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Effects of Pot Size and Planting Media on the Early Seedling Growth Performance of *Azadirachta indica A. Juss*

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Abstract: Neem is a multipurpose tree that is provides food and insecticide and is used for its great number of ethnomedicinal properties. Neem, known botanically as *Azadirachta indica A. Juss* is a member of the mahogany family (Meliaceae), and orders Geraniales, and is synonymous with *Melia azadirachta Linn* and Melia indica Brandis. *Azandirachta indica* originates from the arid and semi-arid areas of Burma and Northeast India. Neem is a large evergreen tree 12 to 20 meters tall and may reach a girth of 1.8 to 2.5 meters with a round, dense crown. The aim of this study was to determine appropriate pot size and growing medium for *Azadirachta indica A. Juss* seedlings, which will be used for successful plantation. For this purpose, polyethylene pots of 15 cm length and 8, 10 and 12 cm lay flats diameter were used. As growing medium, 5 different treatments were used, containing different ratios of top/local soil (TS), forest soil (FS), compost (Co) and sand soil (SS) collected from local, natural forest environments and highly decomposed compost (the different materials get from locally easily available). The experimental design was a Randomized Complete Block Design with 3 replications under open field conditions of forestry nursery. Some morphological properties of the seedlings, such as seedling height and root collar diameter growth parameters were measured ever two weeks for four (4) months old seedlings. The finding of this experimental study revealed/showed that relatively higher growth recorded in GM_2 and GM_4 ratio of composite growing media (3/2 topsoil:2 compost:1 sand soil) composites soil mixed growing media with both 10 cm and 12 cm lay flat polythene pots (PS_2 and PS_3) should be utilized for raising *Azandirachta indica (Neem)* seedling to achieve the best seedlings quality. To obtain the best or optimum seedling quality were the interaction effects of growing media and appropriated containers (pot sizes) were important and basic than doing experiment separately. Knowing the best growing media was the major determinant to get the best quality seedlings at the nursery for successful plantation.

Keywords: Growing Media, Pot Size, *Azandirachta indica (Neem)*, Seedling Quality

1. Introduction

Neem (*Azadirachta indica A. Juss*.) is a multipurpose tree that is provides food and insecticide and is used for its great number of ethno medicinal properties. Neem, known botanically as *Azadirachta indica A. Juss* is a member of the mahogany family (Meliaceae), and orders Geraniales, and is synonymous with *Melia azadirachta Linn* and Melia indica Brandis. *A. indica* originates from the arid and semi-arid areas of Burma and Northeast India [1, 2]. Neem is a large evergreen tree 12 to 20 meters tall and may reach a girth of 1.8 to 2.5 meters with a round, dense crown. The trunk is straight with moderately thick bark. Leaves are alternate, compound, with 7 to 17 toothed leaflets that are alternate or opposite 6 to 7 cm long.

Fruit, seed, and leaves of *A. indica* contain compounds that inhibit, kill, or repel insects, and slow the development of fungi, and limit infectiveness of viruses. It is a fast growing, multipurpose tree for timber, firewood, shade, shelterbelts, fodder, insecticide, oil, fertilizer, rehabilitation of land, bee fodder, toothbrushes, and medicinal uses [1]. Numerous biological and pharmacological activities have been reported including antibacterial [3], antifungal [4], and anti-inflammatory. Earlier investigators have confirmed their role

as anti-inflammatory, anti-arthritic, antipyretic, hypoglycemic, anti-gastric ulcer, antifungal, antibacterial, and antitumor activities [5].

Neem is usually grown from seed but can be propagated from cuttings or root suckers. The plant is hardy and resilient and grows well in poor, rocky soils. Neem tolerates a wide variety of environmental conditions but cannot survive freezing temperatures or being waterlogged, so, why this plant is particularly important for this highly degraded soil in risk climate change for mitigation purpose. Many households and communities depend on this multipurpose tree for the provision of goods and services that include edible fruits, herbal medicines or fuel wood as well as global service by facilitating carbon sequestration with the potential for climate change mitigation [6].

The use of suitable growing medium is essential for production of quality plant seedlings. It directly affects the growth, development and maintenance of the functional rooting system. A good growing medium would provide sufficient support to plant; it would also serve as reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate [7]. Good seedling production depends to a large part on the growing medium used. A substrate (growing medium) should be light in weight to ease transport to the planting site, retain enough moisture to avoid need for frequent watering, porous enough for excess water to drain easily and allow sufficient aeration of the roots [8].

