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Nursery Practices for Producing Standard Seedlings of Some Meliaceae Family Tree Species

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Abstract: This study was conducted at the nursery of Forestry and Timber Trees Department, Horticulture Research Institute, Agriculture Research center, Giza, Egypt, during two seasons of 2016 and 2017. The purpose was to study the effect of planting dates and some planting containers on germination, growth of seedling in nursery and after planting in field of some Meliaceae tree species. Sowing date i.e. April, June and August, for the seeds of four timber tree species (*Khaya senegalensis, K. ivorensis, Swietenia mahagoni* and *Swietenia macrophylla*) and four containers type (trays, beds, poly bags 8x 15cm and poly bags 8 x 26cm size) during nursery culture. The results indicated that, there were significant differences in germination percentage values due to the use of different types of containers and tree seed species. The best date for planting seeds of four species is June. The highest value of germination% resulted from sowing in 8x26 cm polybags for four species during three sowing dates. *K. senegalensis* gave the highest values of germination percentage as compared to the other species in three sowing dates during two seasons. However, after three months of sowing seeds, seedlings in poly bags of 8x15 cm exceeded in seedling height and root length, *S. macrophylla* seedlings were more responsive in terms of seedling height, while *K. senegalensis* seedlings were superior in the root length during the planting seasons. After 6 months of planting, the highest values for stem diameter and number of roots for the resulted seedlings were due to planting in 8x15cm polybags as a container. Meanwhile, sowing in 8x26 cm bags produced the highest values of seedling length, root length and fresh and dry weights of both aerial parts and roots.It can be concluded that, seedlings planted in 8x26-bags in the nursery surpassed others in the measurements of growth and nutritional content after one and two years of cultivation in the permanent field.

Key words: Family Meliaceae · Nursery containers · Seed germination · Sowing dates · Seedling quality

INTRODUCTION

Seedling quality is important to increase the capacity of seedlings to cope with unfavorable environmental conditions and to gain vigorous growth. Germination and rapid early growth of tree seedlings are related to the capacity of plantation establishment [1]. However, the morphological growth for assessing seedling quality can be controlled by nursery cultural practices Akpo *et al*. [2], container volume and growing density that influence western larsh (*Larix occidentalis* Nutt) seedling development during nursery culture and establishment. Also, the effect of nursery management practices on the quality of seedlings has been studied on various tree species [3]. Approximately 5% of the world's forests are plantations, comprising a total area of 187 million ha [4]. In the USA, over 1.5 billion forest tree seedlings are produced annually and more than 1 million ha of plantations are established each year [5]. It is expected that an increase in proportion of the world's wood supply will come from tree plantations [6, 7]. Therefore, plantation establishment is necessary to maintain forest cover and the provision of forest products. Successful plantation establishment depends on the use of seedlings whose morphological and physiological characteristics meet targets associated with favorable growth and survival under an anticipated range of site conditions. Quality seedlings are those which will meet a desired level of growth and survival upon out planting [8, 9]. Seedling production is one of the key steps in scaling up

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or domestication of any species. Each step has to be properly planned and implemented. The way seedlings are handled and managed in a nursery contributes to their survival rate after planting and their subsequent growth performance. Improving seedling quality positively correlates to their survival, growth and productivity. Seedling quality is governed by the genetic make-up of the parent trees and the physical growth of the seedlings. Several types of nurseries exist: individual or private, community or group, central or research, commercial and training nursery [10].

The African mahogany (*Khaya senegalensis*), an exotic species of Meliaceae Family, stands out for its excellent wood quality, high prices in domestic and international markets, wood appreciated for carpentry, woodwork, shipbuilding and production of decorative veneers Nikiema and Pasternak [11]. Its wood is hardwood with excellent commercial value and physical and mechanical properties.It is one of the most economically important trees and used for high-class furniture, joinery, building and construction purposes. It has also high traditional medicinal values and used as an ornamental tree for gardens and avenues.

Khaya ivorensis A. Chev. is a tall forest tree with a buttressed trunk in the family Meliaceae. It grows to be about 40-50 m high. It has thick and reddish-brown bark. It grows many white flowers at the end of its branches. Its wood is durable and is used to make many things such as furniture and paneling. A bark concoction is used as a drink or bath for back pains and as a lotion for rheumatism. Planting the tree improves and enriches the soil, so many people use the tree for that as well [12]. The wood commands a very high price on the market and it is used above all for high quality cabinet work, furniture and expensive interior fishing. Large quantities are also used for boat and ship construction. A high percentage of the wood sold in Europe as Mahogany comes from *K. ivorensis* [13].

