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Influence of pot size on early seedling growth of *Grevillea robusta* and *Cupressus lusitanica* in Kenya

Shadrack Kinyua Inoti * and Doris Cherop

Department of Natural Resources, Faculty of Environment and Resources Development, Egerton University, Kenya. P.O Box 536-20115, Egerton, Kenya.

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Abstract

Pot size is vital for raising of nursery seedlings. Different sizes of pots are needed for various tree species. An experiment was set up to investigate the best pot size for *Cupressus lusitanica* and *Grevillea robusta* species. The experiment was laid down as a RCBD with 8 treatments replicated 3 times. Treatments comprised of 4 different pot sizes as follows: large, medium, small and smallest as well as two species. Forest soil mixture was used for potting and 10 pots were used per each treatment per replicate while 7 plants were randomly selected for sampling. The experiment was carried out from September 2017 for a period of 8 months. The variables measured included; shoot, foliage and roots. ANOVA was done using Genstat package while the means were separated at P< 0.001 using LSD. The results showed that large pots had significantly (P<0.001) higher values in height, shoot fresh biomass, total fresh plant biomass and seedling stem volume compared with the other pot sizes. Large pots also showed significantly higher root collar diameter (6.23 mm) compared with the medium pot (4.33 mm). For species, Cypress showed significantly superior height (27.84 cm) and number of leaves (24.52) compared with Grevillea (18.73 and 18.27 cm respectively). In conclusion, shoot fresh biomass and total fresh plant biomass were positively correlated with pot size. This study recommends the use of large pots for raising Grevillea and Cypress seedlings in the nursery since they take 8 months to attain planting size.

Keywords: Pot size; Cypress; Grevillea; Nursery seedlings

1 Introduction

The success of tree seedling in the field requires that the seedling has high vigour, which is determined by the species genetic potential, site characteristics and the soil [1]. These factors must be optimal to produce a healthy and vigorous seedling [2]. In nursery, if no limitations are imposed on seedling development and management, the most important factors for health and high quality seedling are good soil and suitable container [1]. Pot size is one of the factors that affect the successful development of seedlings [3]. Pots size determines the amount of water, soil nutrients and available space for root development. Several authors have reported that a balanced soil mixture and the suitable pot size need to be determined for every species at each nursery prior to any field planting program to ensure good root and shoot development for the planting program and the pot sizes selected depends on the nursery lifespan and the desired size of the seedlings [4, 5].

Container grown seedlings has become more favored over bare root method in many reforestation projects [6, 8, 9]. This promotes; higher field survival, little soil needed for seedlings, out-planting is possible during any time of the year and especially when the soil moisture is enough [8, 10]. With the increase in use of container planting method by many nurseries, containers are produced in various sizes but many nurseries prefer using smaller sizes to reduce production cost, ease handling and to maximize the limited space, which affects the quality and health of the seedling in the long

* Corresponding author: Shadrack Kinyua Inoti; Email:sinoti@egerton.ac.ke

run thus affecting its survivability in the field. Less information is currently available on the ideal pot size to raise quality seedling of *Cupressus lusitanica and Grevillea robusta* species in the nurseries.

Cupressus lustanica (Mexican cypress) is an evergreen tree, fast growing tree to 35m in height, with a dense conical crown. Branches spread out widely but terminate in pendulous branchlets. Bark on trunk is reddish brown exfoliating in long narrow strips. It grows at high altitude (1100 to 1300m) above sea level [11]. Used for Timber, post, poles ornamental (aesthetic), shade, windbreak live fence and firewood [11]. *Grevillea robusta* on the other hand, is a fast growing tree and can attain a height of 20 m and diameter of up to 25 cm in 15 to 20 years on suitable sites. Grevillea is mainly used for timber, poles/posts and fuelwood. Other uses include bee forage, mulch, soil conservation, wind break, shade and ornamental [12].