In establishing plantations, it is necessary to produce high quality and large number of seedlings with less cost. Nursery technology that aims at the production of seedlings with good root system and healthy shoots under standard operations is necessary [9]. They are prepared to simulate forest soils and compost, which provide the seedlings with good drainage (i.e., good water infiltration and holding capacity), good nutrient content, and mechanical support by holding the roots together. Appropriate soil mix generally makes the nursery pot suited for growth and in turn leads to high survival rate, i.e., minimal loss of seedling through death and damage [9, 10]. Seedlings grown in containers have many advantages such as better survival rate, easier to plant, immediate growth response benefits, cheaper to produce and plant than bare-root seedlings [11].

Forest soil, local soil, and manure are the usual components of nursery soil mixtures. Sand and compost are usual ingredients of soil mixtures in most nurseries in order to reduce the cost of using forest soil, which is economically unacceptable in terms of transportation and depletion of the top forest soil. Sand is important in allowing the roots to have a good penetration, good water drainage and ease detachment of roots without damaging the roots. Compost provides the seedlings with nutrients and organic matter. Therefore, the standard soil mixture will provide the seedling with adequate drainage, proper aeration, adaptation to different soil types and good nutrient supply. For any species, research is needed to find out the optimal substrate (growing media) and appropriated container sizes (pot sizes). When mixing, it is important that all components are finely ground and sieved through a 2 mm-sieve to remove excessively large particles [8]. Potted seedlings have the highest survival rate and initial growth in plantations. In addition, they can be used in wider areas or in areas having different characteristics [12]. Recent economic analyses indicated that potted seedlings can be as economical as bare-root seedlings for attaining similar or better survival rates or growth [13]. Due to continuous mass production techniques, the most important advantages of using potted seedlings are time savings and reduced seedling loss [12]. Overall, the production of quality seedlings requires nutrient management, which was reported as a potential means to change morpho-functional traits of tree seedlings [14].

Since different localities are characterized by different soil types, soil conditions and pot size that affect the growth of seedlings. However, no comprehensive study has been conducted on the appropriate pot size and growing medium for the pot filling material. It is important to investigate and evaluate the effects of proportions of the soil mixture or composites and appropriate seedling raising container or plastic pot size are important for early growth performance of tree species seedlings. The objective of this experiment was to determine the best soil mixture proportion and pot sizes for morphological seedling characteristics and optimum early growth performance of the seedlings of *Azadirachta indica* to enhance its success in propagation and cultivation in the study area.

2. Materials and Methods

2.1. Study Area

This study was conducted at the Forestry Nursery of the Department of Forestry, at Sinana Agricultural Research Center, which located an altitude about 2400 m.a.s.l in Oromia Regional State (7° N latitude and 40° E longitudes). The area is high altitude; sub humid with bimodal rainfall pattern, experiencing an average annual rainfall of 860 mm and monthly mean maximum and minimum air temperatures were 19.5°C and 9.6°C, and for the long term (mean) was 21.1°C and 9.4°C, respectively. The dominant soil type is pellic Vertisol and slightly acidic.

2.2. Seed Procurement, Seed Sowing and Filling of Polythene Pot

The *Azadirachta indica* fruit seeds were selected and purchased from the available sources of the National Tree Seed Project, Ethiopia Forestry Research Center. This is well-known in the country which provided good trees/shrubs seeds quality. Seeds were extracted from the mature fruits of *Azadirachta indica* in which the fruits were mechanically de-pulped to expose the seeds using an appropriated local material. The fruits were split open and deseeded carefully to avoid affecting the anatomical structure of the seed to increase seeds germination. Bottom perforated polythene pots were filled with various planting media of forest soil (FS), compost (Co), sand soil (SS) and local soil (LS) in different pots size (PS_1=8 cm=control, PS_2=10 cm and PS_3=12 cm lay flats) 15 cm in

length and the growing media (GM) or soil mix proportion based on volume GM_1= (2 part local/Top soil:2 part forest soil:1 part sand; GM_2=2 part local soil:2 compost: 1 part sand; GM_3=1 part local soil:2 part forest soil:2 part sand; GM_4=3 part local soil:2 part compost:1 sand soil and GM_5=3 local soil:2 forest soil:1 sand=control). Compost was prepared from locally easily available materials five months ahead of potting. Finally, all materials were sieved, and pot filled. The extracted seeds of *Azadirachta indica* were planted directly into the polythene pots and each filled with the planting/growing media. Watering of the sown seed was done consistently every day after planting or sows the seed to give the seed every condition needed for proper growth.