Swietenia mahagoni (L.) Lam., an evergreen to semi-evergreen tree, up to 30-35 m. Bark grey and smooth when young, turning dark brown, ridged and flaky when old. It has potential use for large scale timber production plantations, especially in dry areas, due to the excellent timber quality. The wood density is 560-850 kg/m3 at 15% moisture content. It is also used in agroforestry, for soil improvement and as an ornamental tree [14].

Honduras or big leaf mahogany (*Swietenia macrophylla* King) is the most commercially important timber species in tropical America [15]. It is one of the best quality timbers for high class furniture and cabinet work due to its light hardwood quality in the world. Also, it is the most important timber tree in neo-tropical forests, has become the flagship species in debates about the feasibility of sustainable tropical forest management [16]. *S. macrophylla* becomes the first widely tree timber species to be listed in Appendix ii of theconvention on international trade in endangered species, forests have been cleared from more than 63% of mahogany's range in Meso America and 26% in South America [17].

Lack of appropriate container types in many regions forces nursery operators to use polybags as readily available containers in production nurseries. Use of polybags filled with native topsoil and then placed on bare-ground is a common practice in nurseries in many countries [18]. However, trees and shrubs should be planted in trays and in other systems that minimize root defects and encourage branching of the root system inside the root ball [19]. Many types of containers are available and each has its advantages and disadvantages. It is a good idea to try new containers for each species on a small scale before buying large quantities. Several container types are used in container plant nurseries and can vary considerably in size [20].

Bags of black polyethylene sheeting are the most commonly used as nursery containers in the world because they are inexpensive and easy to ship and store. It is unfortunate, but poly bags generally produce seedlings with poorly formed root systems that spiral around the sides and the bottoms of the smooth-walled containers. However, volume of the container dictates how large a plant can be grown in it and an optimum size of container is related to the tree species, plant size, density and length of the growing season [21].

Owing to high demand for their seedlings in the different afforestation programs work in Egypt, so we need to know how to produce high-quality seedlings of *Khaya senegalensis*, *K. ivorensis*, *Swietenia mahagoni* and S. *macrophylla* to be raised in nursery. Therefore, the objective of this research was to study the influence of different sowing dates as well as type of containers on germination, growth and biomass production of the previous tree specieseither inside the nursery or strong seedlings to be transplanted in the field.

MATERIALS AND METHODS

This study was conducted at the nursery of Forestryand Timber Trees Department, Horticulture

Research Institute, Agriculture Research Center, Giza, Egypt, during two successive seasons of 2016 and 2017. The study was conducted on four tree seed species from family Meliaceae i.e. *Khaya senegalensis, K. ivorensis*, *Swietenia mahagoni* and *S. macrophylla*. The seeds of *K. senegalensis* and *K. ivorensis* were collected from trees grown in Aswan Botanical Garden, Aswan, Egypt. Meanwhile, seeds of *S. mahagoni* were collected from trees grown in Horticulture Research Institute, Giza. The seeds of *S. macrophylla* were collected from trees grown in Zoology Garden at Giza, Egypt. All seeds of the tested tree species were soaked in tap water for 24 hours and sown in three dates: first of April, June and August for 2016 and 2017 seasons. On the other hand, the different containers type were: trays 40x 60 cm. seedbeds 40x 60 cm. polybags 8x 15cm size and polybags 8 x 26cm size. All types of containers were filled with light, well- drained soils containing clay and sand at the ratio of 1:1 by volume. 60 seeds were sown in tray or bed, with 5cm between seeds and 8 cm between row, three replicates of both trays and beds while, one seed was planted in each polybag for both sizes at about 2 cm depth, with three replicates each of them include 100 polybag.

Recorded Data:

- Germination percentage was measured after germination was completed.
- Seedling height (cm) and root length (cm) were recorded after three months from seed sowing during 2016 and 2017 seasons.
- Seedling height (cm), stem diameter (cm), root length (cm), roots number/ plant, vegetative parts fresh and dry weights and roots fresh and dry weights (gm) were recorded after six months from seed sowing during the two seasons.
- After one and two years from planting in field the seedling height (cm) and root collar diameter (cm) were measured.

Soil Analysis: Nursery and field soil was analyzed as shown in Tables (A&B). The Chemical analysis of underground aquifer irrigation water used in field as shown in Table(c) were analyzed by using the methodology described by Page *et al*. [22].

Chemical Analysis: Determination of N, P and K% in the leaves from all treatments after six months from seed sowing was achieved as done by Pregl [23]; Piper [24] and Brownand Lilliland [25], respectively.