Existence of a logging ban in Kenyan forests [13], greatly decreased the supply of timber and other forest products in the market. This pushed citizens and industries with farms to want to establishing plantations to cater for their demand of forest products. The farmers preferred species are the exotics including; *Cupressus lustanica* and *Grevillea robusta* [14] which are fast growing and they mature fast depending on the rotational period set by the owner. To achieve this quality seedling is required, which are able to survive in the field and can attain its maximum productivity. Therefore, there was need to undertake this study in order to enhance their success in nursery propagation and establishment in the field.

2 Material and methods

2.1 Study site

The study was conducted at Agroforestry tree nursery, Egerton University, Njoro, Kenya, within the east Mau water catchment, which is part of the largest water tower in east Africa [15] The University is located in Njoro, a small community approximately 25 kilometres southwest of the town of Nakuru. The area is drained by river Njoro which emerges from the Mau forest and flows to lake Nakuru, which is one of the largest bird sanctuaries in the world with 400 species [16].The site is located approximately 182 kilometres, by road, northwest of Nairobi. The study site lies on a latitude 0°22'11.0"S, longitude 35°55'58.0"E and an altitude of 2238 m above sea level. The area falls in agro ecological zone Lower Highland 3. The experimental site receives mean annual rainfall of 1200 mm. The distribution of rain is bimodal with long rains between April and August and short rains between October and December yearly. The temperatures in the field lie between 10.2 and 22.0 °C [17]. Soils at the study site are mollic andisols [18] with acidic and moderate fertility [19].

2.2 Experimental design

The experiment was laid down as a Randomized complete block design (RCBD) with 8 treatments replicated 3 times. Treatments comprised use of four different pot sizes with their corresponding diameter and lengths in centimeters as follows: large (9x20), medium (8x19), small (7x13) and smallest (6x10) as well as two species namely: *Cupressus lusitanica* and *Grevillea robusta* [20].

The volume of the pots was calculated using the following formula; $V= (\pi x d^2 h) \div 4$**,** where d= diameter of the pot, while h= height of the pot. Large pot size was 1272 cm^3 in volume and was 1.3, 2.5 and 4.5 times bigger compared with medium, small and smallest pot sizes respectively. Forest soil mixture was used for potting and 10 pots were used per each treatment per replicate while seven plants were randomly selected for sampling. The experiment was carried out from September 2017 to March 2018 for a period of 8 months.

The variables measured included; height, root collar diameter, 3^{rd} internode length, number of leaves, leaf length, root length, shoot, root and total biomass as well as seedling stem volume; $SSV = (\pi x\ d^2 h) \div 6$; where diameter and height are in centimeters.

2.3 Data analysis

Analysis of variance (ANOVA) of the measured variables was done using Genstat statistical package (2013) while the means were separated at $P< 0.001$ using Least significance difference (LSD).

3 Results and discussion

3.1 Effect of varying pot sizes on shoot growth and leaf number of Cupressus lusitanica and Grevillea robusta nursery seedlings

Large pots showed significantly (P<0.001) higher values in height, shoot fresh biomass, total fresh plant biomass and seedling stem volume compared with the other pot sizes (Table 1). However, 3rd internode length was similar for large (9.58 mm) and medium (8.67 mm) pots but these were significantly higher compared with small (6.32 mm) and smallest (5.18 mm) pots.

There was an increase in seedling growth with increase in pot size. This was attributed to availability of more space for plant development and large amount of soil in the pots which supplied more nutrients and water. These findings are in agreement with that by [1] who stated that, the seedlings raised in large pots had significantly greater height and root collar diameter, than those raised in medium and small container. Studies by [3, 21], agrees with this finding, where they reported that there was a positive effect of increasing planting pot size on seedling growth.