2.3. Experimental Design

The experiment was laid out in Randomized Complete Block Design (RCBD) at the Forestry nursery in the study area. The study involved the use of five (5) planting media and three different plastic pots in three (3) replicates. The treatments were: 1. Different pots size (PS_1=8 cm=control, PS_2=10 cm and PS_3=12 cm lay flats) 15 cm in length and 2. The growing media/soil mix proportion based on volume GM_1; GM_2; GM_3; GM_4 and GM_5 (control) were planted for the study. This study was observed for the duration of four (4) months while variables were measured ever two weeks starting from the one month after the required plant seed uniformly germinated and some were transplanted.

2.4. Data Collection and Analysis

Data on growth variables were measured; these include seedling heights were measured from the collar region to the tip of the seedlings using graduated ruler. Collar diameters were measured using a veneer or digital caliper. The growth variables were measured in every two (2) weeks interval for a period of four (4) months. The growth variables (seedling heights and collar diameter) data obtained was subjected to two-way analysis of variance (ANOVA) by using Duncan's Multiple Range Test (DMRT) to identify whether there was a significant difference (at the 5% probability threshold) between the means of the treatments as a function of the variables studied. To do this, Genstat 18th EDITION used to analyze the data.

3. Results

3.1. Growth Parameter (Height and Root Collar Diameter)

3.1.1. Growing Containers (Pot Sizes)

The ANOVA showed that the mean measured height of *Azadirachta indica* seedling plants on PS_2 (7.15 cm) was significantly different (p=0.025) from that observed on PS (5.67 cm). However, the height measured on PS_1 and PS_2 is not significantly that of PS_3 (6.87 cm). In terms of root collar diameter, PS_2 were 0.327 cm girth thicker than those grown in PS_1 (0.252 cm) and PS_3 (0.29 cm), respectively.

3.1.2. Substrates (Growing Media)

According to the analysis of variance which confirmed or shown that mean measured height of *Azandirachta indica* seedlings plants on media growth soil mixture (composite) ratio of GM_2 was significantly different (p=0.004) from that observed on growing media soil mixture of GM_5 was 5.53 cm and GM_2 was significantly different (p=0.019) from that of growing media composite ratio of GM_3 seedlings height as 6.00 cm and growing media mixture ratio of GM_4 was 6.22 cm. The difference observed among other sources root collar diameter (RCD) measured parameter of variation were not statistically significant.

Table 1. *ANOVA Result on the Comparative (two-way interactions) Effects of Different Growing Media (GM) and Pot Size (PS) on Azandirachta indica (Neem) Seedling's height (Ht) and Root Collar Diameter (RCD) after four (4) months in the Nursery Study Area.*

Treatment combination	Variables		Treatment combination	Variables	
	Ht (cm)	RCD (cm)		Ht (cm)	RCD (cm)
1. Pot Size (PS)			3. Interaction effects		
PS_1	5.67^{a}	0.252^{a}	GM_1xPS_1	6.50^{abc}	0.263^{abc}
PS_2	7.15^{b}	0.327^{b}	GM_2xPS_1	6.50^{abc}	0.275^{abc}
PS_3	6.87^{ab}	0.29^{ab}	GM_3xPS_1	5.50^{ab}	0.231^{a}
CV	26.1	24.1	GM_4xPS_1	5.17^{a}	0.236^{ab}
LSD (5%)	1.28	0.521	GM_5xPS_1	4.70^{a}	0.255^{ab}
2. Growth media (GM)			GM_1xPS_2	8.17^{bc}	0.307^{abc}
GM_1	7.06^{ab}	0.289^{a}	GM_2xPS_2	8.67^{c}	0.349^{bc}
GM_2	8.00^{b}	0.316^{a}	GM_3xPS_2	6.50^{abc}	0.285^{abc}
GM_3	6.00^{a}	0.263^{a}	GM_4xPS_2	6.17^{abc}	0.372^{c}
GM_4	6.22^{a}	0.306^{a}	GM_5xPS_2	6.23^{abc}	0.32^{abc}
GM_5	5.53^{a}	0.274^{a}	GM_1xPS_3	6.5^{abc}	0.296^{abc}
CV	26.1	24.1	GM_2xPS_3	8.83^{c}	0.324^{abc}
LSD (5%)	1.652	0.673	GM_3xPS_3	6.00^{abc}	0.271^{abc}
			GM_4xPS_3	7.33^{abc}	0.311^{abc}
			GM_5xPS_3	$5,67^{ab}$	0.247^{ab}
			VC	26.1	24.1
			LSD (5%)	2.861	1.165