Statistical Analysis: The experiment was conducted in a factorial experiment in a complete randomized design for each sowing date during the two seasons, with 4 tree species (*Khaya senegalensis*, *K. ivorensis*, *Swietenia macrophylla* and *S. mahagoni*) and 4 containers type (beds, trays, polybags 8x 15cm and polybags 8 x 26cm size) with three replicates, each replicate contained 8 containers. The differences between the means of the treatments for the experiment were compared by using LSD test at 5% probability according to Snedcor and Cochran [26].

Table A: Mechanical and chemical analysis of the used soil in nursery

Course sand %		Fine sand %			Silt %		Clay %		Texture grade	
18.5		10.5			36.0		35.0		Clayey Loam	
			Soluble anions (meq/l)				Soluble cations (meq/l)			
E.C. (dS/m)	pH	SP	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca++	Mg++	Na+	K+
1.52	7.81	35.0	-	1.10	10.80	3.10	4.50	4.0	6.0	0.50

Table B: Mechanical and chemical analysis of field planting soil

Course sand %		Fine sand %			Silt %		Clay %		Texture grade	
92.0		4.0			1.9		2.1		Sandy	
			Soluble anions (meq/l)				Soluble cations (meq/l)			
E.C. (dS/m)	pH	SP	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca++	Mg++	Na+	K+
2.3	7.80	20.0	-	1.0	3.70	15.40	13.0	5.30	1.60	0.20

Table C: Chemical analysis of the used underground aquifer irrigation water in field planting

		Soluble anions (meq/l)				Soluble cations (meq/l)					
E.C. (dS/m)	pH	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca++	Mg++	Na+	K+	SAR	RSC
2.5(1600ppm)	7.60	-	3.1	15.7	6.20	6.5	6.0	11.3	1.2	4.52	-

Table 1: Effect of tree species and sowing date (April, June and August) on germination percentage (%) during 2016 and 2017 seasons

	1st season 2016				2nd season 2017			
	Sowing date (B)				Sowing date (B)			
Tree species (A)	April	June	August	Means (A)	April	June	August	Means (A)
Khaya senegalensis	72.06	84.97	66.33	74.45	70.83	82.88	74.00	75.91
K. ivorensis	22.00	57.18	55.00	44.73	30.75	57.50	54.00	47.42
Swietenia mahagoni	57.04	68.31	68.39	64.58	57.83	67.17	66.33	63.78
S. macrophylla	30.35	68.14	67.25	55.25	35.75	68.42	69.67	57.95
Means (B)	45.36	69.65	64.24		48.79	68.99	66.00	
LSD (0.05)	A: 1.26 B:1.26 AB:2.52		A: 1.74 B: 2.01 AB:3.48					

RESULTS AND DISCUSSIONS

Effect of Tree Species and Sowing Date on Germination Percentage (%): Data presented in Table (1) indicated that, there are significant differences in germination percentage due to both sowing date and tree seed species. Germination percentage was significantly increased in June during two seasons (69.65 and 68.99%), respectively as compared to April and August. The highest germination rate was in *Khaya senegalensis* (74.45 and 75.91 %) as compared to the other species, followed by *Swietenia mahagoni* (64.58 and 63.78%) then *S. macrophylla* (55.25 and 57.95 %) compared with *K. Ivorensis* which gave the lowest percentages (44.73 and 47.42 %) during two seasons, respectively. The interaction between sowing date and tree speciesseed, results showed that, the highest germination percentage was in *Khaya senegalensis* in June during two seasons as compared to the other interactions. However, the lowest germination percentage was in *K. ivorensis* in April during two seasons as compared to the other interactions.

Data presented in Table (2) indicated that, there were significant differences in germination percentage due to both tree species and types of planting containers. Germination percentage in April of *K. senegalensis* significantly increased (72.06 and 70.83% in first and second seasons, respectively) as compared to other tree species followed by *S.mahagoni* (57.04 and 57.83% in the two seasons, respectively). On the other hand, the effect of nursery container type the same data cleared that, sowing seeds in polybags of 8x26 cm size significantly increased germination percentage (60.58 and 64.75% in the two seasons, respectively) as compared to other nursery container types. Concerning the interaction between tree seed species and nursery container type the same data showed that, sowing seeds of *K.senegalensis* and *S. mahagoni* in polybags of 8x26cm size significantly increased germination percentage (86.57, 83.67 and 87.50, 83.33% in the two seasons, respectively) as compared to other interactions.

Germination percentage of *K. senegalensis* significantly increased (84.97 and 82.88%) in June during first and second seasons, respectively as compared to other tree seed species.