Table 1 Effect of pot size on shoot growth and number of leaves of *Grevillea robusta* and *Cupressus lusitanica* seedlings in the nursery

Pot size	Pot diameter x length (cm)	Pot Volume (cm^3)	Height (cm)	Internode length (mm)	Shoot fresh biomass (g)	Total fresh plant biomass (g)	Seedling stem volume (cm^3)	Leaf number
Large	9x20	1272	30.12 ^{a}	9.58 ^{a}	11.47^{a}	17.02 ^{a}	5.98 ^{a}	24.00 ^{a}
Medium	8x19	955	24.22 ^{b}	8.67 ^{a}	9.50 ^{b}	14.33 ^{b}	2.58 ^{b}	21.87 ^{b}
Small	7x13	500	20.23 ^{c}	6.32 ^{b}	6.35 ^{c}	10.17 ^{c}	1.68 ^{bc}	20.02 ^{c}
Smallest	6x10	283	18.57 ^{c}	5.18 ^{b}	4.77 ^{d}	7.38 ^{d}	1.13 ^{c}	19.72 ^{c}
Species								
Cupressus lusitanica			27.84 ^{a}	8.88 ^{a}	6.58 ^{b}	10.16 ^{b}	2.52 ^{a}	24.52 ^{a}
Grevillea robusta			18.73 ^{b}	5.99 ^{b}	9.47 ^{a}	14.29 ^{a}	3.18 ^{a}	18.27 ^{c}
P value			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CV%			11.5	14.8	13.8	13.6	33.9	5.0
LSD			3.32	1.36	1.37	2.06	1.19	1.86

Means with different superscript letters within a column differ significantly using LSD at P<0.001.

Similarly, medium pots showed significantly superior growth in height, shoot fresh biomass and total fresh biomass compared with small and smallest pots. These findings are similar to that by [22], who reported that larger pots had higher growth in shoot compared to the small pots. The smallest pots also showed significantly the lowest growth in shoot fresh biomass and total fresh biomass compared with all the other pot sizes. This was attributed to reduced soil volume in the pots, causing reduced water and nutrients uptake by plants and obstruction of roots development. Similar results were reported by [23] who stated that, small pots caused root restriction lowering water and nutrients uptake resulting to reduced plant biomass, canopy growth and inhibited root growth leading to poor growth, which is in agreement with the findings of these study.

Large pots showed significantly higher number of leaves compared with the other pot sizes. Similarly, medium pots showed significantly superior number of leaves compared with the small and smallest pots. Generally, shoot fresh biomass and total fresh plant biomass were positively correlated with pot size. This finding is in agreement with that by [22].

For species, *Cupressus lusitanica* showed significantly (P<0.001) superior height (27.84 cm), 3rd internode length (8.88 mm) and number of leaves (24.52) compared with *Grevillea robusta* (18.73 cm, 5.99 mm and 18.27 respectively). On the other hand, *Grevillea robusta* showed significantly higher shoot fresh biomass and total fresh biomass compared

with *Cupressus lusitanica.* The higher biomass of *Grevillea robusta* can be attributed to the broad foliage compared with the scale leaves of *Cupressus lusitanica* (Fig. 1).

Recent studies by [24], confirms that *Cupressus lusitanica* performed better than *Grevillea robusta* in different soil mixtures although this was not done in these study. Earlier work by [25] stated that the effect of pot sizes on seedling growth depend on the type of species to be grown which corroborates with the findings of this study, in that the two species showed different growth characteristics. The findings by [26], showed that species of plants responds differently to container size with regards to biomass distribution. Which explains the difference observed in the two species used in the study.

Figure 1 Seedlings of Grevillea and Cypress raised in different pot sizes

From Left: G+ L, G+ M, G+S, G+SS, C+L, C+M, C+S & C+SS. Where: G= Grevillea; C= Cypress; L=Large pot; M= Medium pot; S= Small pot & SS= Smallest pot

3.2 Effect of pot size on root growth of *Grevillea robusta* and *Cupressus lusitanica* seedlings in the nursery

Large and medium pots showed similar values in all the root variables measured except root collar diameter where the former (6.23 mm) was significantly (P<0.001) higher compared with the latter (4.33 mm) (Table 2).