Means on the same column with different superscripts letter(s) are statistically significant ($p \leq 0.05$) using Duncan's Multiple Range Test (DMRT)
Growing Media (GM) =GM_1=2 top soil:2 Forest soil:1 sand soil; GM_2=2 Top soil:2 Compost:1 Sand soil; GM_3=1 Top soil:2 Forest soil:2 Sand soil; MG_4=3 top soil:2 Compost:1 Sand soil; and GM_5=Control=3 top soil:2 Forest soil:1 Sand soil.
Pot Size (PS) =PS_1=8 cm; PS_2=10 cm and PS_3=12 cm lay flats and 15 cm length for all pot size.

3.2. Interaction Effects (Growing Media Xs Pot Size)

The interaction effects of growing media (GM) and pot size (PS) on the optimum seedling early growth performance of *Azandirachta indica* were different in different growing media soil mixtures and growing pot size interactions. According to the ANOVA the mean measured parameters of height and root collar diameter of the *Azandirachta indica* plant seedlings shown on (Table 1). The rate of *Azandriachta indica* seedling growth increments in height and root collar diameter were different with in constant interval of one month from the first (8 weeks after sowing) to final 20 weeks after sowing were varied within and among growth parameters (height and collar diameter) (Figures 1&2).

3.2.1. Height Measured Parameter

The ANOVA shown that the mean height measured of *Azandirachta indica* plant seedlings on the interactions of growing media soil mixture or composite ratios and different pot sizes GM_2xPS_2 (8.67 cm) was significantly different (p=0.008, 0.018, 0.031, and 0.040) from that observed on GM_5xPS_1=control; GM_4xPS_1; GM_3xPS_1 and GM_5xPS_3 were, respectively. Plus, growing media GM_2xPS_3 was 8.83 cm measured mean height of *Azandirachta indica* seedlings was significantly different (p=0.006, 0.013, 0.031 and 0.024) GM_5xPS_1 (4.7 cm); GM_4xPS_1 (5.17 cm); GM_5xPS_3 (5.67 cm) and GM_3xPS_1 (5.50 cm) respectively. Finally, the mean measured of *Azandirachta indica seedlings* height on GM_1xPS_1 (8.17 cm) was significantly different (p=0.019 and 0.04) on GM_5xPS_1 (4.7 cm) and GM4xPS1 (5.17 cm), respectively. In another way seedlings height of *Azandirachta indica* showed GM_2xPS_3 as had 8.83 cm mean height recorded followed by GM_2xPS_2 (8.67 cm), GM_1xPS_2 had a mean height of 8.17 cm while GM_5xPS_1 (control) had the relatively lowest mean seedlings height (4.70 cm). The highest height growth recorded between 12 and 16 weeks after sowing for all interactions (MGxPS) which leads/shown the height grown difference significant or not (Table 1). In case of seedling height growth parameter the highest height growth rate recorded between the age of 12 and 16 weeks after sowing (wksAs) with the same or constant managements even if the experiment was done in open environment. This age or time when *Azandirachta indica* seedling height growth was highest which contributed the all experiment growth significant difference observed among the different interaction effects growth media and pot sizes (Figure 1).