As regarded to the effect of nursery container types the same data showed that, using polybags of 8x26 cm size significantly increased germination percentage (86.67 and 84.67% in first and second seasons, respectively) as compared to other nursery container types. Concerning the interaction between tree seed species and nursery containers type, *K.senegalensis* seeds sown in polybags of 8x26 cm size significantly increased germination percentage (94.00 and 92.00% in the two seasons respectively) as compared to other interactions.

However, in August, germination percentage significantly increased for *S. mahagoni* (68.39 %) in the first season and for *K. senegalensis* in the second one (74.00 %) as compared to other tree seed species. For the effect of nursery container type the same data showed that, sowing seeds in polybags of 8x26 cm size significantly increased germination percentage (77.92 and 79.08% in the two seasons, respectively) as compared to other nursery container types. Regarding the interaction between tree seed species and nursery container typesdata cleared that, sowing seeds of *S. mahagoni* in polybags of 8x26cm size significantly increased germination percentage (88.33 and 83.33 in the two seasons respectively) as compared to other interactions, with the exception sowing seeds of *K. senegalensis* in the same container size in second season only.

Based on our results the following combinations are proposed for maximum germination% in nursery for the tested Meliaceae tree seeds: sowing seeds in clay and sand 1:1 by volume, polybags container 8 x 26 cm size in

Table 2: Effect of treespeciessowing seeds inApril, June and August and nursery containers types on germination percentage (%) during 2016 and 2017 seasons

	1st season 2016					2nd season 2017				
	Container types (B)					Container types (B)				
Tree species (A)	Trays	Beds	bags 8x15cm	Bags 8x26cm	Mean (A)	Trays	Beds	Poly bags 8x 15cm	Poly bags 8 x 26cm	Mean (A)
					April sowing					
Khaya senegalensis	59.67	66.00	76.00	86.57	72.06	61.33	65.00	73.33	83.67	70.83
K. ivorensis	16.00	20.33	24.67	27.00	22.00	19.00	24.00	36.67	43.33	30.75
Swietenia mahagoni	24.00	35.33	81.33	87.50	57.04	27.67	46.00	74.33	83.33	57.83
S. macrophylla	21.17	25.00	34.00	41.23	30.35	24.00	32.00	38.33	48.67	35.75
Mean(B)	30.21	36.67	54.00	60.58		33.00	41.75	55.67	64.75	
LSD (0.05)	A: 0.79		B:0.79	AB:1.58		A: 2.02		B: 2.02	AB:4.04	
					June sowing					
Khaya senegalensis	77.00	80.00	88.87	94.00	84.97	74.00	77.00	88.50	92.00	82.88
K. ivorensis	35.70	47.00	70.00	76.00	57.18	37.00	50.00	69.00	74.00	57.50
Swietenia mahagoni	44.67	55.57	84.67	88.33	68.31	43.00	56.00	83.00	86.33	67.17
S. macrophylla	44.00	56.23	84.00	88.33	68.14	39.00	71.33	77.00	86.33	68.42
Mean(B)	50.34	59.70	81.88	86.67		48.25	63.58	79.38	84.67	
LSD (0.05)	A: 0.79		B: 0.79	AB:1.58		A: 0.97		B: 0.97	AB:1.94	
					August sowing					
Khaya senegalensis	44.00	64.00	77.00	80.33	66.33	60.00	73.33	77.67	85.00	74.00
K. ivorensis	37.00	46.00	69.00	68.00	55.00	34.33	50.00	61.67	70.00	54.00
Swietenia mahagoni	44.67	55.57	85.00	88.33	68.39	47.67	59.67	74.67	83.33	66.33
S. macrophylla	56.00	65.00	73.00	75.00	67.25	59.00	69.00	72.67	78.00	69.67
Mean(B)	45.42	57.64	76.00	77.92		50.25	63.00	71.67	79.08	
LSD (0.05)	A: 0.77		B: 0.77	AB:1.54		A: 2.88		B: 2.88	AB:5.76	

June period: Most of the tropical species require warm temperatures and will only germinate if temperatures are above 70°F (21°C). In addition, some species germinate better when exposed to alternating temperatures [27]. Matin and Banik[28] raised seedlings of different tree species in 3 different sizes of polybags and pointed out that the small sized polybags are recommended for the propagation of silkoroi, champa and gamar and the medium sized polybags for teak and chapalish. However, germination percentage was less because of the influence of the poor aeration porosity in containers and less water holding capacity in nursery practice used for the germination study. Similar trend has been also observed by Derby and Hinesley [29]; Chavan and Tembhurne [30] and Vidyasagaran *et al.* [31]. Moreover, the differences in germination timing resulted in plants being subjected to different abiotic/biotic conditions during growth and reproduction, which may have effects on the seed dormancy and germination [32].