Table 2 Effect of pot size on root growth on *Grevillea robusta* and *Cupressus lusitanica* seedlings in the nursery

Pot size	**Pot diameter x length (cm)**	**Pot Volume (cm3)**	**Root collar diameter (mm)**	**Root length (cm)**	**Root biomass (g)**	**Root: shoot ratio**
Large	9x20	1272	6.23 ^{a}	31.20 ^{a}	5.55 ^{a}	0.625 ^{a}
Medium	8x19	955	4.55 ^{b}	31.05 ^{a}	4.83 ^{a}	0.540^{ab}
Small	7x13	500	3.52 ^{c}	24.25 ^{b}	3.82 ^{b}	0.525^{ab}
Smallest	6x10	283	3.42 ^{c}	22.80 ^{b}	2.62 ^{c}	0.483 ^{b}
Species						
Cupressus lusitanica			3.61 ^{b}	32.28 ^{a}	3.58 ^{b}	0.567 ^{a}
Grevillea robusta			5.25 ^{a}	22.38 ^{b}	4.83 ^{a}	0.520 ^{a}
P value			<0.001	<0.001	<0.001	<0.001
CV%			9.4	9.5	16.7	18.5
LSD			0.51	3.132	0.87	0.124

Means with different superscript letters within a column differ significantly using Least significance difference (LSD) at P<0.001.

Consequently, large and medium pots showed significantly superior root collar diameter, root length and root fresh biomass compared with the small and smallest pot sizes. This finding is in agreement with by studies by [1] who stated

that large pots led to high growth in shoot and roots. Other earlier studies by [26] showed that larger pots had higher root: shoot ratio in *cajanus cajan* and *Sesbania sesban*. The current findings are Similar to the work by [28] who confirms that large planting pots produce seedlings with a longer taproot during the nursery period, which favours growth of deep root system in the field.

On the other hand, small and smallest pots were similar in all the root variables measured except root fresh biomass where the former (3.82 g) was significantly higher compared with the latter (2.62 g). This could have been as a result of increased volume in the former having adequate space for root development. In addition, root to shoot ratio was significantly higher for large ones (0.63) compared with the small pots (0.48). This could have been attributed to growth inhibition caused by the small size of the container limiting the plant's water and nutrients uptake for the plant development. This finding is supported earlier studies by [29] who stated that small pots reduce dry matter of roots, stems, leaves and fruits. Studies by [30] and [23] on ideal pots for jojoba reported that there was increase in stem diameter of seedlings planted on larger pot. This is in agreement with the findings of this study which revealed that seedlings raised in large pots produced largest seedlings

For species, *Grevillea robusta* showed significantly ($P<0.001$) higher root collar diameter and root fresh biomass compared with *Cupressus lusitanica.* Similarly, *Cupressus lusitanica* showed significantly higher root length (32.28 cm compared with Grevillea (22.28 cm). Results also showed that *Grevillea robusta* had a higher growth in root biomass compared with *Cupressus lusitanica* and this could have led to superior shoot and root collar diameter in the former. This finding is supported by [26], who reported that species of plants responds differently to container size with regards to biomass distribution.

4 Conclusion

Generally, shoot fresh biomass and total fresh plant biomass were positively correlated with pot size. This shows the larger the seedling pots the better the growth in biomass and vice versa. The result shows that the small pots supported a limited shoot growth compared with root growth which is a favorable adaptation for dry lands.

Recommendations

This study recommends the use of large pots for raising Grevillea and Cypress seedlings in the nursery since they take 8 months to attain plantable size of 30 cm in height and 4 mm in root collar diameter. This stage also showed superior growth in most of the variables measured hence better survival in the field after out planting.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors confirm that there is no conflict of interest as pertains to the current paper.

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