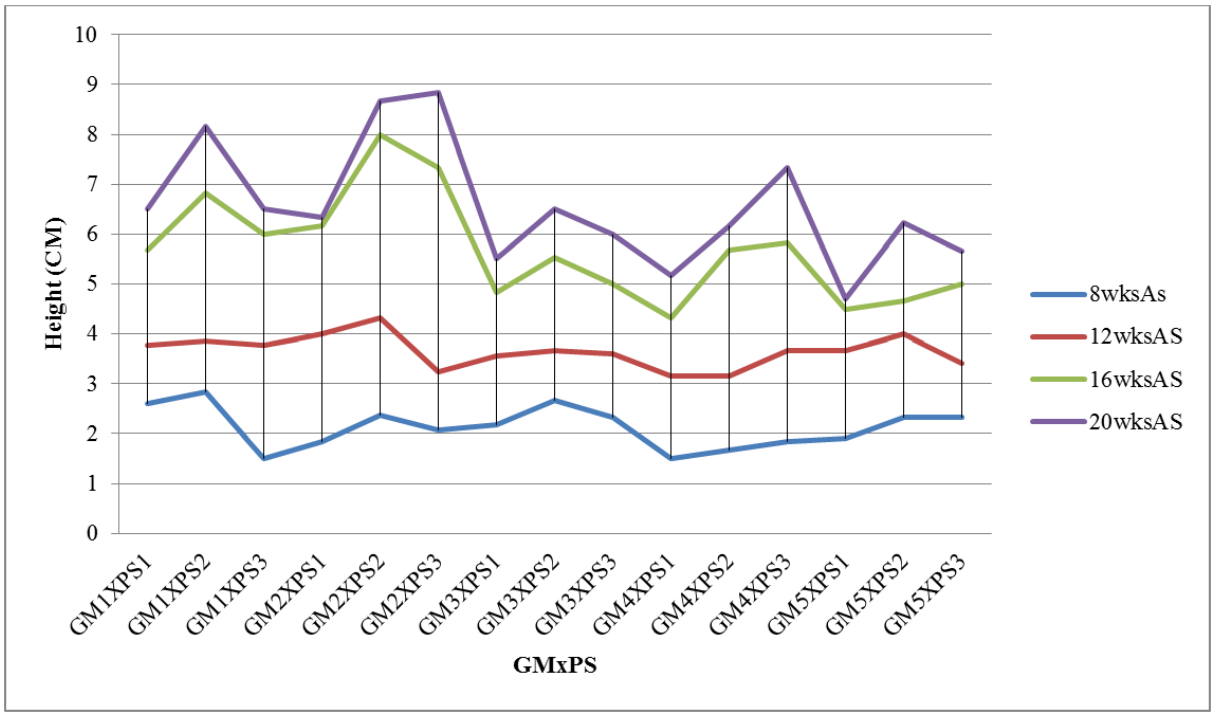

Figure 1. *Effects of Different Growing Media (GM) and Pot Size (PS) on Azandirachta indica (Neem) Seedling's height (Ht) in weeks after sowing (wksAS) for 20 weeks.*

3.2.2. Root Collar Diameter (RCD)

In case of root collar diameter growth parameter ANOVA shown that the mean measured root collar diameters of *Azandirachta indica* plant seedlings on GM_4xPS_2 (0.372 cm) root collar thickness was statistically significantly different (p=0.019, 0.023, 0.036, and 0.047) from that seedlings root collar diameter measured on GM_3xPS_1 (0.231 cm); GM_4xPS_1 (0.236 cm); GM_5xPS_3 (0.567 cm) and GM_5XPS_1 (0.47 cm), respectively. The mean measured root collar diameters growth of plant seedlings ranged from 0.231 cm (GM_3xPS_1) to 0.372 cm (GM_4xPS_2) (Table 1). In case of seedling root collar diameter growth parameter the highest RCD growth rate recorded between the age of 8 and 12 weeks after sowing

(wksAs) with the same or constant managements even if the experiment was done in open environment. This age or time when *Azandirachta indica* seedling RCD growth was higher this contributed the all experiment growth significant difference observed among the different interaction effects growth media and pot sizes (Figure 1).