Effect of Tree Seed Species and Nursery Container Types on Seedling Height and Root Length (cm) after Three Months from Sowing of Some Meliaceae Tree Species: Data presented in Table (3) indicated that, *S. macrophylla* significantly produced the longest seedlings (13.54 and 13.29 cm in the first and second seasons, respectively) as compared to all other tree species. However, the longest roots were in case of *K. senegalensis* as compared to the rest of the tree species for both seasons (11.27 and 9.41 cm, respectively). Moreover, the shortest values for seedling height were obtained from *K. ivorensis* seeds (10.01 and 9.03 cm in first and second seasons, respectively). As for the effect of nursery container type it can be concluded that, sowing seeds of the tested trees in polybags of 8 x 15cm size significantly increased seedling height and root length compared with other types of containers used after 3 months (12.35, 12.81 and 10.15, 9.63 cm in the two seasons respectively), with the exception of polybags of 8x26cm size for seedling height in the first season only. Regarding the interaction between the tree species and container types, the highest value of seedling height in the two seasons was due to sowing *S. macrophylla* seeds in polybags of 8 x 15 cm, while sowing *K. senegalensis* seeds in polybags of 8 x26cm size resulted in the highest value of root length compared to the other interaction treatments.

Effect of Tree Species and Nursery Container Types on Seedling Height and Stem Diameter (cm) after Six Months from Sowing Seeds of Some Meliaceae Tree Species: The effect of tree species seed and nursery containers type on seedlings height (cm) and stem diameter (cm) after six months from sowing seeds were shown in Table (4). There were significant

Table 3: Effect of treespecies and nursery container types on seedling height and root length (cm) after three months from sowing seeds during 2016 and 2017 seasons

	1st season 2016					2nd season 2017				
	Container types (B)					Container types (B)				
Tree species (A)	Trays	Beds	bags 8x15cm	Bags 8x26cm	Mean (A)	Trays	Beds	Poly bags 8x 15cm	Poly bags 8 x 26cm	Mean (A)
					Seedling height (cm)					
Khaya senegalensis	11.00	11.62	12.07	13.33	12.01	8.00	10.50	12.50	12.73	10.93
K. ivorensis	9.43	9.64	10.72	10.24	10.01	6.93	7.90	10.80	10.50	9.03
Swietenia mahagoni	11.99	11.72	12.36	13.97	12.51	11.13	11.37	13.43	13.00	12.23
S. macrophylla	13.07	13.10	14.24	13.77	13.54	12.30	12.60	14.50	13.77	13.29
Mean(B)	11.37	11.52	12.35	12.83		9.59	10.59	12.81	12.50	
LSD (0.05)	A: 0 .52		B: 0.52	AB:1.03		A:0.32		B: 0.32	AB: 0.63	
					Root length (cm)					
Khaya senegalensis	10.50	9.50	11.57	13.50	11.27	6.10	7.50	12.07	11.97	9.41
K. ivorensis	5.00	6.67	9.77	9.70	7.78	5.20	6.03	9.27	8.66	7.29
Swietenia mahagoni	6.55	6.29	10.90	8.18	7.98	7.00	6.03	9.93	7.73	7.68
S. macrophylla	5.93	6.00	8.37	6.73	6.76	6.07	6.00	7.23	6.87	6.54
Mean(B)	7.00	7.12	10.15	9.53		6.09	6.39	9.63	8.81	
LSD (0.05)	A: 0.93		B: 0.93	AB:1.87		A: 0.55		B: 0.55	AB:1.11	

Table 4: Effect of treespecies and nursery container types on seedling height and stem diameter (cm) after six months from sowing seeds during 2016 and 2017 seasons

