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Manure soil amendment for *Grevillea robusta* seedlings in the Kenyan highlands

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Abstract

Grevillea robusta seedlings are of high demand in Kenyan agricultural landscapes especially in agroforestry systems, yet the ideal soil mixture is not identified. This experiment was to determine the ideal potting soil mixture for Grevillea species. A Complete Randomized Design (CRD) with 4 treatments replicated 3 times was employed. Four treatments were used; Forest soil, Agricultural soil, Forest soil + Manure and Agricultural soil + Manure. The experiment was done for 8 months in 2020 at Egerton University tree nursery. Data was collected on seedling survival, height, root and foliage variables. One-way ANOVA was performed on the measured variables using SAS statistical package while the means were separated using LSD at P≤ 0.05. Results showed that Agricultural soil + Manure was significantly higher (P≤0.05) in all the shoot and foliage variables compared with Agricultural soil alone except for internode length. Besides, Agricultural soil + Manure showed similar growth performance with Forest soil alone. However, the former showed significantly higher leaf length (20.2 cm) compared with Forest soil + Manure (14 cm). Results showed that Forest soil and Agricultural soil + Manure had significantly higher (P≤0.05) root biomass compared with Agricultural soil (2.77 g), while root collar diameter, root length and root to shoot ratio were similar. It is, therefore, recommended that tree nurseries located far from forests can use a potting soil mixture of Agricultural soil + manure in raising Grevillea seedlings since this gives similar growth performance with forest soil.

Keywords: *Grevillea robusta*; Soil mixture; Seedling growth; Tree nursery

1. Introduction

Seedling production nurseries have been receiving much attention because of increasing demand for seedlings [1]. Over 50% of smallholder seedlings planted are sourced from tree nurseries nearby [2]. However, smallholder tree farmers have been documented in several studies to face challenges in availability of quality planting materials which in turn affect the quality of the subsequent trees established [3, 4]. A previous study by [2] demonstrates that large scale nurseries are having an edge over many smallholder nurseries in terms of seedlings performance based on good quality seed practices.

Forests have been experiencing losses estimated to be 150,000 – 200,000 ha annually, hence, minor stands of disturbed forests. Therefore, restoration practices such as reforestation, afforestation and agroforestry is paramount for forest conservation [3]. To achieve this, approximately 1.3 billion plants are needed annually [5]. Getting appropriate rooting media is, thus, good for standard seedling production at nursery levels because it encourages high rate of survival when transplanted [5]. Potting media is, therefore, known to; support seedlings, improve microbial activities, provide nutrients, air and water to plant roots. This implies that good growing media results into development of healthy, vigorous fibrous root system hence quick growth [6]. In addition, containerized seedlings have high survival rate than bare-rooted seedlings [3, 7]. Growing media can entail; peat, compost, organic remains, manure among others and can be a mixture or pure [8].

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Choosing the right growing media is critical in early seedlings performance. Standard media produces vigorous seedlings, improve seedling growth rate [9, 10], increases seedling survival and determines standard potting mixture hence avoid wastage of media ingredients [5]. Growing media is thus known to influence germination, emergence, growth and quality of seedlings in nursery [7, 8]. Several studies have shown that several materials can be used for growing media preparation, but the final choice depends on the ability of the media to sustain plant growth [9, 11]. On the other hand, more recent studies [12,11,7] have reported that smallholder farmers lack the know-how about the effects of various soil mixture composition on the seedling growth performance. Nutrients from manure are released within 4 to 8 weeks after application [13].

Suitable growing medium in seedling production is, therefore, crucial for quality seedlings since growth, maintenance and growth of rooting system [1, 3, 5]. In addition, it provides anchorage, reservoir for water and nutrients as it allows for gaseous exchange. Therefore, it should allow for moisture retention, aeration [10] and ease transportation during transplanting. This implies that a good growing medium should imitate forest soils which provide good drainage and sufficient nutrients [7]. Growing medium, therefore, is a composition of organic matter that is formulated to provide chemical and physical plant requirements in order to achieve a desirable growth and development [10].

