. J. and Kozlowski, T. T. 1979. Physiology of woody plants. Academic Press, Inc., New York, NY. 811 pp.

Mtambalika, K., Munthali, C., Gondwe, G. and Missanjo, E. 2014. Effect of seed size of *Afzelia quanzensis* on germination and seedling growth. Int. J. For. Res.doi:10.1155/2014/384565.

Mulofwa, J., Simute, S. and Tengnas, B. O. 1994. Agroforestry manual for extension workers in southern Province, Zambia. Regional Soil Conservation Unit, RSCU/Swedish International Development Authority, SIDA, Nairobi.

Okunomo, K., Ogisi, D. O. and Bosah, B. O. 2009. Effect of growth media on germination and seedling growth of *Persea americana* (Mill.). J. Food Agric. Environ.7(1): 111−113.

Okunomo, K., Oghenerhoro, E. O. and Ojeifo, I. M. 2004. Effect of soil type on germination and seedling growth of *Dacryodes edulis* (Don.G. Lam H.J.). J. Sustain. Trop. Agric. Res.12: 46−50.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. 2009. Agroforestry Data Base: A Tree Reference and Selection Guide Version 4.0, 2009.

Osaigbovo, A. U. and Orhue, E. R. 2012. Effect of potting media and watering frequencies on the growth of paper fruit (*Dennetia tripetala*) seedlings. Bay. J. Pure Applied Sci. 5(2): 73–78.

Palgreave, K. C. 2002. Trees of Southern Africa. (3rd Ed). Revised by M.C. Coates. Struik Publishers, Cape Town.

Palmer, E. and Pitman, N. 1972. Trees of Southern Africa. (Vol. 2) Balkema, A.A.,Cape Town.

Pullinger J. S. and Kitchin, A. M. 1982. Trees of Malawi, Blantyre Print and Publishing, Blantyre, Malawi.

Rasebeka, L., Mathowa, T. and Mojeremane, W. 2014. Effect of seed pre-sowing treatment on germination of three Acacia species indigenous to Botswana.Int. J. Plant Soil Sci. 3(1): 62−70.

Roberts, B.R. 2006.Compost-containing substrates and their effect on post-transplant growth of containerized tree seedlings. Arbor. Urban For. 32(6): 289–296.

Schollenberger, C. J. and Simon, R. H. 1945. Determination of exchangeable capacity and exchangeable bases in soils-ammonium acetate method. Soil Sci. 59(1): 13−24.

Sekepe, L., Mathowa, T. and Mojeremane, W. 2013. Evaluating the growth response of *Cassia abbreviata* oliv. seedlings to growing media in Botswana. Res. J. Agric.For.Sci.1(10):10−14.

Six J., Elliott E. T. and Paustian, K. 2000. Soil structure and soil organic matter II. A. Normalized stability index the effect of mineralogy. Soil Sci. Soc. Am. J. 64(3): 1042−1049.

Storrs, A. E. G. 1995.Know Your Trees: Some of the Common Trees Found in Zambia. Regional Soil Conservation Unit, (RSCU), Nairobi.

Tinus, R. W. and McDonald, S. E. 1979. How to grow tree seedlings in containers in greenhouses. USDA For. Serv., Rocky Mt. For. Range Exp. Stn., Fort Collins, Colo. Gen. Tech. Rep. RM-60. 256p.

Tisdale J. M. and Oades J. M. 1982. Organic matter and water stable aggregates in soils. J. Soil Sci. 33(2): 141–163.

Van Wyk, B. and Van Wyk, P. 2000. Photographic guide to trees of Southern Africa, Struik, Cape Town, South Africa.

Vendrame, A. W., Maguire, I. and Moore, K. K. 2005. Growth of selected bedding plants as affected by different compost percentages. Proc. Fla. State Hort. Soc. 118: 368−371.

Walters, M., Midley, J. J. and Somers, M. J. 2004. Effects of fire and fire intensity on the germination and establishment of *Acacia karoo*, *Acacia nilotica*, *Acacia luederitzii* and *Dichrostachys cineria* in the field. BMC. Ecology, 4: 1−13.

Wilson S. B., Stoffella, P. J. and Graetz. D. A. 2001. Use of compost as a media amendment for containerized production of two subtropical perennials. J. Environ. Hort. 19(1): 37−42.

Young, A. 1989. Agroforestry for soil conservation, International Council for Research in Agroforestry, BPCCWheatons, Exeter, UK.