	1st season 2016					2nd season 2017				
	Container types (B)					Container types (B)				
Tree species (A)	Trays	Beds	bags 8x15cm	Bags 8x26cm	Mean (A)	Trays	Beds	Poly bags 8x 15cm	Poly bags 8 x 26cm	Mean (A)
					Seedling height (cm)					
Khaya senegalensis	19.73	19.17	26.37	31.52	24.20	18.23	17.87	25.70	28.23	22.51
K. ivorensis	11.51	14.00	16.00	14.67	14.04	13.68	14.07	15.50	14.50	14.44
Swietenia mahagoni	21.33	18.67	27.83	23.87	22.93	21.33	16.54	27.00	23.40	22.07
S. macrophylla	21.33	20.50	25.43	26.22	23.37	19.67	25.13	24.55	26.50	23.96
Mean(B)	18.48	18.08	23.91	24.07		18.23	18.40	23.19	23.16	
LSD (0.05)	A:1.29		B: 1.29	AB:2.58		A:1.03		B: 1.03	AB:2.06	
					Stem diameter (cm)					
Khaya senegalensis	0.45	0.33	0.52	0.60	0.48	0.40	0.36	0.51	0.54	0.45
K. ivorensis	0.28	0.30	0.45	0.40	0.36	0.28	0.31	0.45	0.40	0.36
Swietenia mahagoni	0.40	0.37	0.43	0.45	0.41	0.40	0.35	0.45	0.45	0.41
S. macrophylla	0.37	0.39	0.52	0.48	0.44	0.37	0.46	0.52	0.46	0.45
Mean(B)	0.38	0.35	0.48	0.48		0.36	0.37	0.48	0.46	
LSD (0.05)	A: 0.05		B: 0.05	AB:0.09		A: 0.03		B:0.03	AB:0.07	

differences in the values of seedling height and diameter after six months from sowing seeds in the different types of nursery containersduring the two seasons. Seedling height of *S. macrophylla* significantly increased (23.37 and 23.96 cm in first and second season, respectively) as compared to other tree species with the exception of *K. senegalensis* and *S. mahagoni* seedlings height in the first season only. The shortest seedlings were obtained in *K. ivorensis* (14.04 and 14.44 cm in first and second seasons, respectively) as compared to other tree species. Concerning the effect of nursery container type the same data revealed that, sowing seeds in polybags of 8x26 cm and polybags of 8x15 cm significantly increased seedlings height (24.07, 23.16 and 23.91, 23.19 cm in first and second seasons, respectively) as compared to other nursery containers type. Regarding the interaction between tree species and nursery container types, data presented in Table (4) cleared that, sowing seeds of *K. senegalensis* in polybags of 8x26 cm significantly increased seedlings height (31.52 and 28.23

Table 5: Effect of treespecies and nursery container types on root length (cm) and root number after six months from sowing seeds during 2016 and 2017 seasons

	1st season 2016					2nd season 2017				
	Container types (B)					Container types (B)				
Tree species (A)	Trays	Beds	bags 8x15cm	Bags 8x26cm	Mean (A)	Trays	Beds	Poly bags 8x 15cm	Poly bags 8 x 26cm	Mean (A)
					Root length (cm)					
Khaya senegalensis	26.73	24.67	24.77	36.10	28.07	19.73	16.00	24.30	37.30	24.33
K. ivorensis	15.61	17.00	22.50	29.00	21.03	16.04	14.38	22.33	28.00	20.19
Swietenia mahagoni	25.67	28.00	25.00	31.17	27.46	26.33	19.27	24.50	29.67	24.94
S. macrophylla	16.80	18.57	24.67	29.72	22.44	17.60	19.63	26.13	24.70	22.02
Mean(B)	21.20	22.06	24.23	31.50		19.93	17.32	24.32	29.92	
LSD (0.05)	A: 3.26		B: 3.26	AB:6.52		A: 2.08		B: 2.08	AB:4.15	
					Root number					
Khaya senegalensis	3.33	4.33	5.40	5.27	4.58	2.93	4.13	4.50	5.40	4.24
K. ivorensis	2.17	2.73	3.77	3.90	3.14	2.82	2.85	3.20	3.70	3.14
Swietenia mahagoni	5.20	4.53	7.90	6.47	6.03	6.27	5.53	7.80	5.60	6.30
S. macrophylla	4.00	6.47	5.37	5.33	5.29	3.80	6.13	4.93	4.83	4.92
Mean(B)	3.68	4.52	5.61	5.24		3.95	4.66	5.11	4.88	3.68
LSD (0.05)	A:0.10		B:0.10	AB:0.20		A: 0.15		B: 0.15	AB:0.29	

cm in the two seasons, respectively) as compared to other interactions, with the exception of sowing seed of *S. mahagoni* in polypage of 8x15cm and sowing seeds of *S.macrophylla* in polybags of 8x26 cm in the second season only.