Growing nursery media is of major concern to agro foresters since this is where most variations in seedling performance occurs [8, 14, 15]. The variations emerges from the different soil types [9] and their amendments, which comprise of several own combinations [16, 17]. This has led to a gap in looking at the actual smallholder tree nursery farmer practice and comparing with ideal that can be adaptable to the farmers [18, 12]. The implications of the growing media on the performance of commercial tree species is an important factor [8] as it forms the basis on how farmers make adjustments to their tree nursery practices [19, 20, 21].

Limited studies have previously focused on growing medium for Grevillea tree species and its early growth performance whose smallholder farmers' preference was observed to be high in agroforestry systems within the Kenyan highlands [22]. On the other hand, more concentration was done on large scale nurseries with less attention on smallholder tree nurseries and also the growing media variation were not specific on sources of some of the media composition [23, 24].

The present study sought to analyze the effect of different soil mixtures on early growth performance of *Grevillea robusta* nursery seedlings. The specific objectives were; i) to determine the effect of varying soil mixtures on height and foliage growth, ii) to determine the effects of varying soil mixtures on root growth. This will provide the best soil mixture that can be recommended for *Grevillea robusta* nursery seedlings for smallholder tree farmers in Kenya.

2. Material and methods

2.1. Study site description

The study was conducted at Agroforestry tree nursery, Egerton University, Njoro, Kenya, within the eastern Mau water-catchment. The study site lies on a latitude of 0°22'11.0"S, longitude of 35°55'58.0"E and an altitude of 2,238 m. The area falls in agro ecological zone Lower Highland 3. The experimental site receives mean annual rainfall amount of 1200 mm while the distribution of rain is bimodal with long rains between April and August and short rains between October and December. The temperatures lie between 10.2 and 22.0°C [25] while the soils are mollic andosols [26] with relatively high levels of phosphorus.

2.2. Experimental design

The experiment was laid down in a Complete Randomized Design (CRD) with 4 treatments replicated 3 times. The four treatments were as follows; forest soil, agricultural soil, forest soil + manure and agricultural soil + manure. The agricultural + manure was added in the ratio 2:1 respectively.

Medium sized pots were filled with different soil mixtures and planted with Grevillea seedlings which were transplanted from a germination bed after 3 weeks since sprouting. Ten pots were used per treatment in each replicate. The seedlings were raised for 8 months in the nursery in 2020, after which sampling was carried out for data collection on shoot, foliage and root variables. Seven seedlings were selected randomly for measurements per treatment in each replicate.

2.3. Data analysis

One-way analysis of variance (ANOVA) model was used to test for differences between treatment means using SAS statistical package while the significantly different treatment means were separated by F ratio using Least Significance Difference (LSD) at $P \leq 0.05$ [27]

3. Results and discussion

3.1. Effect of different potting soil mixtures on shoot and foliage growth of *Grevillea robusta* nursery seedlings

Results showed that a mixture of agricultural soil + manure was significantly higher **(***P*≤0.05**)** in all the shoot and foliage variables compared with agricultural soil alone except for internode length (Table 1). On the other hand, the agricultural soil + manure mixture was also significantly superior in leaf length (20.2 cm) compared with forest soil + manure (14 cm). However, all the other variables were similar in agricultural soil + manure mixture, forest soil alone and forest soil + manure mixture. On the other hand, forest soil alone was significantly higher in shoot biomass (12.2 g) and total plant fresh biomass (18.3 g) compared with agricultural soil alone (6 g and 8.77 g respectively).