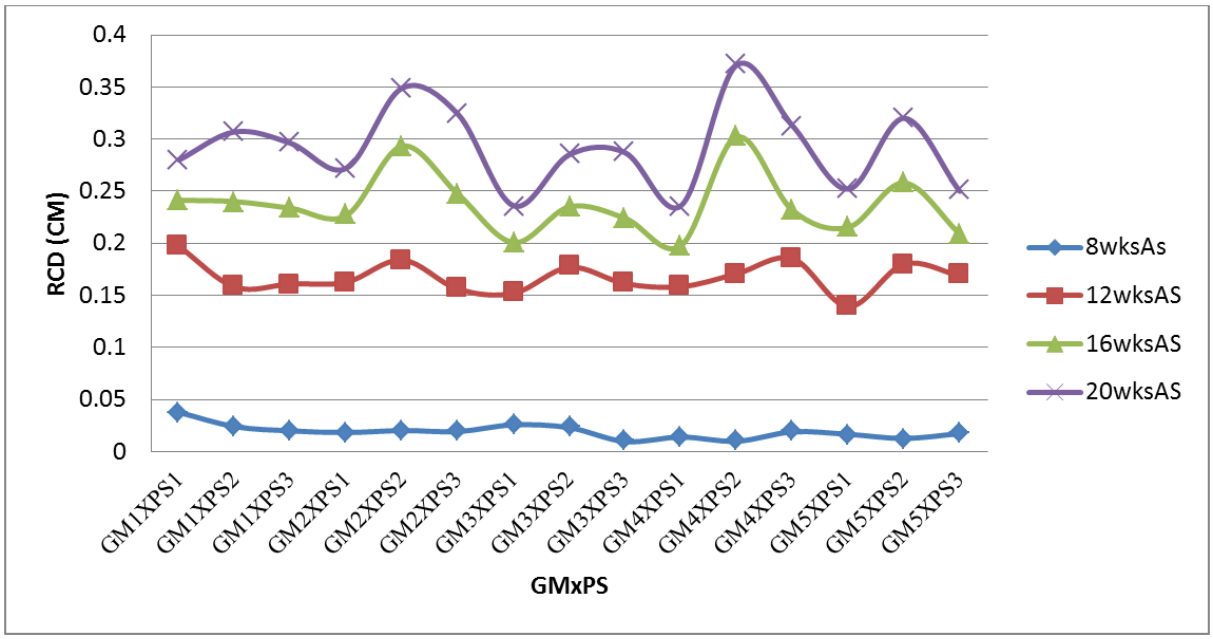

Figure 2. *Effects of Different Growing Media (GM) and Pot Size (PS) on Azandirachta indica (Neem) Seedling's Root Collar Diameter (RCD) in weeks after sowing (wksAS) for 20 weeks.*

4. Discussions

The result on the height growth of *Azandirachta indica (Neem)* showed that the highest height was recorded by the composite or soil mixed ratio 2:2:1 (Topsoil:compost:Sand soil) with in 12 cm plastic pots and followed by plastic pots size with 10 cm with similar composite or soil mixed ratio growing media. These results agree with the work of [15] who obtained the higher seedlings height of decomposed poultry droppings than others treatments with P. bicolor plant. The result on seedlings growth collar diameter *Azandirachta indica (Neem)* implied that the best mean root collar diameter (girth) thicker was recorded in 3:2:1 and 2:2:1 (Topsoil:Compost:sandy soil) composite soil with 10 cm plastic bags/pots. Relatively slow growth recorded in 1:2:2 (topsoil:forest soil:sandy soil) mixed ratio within 8 cm plastic pot size. General this study result agrees with the work of [16] also suggested that soil, sand and compost in the ratio of 1:1:2 is the best for growth and survival of *Acacia catechu* Willd, seedlings. The finding collaborates with the work of [17] who reported highest plant height of *Jatropha curcas* and [18] of *Adansonia digitata* in the mixture. The result disagrees with [19] who recorded better increment in topsoil of *Persea americana*. This also contradicts the work of [20] who recorded better performance in river sand. These findings agree with the work of [21] who recorded least diameter in fine sand. The study has demonstrated that *Azandirachta indica (Neem)* seedling early growth responded differently to the various composite soil mixture growing media and different polythene pot sizes. However, 2:2:1 (topsoil:compost:sandy soil) with in 12 cm pot size, 2:2:1 (topsoil:compost:sandy soil) with in 10 cm pot size and 3:2:1 (topsoil:compost:sandy soil) with in 10 cm pot sizes give the best result with respect to all measured growth parameters of the *Azandirachta indica (Neem) species*.

5. Conclusion

The finding of this experimental study revealed/showed that relatively higher growth recorded in GM4 (3 top soil:2 compost:1 sand soil) ratio of composite growing media; this could be good soil characteristics (compost is non-toxic, good aeration, water holding capacity and rich in NPK (Justice 1972) with in 10 cm pot sizes (PS_2) which favoring the rapid early growth of *Azandirachta indica (Neem)* species.

Based on this finding the following combinations treatments are proposed to get optimum and quality seedling growth in nursery for *Azandirachta indica (Neem)* species were first 2:2:1 (topsoil:compost:sandy soil) followed by 3:2:1 (topsoil:compost:sandy soil) and 2:2:1 (topsoil:forest soil:sandy soil) composite soil mixed ratio as 3rd option for plant growing media in 10 cm lay flats polythene pots. To obtain the best or optimum seedling quality were the interaction effects of growing media and appropriated containers (pot sizes) were important and basic than doing experiment separately. Knowing the best growing media was the major determinant to get the best quality seedlings at the nursery for successful plantation. Studies have shown that growth media affect plant growth parameters characteristics

(height, root collar diameter) were significantly affected by the growing media. This is due to nutrient variation in the growing media which is farther needs investigation on growing media nutrients.

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