Concerning stem diameter data presented in Table (4) illustrated that, seedlings stem diameter were significantly increased with *K. senegalensis* followed by *S. macrophylla* (0.48 and 0.45cm) and (0.44 and 0.45 cm) in first and second seasons respectively as compared to other tree species. Regarding the effect of nursery container types the same data showed that, sowing seeds in polybags of 8x15 and 8x26 cm size significantly increased stem diameter (0.48 and 0.48cm) and (0.48 and 0.46 cm) in the two seasons, respectively as compared to other nursery container type. As for the interaction between tree species and nursery container type, sowing seeds of *K. senegalensis* in polybags of 8x26 cm size significantly increased stem diameter (0.60 and 0.54 cm in first and second seasons, respectively) as compared to other interactions with the exception of sowing seeds of *K. senegalensis* and *S. macrophylla* in polybags of 8x15 cm in the second season only.

Effect of Tree Species and Nursery Container Types on Root Length (cm) and Root Number after Six Months from Sowing Seeds of Some Meliaceae Tree Species: Data presented in Table (5) indicate the effect of tree seed species and nursery container types on length and number of roots after six months from sowing seeds. There were significant differences between the values of root length and number as a result of planting in different containers types and using different tree species seeds during the two planting seasons. It can be concluded that, *K. senegalensis* and *S.mahagoni* significantly gave the highest root length (28.07 and 27.46 cm) and (24.33 and 24.94 cm) in first and second seasons, respectively as compared to other tree species. For the effect of nursery container types, the same data revealed that, sowing seeds in polybags of 8x26 cm size significantly increased root length (31.50 and 29.92 cm) in first and second seasons, respectively) as compared to other nursery container types.However, the interaction between tree species and container types was significant during the two seasons, the highest root length values were obtained due to sowing seeds of *K. senegalensis* in polybags of 8 x 26cm size (36.10 and 37.30 cm in first and second seasons, respectively) as compared to other interactions, with the exception of sowing seeds of *S. mahagoni* and *S. macrophylla* in the same nursery container type in first season only. As for the effect of tree species seed on root number, the data in the same Table cleared that, root number of *S. mahagoni* significantly increased (6.03 and 6.30 in first and second seasons, respectively) as compared to other tree species. Concerning the effect of nursery container types, the same data showed that, sowing seeds in polybags of 8x15 cm size significantly increased root number, while seeds sown in trays gave the lowest root number (3.68 and 3.95 in first and second seasons, respectively) as compared to

Table 6: Effect of tree species and nursery container types on aerial parts fresh and dry weights (g) after six months from sowing seeds of some Meliaceae tree species

	1st season 2016					2nd season 2017				
	Container types (B)					Container types (B)				
Tree species (A)	Trays	Beds	bags 8x15cm	Bags 8x26cm	Mean (A)	Trays	Beds	Poly bags 8x 15cm	Poly bags 8 x 26cm	Mean (A)
					Aerial parts f.w. (gm)					
Khaya senegalensis	5.55	2.87	7.75	12.40	7.14	3.34	3.30	6.57	9.42	5.66
K. ivorensis	1.25	1.47	3.67	2.53	2.23	1.74	1.28	3.50	2.20	2.18
Swietenia mahagoni	4.70	3.60	7.06	6.61	5.49	4.37	2.63	6.69	6.63	5.08
S. macrophylla	3.01	3.54	8.32	8.03	5.73	2.97	5.72	7.89	7.54	6.03
Mean(B)	3.63	2.87	6.70	7.39		3.10	3.23	6.16	6.45	
LSD (0.05)	A: 0.72		B: 0.72	AB:1.44		A: 0.48		B: 0.48	AB:0.95	
					Aerial parts d.w. (gm)					
Khaya senegalensis	1.67	0.87	2.23	3.58	2.09	1.02	1.00	1.90	2.84	1.69
K. ivorensis	0.30	0.40	1.06	0.75	0.63	0.54	0.41	1.03	0.63	0.65
Swietenia mahagoni	1.47	1.13	2.31	2.17	1.77	1.53	0.88	2.21	2.20	1.71
S. macrophylla	1.02	1.17	2.56	2.51	1.81	0.97	1.92	2.43	2.34	1.91
Mean(B)	1.12	0.89	2.04	2.25		1.02	1.05	1.89	2.00	
LSD (0.05)	A: 0.21		B:0.21	AB:0.42		A: 0.16		B: 0.16	AB:0.32	

the other nursery container types. Regarding the interaction between tree species and nursery container types it was significant during the two seasons, data presented in Table (5) showed that sowing of *S.mahagoni* seeds in polybags of 8x15 cm size significantly increased root number (7.90 and7.80 in first and second seasons, respectively) as compared to other interactions.