Table 1 Effect of different potting soil mixtures on shoot and foliage growth of *Grevillea robusta* nursery seedlings

Potting mixtures	Height (cm)	No. of leaves	Leaf length (cm)	Internode length (mm)	Shoot biomass (g)	Total plant fresh biomass (g)
Forest soil	23.3 ab	12.33 ab	17.13 ab	11.67	12.2 a	18.3 a
Agricultural soil	20 b	11.5 b	14.07 b	9.67	6 b	8.77 b
Forest soil + Manure	23.2 ab	11.9 ab	14 b	8	8.4 ab	12.3 ab
Agricultural soil + Manure	28 a	13.03 a	20.2 a	12.33	12.7 a	19.1 a
P ≤0.05				NS		
% CV	14.5	6.5	14.8	48.2	33.1	32
LSD	6.465	1.482	4.53	9.46	6.12	8.81

Means with the same letter(s) in each column are not significantly different to each other using LSD at P ≤ 0.05. NS= No significant difference among the means in each column

Forest soil and forest soil + manure mixture did not show any significant differences in all the shoot and foliage variables. This shows that it is not necessary to add any organic manure in forest soil since it has adequate nutrients to support nursery seedlings. Agricultural soil + manure mixture, however, reported increased seedling height compared with the other growing media. The results were similar to that demonstrated by [28], who showed that organic nutrient sources have a significant influence on *Grevillea robusta* seedling height at various stages of growth. Studies have reported that using manure significantly increases plant height [28, 29]. This is because, manure increases nutrients which facilitates growth rates in nursery seedlings [6, 10]. In addition, in cooperating organic manure in rooting media increases root collar development in seedlings [6]. This study was also congruent with other studies that a mixture of soil media in pots greatly influence seedling height development compared with single medium [5, 8]. Therefore, high seedling height in mixed growing media can be attributed to abundance of nutrients [8].

This study again conformed with a previous study that was done on lettuce seedlings using coconut fiber + rice mill waste + soil [8]. This study was, however, contrary to the recent findings by [1] that a mixture of soil media (forest soil + farmyard manure) improved *C. lusitanica* seedling height. The present study revealed that a mixture of forest soil + manure had no significant influence on seedling height. However, depending on plant species, different growing media have different response in relation to seedling height, leaf number among other parameters [7, 30]. Another study by [31] also reported increased seedling height in *Rothmannia hispida* seedlings using pure sawdust compared with topsoil + sawdust. The current study only considered manure amendments and soil mixture. However, many studies have demonstrated that a mixture of growing media is better for seedling height development since moisture is retained as well as easy root penetration [32, 33, 10].

The number of leaves recorded were higher in agricultural soil + manure mixture compared with the other growing media. This was contrary to the findings by [9], who reported increased leaf number in pure topsoil compare with other soil mixtures. In this study, the high leaf number could be attributed to high organic matter in agricultural soil + manure mixture which regulated nutrients and water, therefore, increasing seedling quality [30]. The varying number of leaves in the different growing media from the current study was again similar to other previous studies [8, 32, 33]. An earlier study by [6] on combination of goat manure with clay soil and sand showed a significant influence of the media on plant height and leaf count after 8-12 weeks. The current study was also similar to other studies that reported that having manure in planting media increases number of leaves [28].

This study again recorded high internode length in agricultural soil + manure mixture than the other growing media. The results corroborated with that of [7], who demonstrated that soil mixture increased internode length of *Leucaena pallida* seedlings. However, the authors reported that soil mixture did not affect internode number. Similar findings were reported by previous studies on increased internode length of nutmeg (*Myristica fragrans*) in mixed growing media of soil + farmyard manure + vermicompost + rice husk + coco peat [33].

Additionally, the current study reported high shoot and total fresh biomass in agricultural soil + manure mixture compared with the other growing media. These results were in line with other studies [32, 33] that mixed growing media provides the required conditions (nutrients and water) for seedling growth, hence, increased number of shoots. Manure in precise increases the survival and growth rate of seedlings since it retains moisture as well as provides nutrients to the seedlings, leading to high shoot biomass [30]. Many researchers have, therefore, affirmed that a mixture of growing media increases survival rates of seedlings [5, 8, 30, 13].

3.2. Effect of different potting soil mixtures on root growth of *Grevillea robusta* nursery seedlings

Results showed that forest soil (6.1 g) and a mixture of agricultural soil + manure (6.43 g) had significantly higher ($P \leq 0.05$) root biomass compared with agricultural soil alone (2.77 g), while root collar diameter, root length and root to shoot ratio were similar. This can be explained by the relatively high levels of phosphorus in the surrounding agricultural lands, which therefore tends to make agricultural soils to have adequate amount for root development of seedling (Table 2).

Table 2 Effect of different potting soil mixtures on root growth of *Grevillea robusta* nursery seedlings

Potting mixtures	Root collar diameter (mm)	Root length (cm)	Root biomass (g)	Root to shoot ratio
Forest soil	6.33	18.7	6.1 a	0.51
Agricultural soil	5.4	16	2.77 b	0.473
Forest soil + Manure	5.5	16.7	3.87 ab	0.44
Agricultural soil + Manure	6.67	18.67	6.43 a	0.507
P ≤0.05	NS	NS		NS
% CV	14.4	8.6	34.4	23.5
LSD	1.624	2.848	3.104	0.2134

Means with the same letter(s) in each column are not significantly different to each other using LSD at P ≤ 0.05. NS= No significant difference among the means in each column.

Forest soil and agricultural soil + manure mixture reported a relatively high root collar diameter, root length and root biomass. Similar results were reported by [30], who reported that *Olea europaea* seedling root collar diameter increased in a mixed growing media (farmyard manure + urea). Findings from the present study were also congruent with that of [29] who reported increased root collar diameter of *Tectona grandis* seedlings planted in topsoil that either had poultry dung or cow dung but low root collar diameter in pure topsoil. The composition of growing media is, therefore, known to significantly affect root collar development just as in other plant parameters [7].

The current study also revealed that those seedlings planted in forest soil and agricultural soil + manure mixture generally had increased root length. This was attributed to high organic matter in the media [5]. The results from this study were, however, contrary to the findings by [31] who reported an increased root length in *Rothmannia hispida* seedlings planted in pure sawdust as a rooting medium. However, the current study corroborated with previous studies that having a mixture of growing media increases root length. This was confirmed by [33] who reported an increased root length of nutmeg grafts seedlings planted in soil + farmyard manure + vermicompost + sand + coco peat as rooting medium.

The results were again in agreement with [5] who reported increased root growth of *Cordia africana* and *Albizia gummifera* seedlings in soil mixture (forest soil + compost + sand) as opposed to pure top soil. This was related to lack of organic matter hence less nutrients in the soil. Therefore, right proportion of growing media results into healthy vigorous seedlings [6, 7, 9]. In addition, use of manure in planting media improves the growth and survival rates of tree seedlings [30]. The current study, hence, demonstrates the importance of using mixed rooting media in planting.

Agricultural soil + manure mixture again recorded high root biomass compared to the other potting media. This could be related to high phosphorus level in the agricultural soil and high moisture retained by manure [34]. These results were similar to the earlier findings by [6] who reported an increased total dry root weight with increase in goat manure in the planting media. Low amount of nutrients in the soil such as nitrogen and phosphorus influences root biomass, hence, shoot to root biomass ratio. In addition, low nitrogen presence in growing media increases root biomass [35].

Root to shoot ratio was recorded high in forest soil and agricultural soil + manure mixture while the other potting media recorded similar results. This was related to the presence of phosphorus and nitrogen in the media which increased root development [35]. The results were contrary to previous findings by [34] who reported low root to shoot biomass ratio of spring wheat in a potting mix containing peat moss, sand, and vermiculite mixture (1:1:1) due to low phosphorus content in the mixture. Therefore, there is a synergistic interaction between soil nutrients and minerals on seedling growth and development [34].

4. Conclusion

Agricultural soil alone does not have adequate nutrients for seedling growth. However, addition of organic manure makes it ideal for use in raising Grevillea seedlings in the nursery. On the other hand, the results show that forest soil alone has adequate nutrients to support nursery seedlings.

Recommendations

Nursery practitioners located far from forest areas can therefore use a mixture of agricultural soil and manure in raising nursery seedlings. On the other hand, the forest nurseries and also those near the forest can use forest soil for growing seedlings. Forest soil does not require further fortification with organic residues or artificial fertilizers but can be used alone. Further research can explore the best amendment material for improving agricultural soil for raising nursery seedlings in various localities depending on locally available amendment materials.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest as pertaining to the current research.

References

[1] Owino JO, Onyango AA, Angaine PM, Inoti SK. Effect of Soil Mixtures on Early Growth Performance of Grevillea robusta and Cupressus lusitanica Seedlings in the Highlands of Kenya. 2022 Aug 11;34(22):597–609.

[2] Rams Beltrán E. Silvicultural management of smallholder commercial tree plantations in the Southern Highlands of Tanzania: characterization and influencing factors. [MSc. Thesis]. University of Helsinki; 2019.

[3] Dedefo K, Derero A, Tesfaye Y, Muriuki J. Tree nursery and seed procurement characteristics influence on seedling quality in Oromia, Ethiopia. For Trees Livelihoods. 2017;26(2):96–110.

[4] Havyarimana D, Muthuri C, Muriuki J, Mburu D. Constraints encountered by nursery operators in establishing agroforestry tree nurseries in Burundi. Agrofor Syst. 2019;93(4):1361–1375.

[5] Mulugeta G. Effect of different potting mixture on the seedling growth and survival of Albizia gummifera and Cordia africana. J Nat Sci Res. 2014;4(3):25–33.

[6] Elbasheer YHA, Mohammed AKE, Alalem S. Nursery Potting Mix Medium using Azadirachta indica Seedlings as A Model. 2018 Dec; 5:177–196.

[7] Abebe H. Effects of Pot Size and Planting Media on the Early Seedling Growth Performance of Azadirachta indica A. Juss. J Plant Sci. 2021;9(4):208–213.

[8] Okechukwu GCE, Ngwu OE, Awere SU. Effect of potting media on the growth and leaf yield of lettuce (Lactuca sativa) in Agbani Nkanu south, Nigeria. 2021 Jun 2;1(2):1–8.

[9] Ikyaagba ET, Amonum JI, Usman IA, Asiegbu EA, Amagu K. Effects of Growth Media on Germination and Early Growth of Afzelia africana sm ex pers. Annu Res Rev Biol. 2018;29(2):1–7.

[10] Iroko OA, Amadi JO, Rufai SO, Wahab WT. Comparative effect of different potting media on the early growth of Entandophragma angolense (Welw.). 2020 Dec;1(2):67–70.

[11] Lim SH, Kim SH, Park JJ, Park YS, Dhungana SK, Kim ID. Quality characteristics and antioxidant activities of lotus (Nelumbo nucifera Gaertn.) sprouts grown under different conditions. 2020;666–674.

[12] Kitonga K, Jamora N, Smale M, Muchugi A. Use and benefits of tree germplasm from the World Agroforestry genebank for smallholder farmers in Kenya. Food Secur. 2020 Oct;12(5):993–1003.

[13] Andrews N, Foster J. Organic fertilizer calculator. Tool Comp Cost Nutr Value Nitrogen Availab Org Mater Or State Univ Ext Serv EM. 2007;1–10.

[14] Hubbel KL, Ross-Davis AL, Pinto JR, Burney OT, Davis AS. Towards Sustainable Cultivation of Pinus occidentalis Swart z in Haiti: Effects of Alternative Growing Media and Containers on Seedling Growth and Foliar Chemistry. Forests. 2018;9(7):1-14.

[15] Marler TE. Repetitive pruning of Serianthes nursery plants improves transplant quality and post-transplant survival. Plant Signal Behav. 2019;14(8):1-6.

[16] Sax MS, Scharenbroch BC. Assessing alternative organic amendments as horticultural substrates for growing trees in containers. J Environ Hortic. 2017;35(2):66–78.

[17] Jim CY, Ng YY. Porosity of roadside soil as indicator of edaphic quality for tree planting. Ecol Eng. 2018; 120:364–374.

[18] Rahman SA, Sunderland T, Roshetko JM, Healey JR. Facilitating smallholder tree farming in fragmented tropical landscapes: Challenges and potentials for sustainable land management. J Environ Manage. 2017; 198:110–121.

[19] [19] Khurram S, Burney OT, Morrissey RC, Jacobs DF. Bottles to trees: Plastic beverage bottles as an alternative nursery growing container for reforestation in developing countries. Plos One. 2017 May 31;12(5):1–21.

[20] Aderounmu AF, Asinwa IO, Adetunji AO. Effects of seed weights and sowing media on germination and early growth of Afzelia africana Smith ex Pers. J Agric Ecol Res Int. 2019;19(3):1–11.

[21] Afzal I, Javed T, Amirkhani M, Taylor AG. Modern seed technology: Seed coating delivery systems for enhancing seed and crop performance. Agriculture. 2020;10(11):1–20.

[22] Ashiono FA. Effects of Sawdust and Cow Manure Mixtures on Growth Characteristics of Blue Gum (Eucalyptus saligna) Seedlings in South Kinangop Forest, Kenya [PhD Thesis]. Karatina University; 2020.

[23] Kipkemboi K, Odhiambo KO, Odwori PO. Adoption of tree nursery practices as strategic enterprise at millenium villages project, Siaya County, Kenya. Afr Environ Rev J. 2019;3(2):26–34.

[24] Panda MR, Pradhan D, Dey AN. Effect of different growing media on the performance of teak (Tectona grandis linn.) stump in nursery. Indian J Ecol. 2021;48(4):1051–1055.

[25] Ngetich KF, Mucheru-Muna M, Mugwe JN, Shisanya CA, Diels J, Mugendi DN. Length of growing season, rainfall temporal distribution, onset and cessation dates in the Kenyan highlands. Agric For Meteorol. 2014; 188:24–32.

[26] Kinyanjui HC. Detailed soil survey of Tatton Farm, Egerton College, Njoro. Minist Agric-Natl Agric Lab Nairobi Kenya. 1979 Sep 12;2–19.

[27] Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2010; 2:680–690pp.

[28] Khaple AK, DevaKumar AS, Maruti G, Niranjan SP. Influence of potting media on Grevillea robusta A. Cunn: Seedlings at nursery stage. Inter J Basic Appl Sci. 2010; 1:328–332.

[29] Omokhua GE, Fredrick C, Okakpu CN. Seedling Growth of Tectona grandis using Different Potting Mixture. Methodology. 2021 Jul;24(6):17–24.

[30] Gebre T, Chinthapalli B, Anjulo MM, Robinson D. The impacts of post plantation management practices on growth and survival rate of selected tree species in Mirab Abaya District, Southern Ethiopia: An experimental approach. J Hortic For. 2022;14(3):28–41.

[31] Alex A, Usman IA, Mbah SC. Effects of growth media and water quantity on seedling growth and survival of Rothmannia hispida (K. schum). J Res For Wildl Environ. 2020;12(3):64–71.

[32] Nanayakkara GT, Dissanayake SM, Palihakkara IR. Effect of different potting types and different organic manure levels on early stages of bamboo (Dendrocalamus asper) growth inside oil palm plantation in low country wet zone (wl 2a) in Sri Lanka. Int J Res Appl Sci Biotechnol. 2020;7(5):119–124.

[33] Rajput DC, Gawankar MS, Salvi BR, Khandekar RG, Parulekar YR, Salvi VG. Effect of potting media on growth of soft wood grafts of nutmeg (Myristica fragrans Houtt.). IJCS. 2019;7(5):2949–2952.

[34] Epie KE, Maral E. Shoot and root biomass, phosphorus and nitrogen uptake of spring wheat grown in low phosphorus and moisture content conditions in a pot experiment. J Plant Nutr. 2018;41(17):2273–2280.

[35] Tolley S, Mohammadi M. Variation in root and shoot growth in response to reduced nitrogen. Plants. 2020;9(2):1–17.