Effect of Tree Species and Nursery Container Types on Aerial Parts Fresh and Dry Weights (g) after Six Months from Sowing Seeds of Some Meliaceae Tree Species: Data presented in Table (6) showed the effect of tree species and nursery container types on fresh and dry weights of aerial parts after six-month from sowing seeds. Fresh weight of aerial parts of *K. senegalensis* significantly increased (7.14 and 5.66 gm in first and second seasons, respectively) as compared to other tree species, with the exception of *S. macrophylla* in the second season only. As for the effect of nursery container type, sowing seeds in polybags of 8x26 and 8x15 cm significantly increased aerial part fresh weight (7.39 and 6.45 gm) and (6.70 and 6.16gm) in the two seasons, respectively as compared to other nursery containers type. Concerning the interaction between tree species and nursery container types data showed that, sowing seeds of *K. senegalensis* in polybags of 8x26 cm significantly increased aerial parts fresh weight (12.40 and 9.42 gm in first and second seasons, respectively) as compared to other interactions.

Also, for dry weight of the aerial parts, dry weight of vegetative parts of *K. senegalensis* and *S. macrophylla* significantly increased (2.09 and 1.91 gm in first and second seasons, respectively) as compared to other tree species, while *K. ivorensis* significantly gave the lowest aerial parts dry weight (0.63 and 0.65 gm) as compared to other tree species. On the other hand, the effect of nursery container types the same data illustrated that, sowing seeds in polybags of 8x26 and 8x15 cm significantly increased aerial parts dry weight (2.25 and 2.00gm) and (2.04 and 1.89gm) in first and second seasons, respectively as compared to other nursery container types. Regarding the interaction between tree species and nursery container types, sowing seeds of *K. senegalensis* in 8x26 cm size polybags significantly increased aerial parts dry weight (3.58 and 2.84 gm in the two seasons, respectively) as compared to other interactions.

Effect of Tree Species and Nursery Container Types on Roots Fresh and Dry Weights (g) after Six Months from Sowing Seeds of Some Meliaceae Tree Species: Data presented in Table (7) showed the effect of tree species and nursery container types on the fresh and dry weights of roots after six-months from sowing seeds. It can be concluded that, *K. senegalensis* significantly gave the heaviest root fresh weight (1.61 and 1.39 gm in the two seasons, respectively) as compared to other tree species. However root fresh weight significantly decreased in

Table 7: Effect of tree species and nursery container types on roots fresh and dry weights (g) after six months from sowing seeds during 2016 and 2017 seasons

	1st season 2016					2nd season 2017				
	Container types (B)					Container types (B)				
Tree species (A)	Trays	Beds	bags 8x15cm	Bags 8x26cm	Means (A)	Trays	Beds	Poly bags 8x 15cm	Poly bags 8 x 26cm	Mean (A)
					Root f.w. (gm)					
Khaya senegalensis	1.46	0.53	1.96	2.50	1.61	0.93	0.60	1.58	2.44	1.39
K. ivorensis	0.28	0.40	1.05	0.67	0.60	0.40	0.45	0.97	0.55	0.59
Swietenia mahagoni	1.00	0.83	1.39	1.35	1.14	1.13	0.73	1.29	1.25	1.10
S. macrophylla	0.63	0.84	1.31	1.44	1.06	0.80	1.28	1.35	1.17	1.15
Mean(B)	0.84	0.65	1.43	1.49		0.82	0.77	1.30	1.35	
LSD (0.05)	A: 0.15		B: 0.15	AB:0.30		A: 0.13		B: 0.13	AB:0.26	
					Root d.w. (gm)					
Khaya senegalensis	0.36	0.17	0.53	0.81	0.47	0.23	0.20	0.42	0.64	0.37
K. ivorensis	0.07	0.13	0.32	0.20	0.18	0.11	0.10	0.30	0.15	0.17
Swietenia mahagoni	0.30	0.20	0.38	0.38	0.32	0.37	0.17	0.38	0.35	0.32
S. macrophylla	0.21	0.24	0.47	0.42	0.34	0.23	0.37	0.45	0.33	0.35
Mean(B)	0.23	0.19	0.42	0.45		0.24	0.21	0.39	0.37	
LSD (0.05)	A: 0.06		B: 0.06	AB:0.12		A: 0.03		B: 0.03	AB:0.07	

Table 8: Effect of tree species and nursery container types on nitrogen, phosphorus and potassium % in the leaves of *Khaya senegalensis*, *K. ivorensis*, *Swietenia mahagoni* and *S. macrophylla* seedlings at six months old

	N%					P%					K%				
	Container types					Container types					Container types				
Tree species	Trays	Beds	bags 8x15cm	Bags 8x26cm	Mean	Trays	Beds	bags 8x15cm	Bags 8x26cm	Mean	Trays	Beds	bags 8x15cm	Bags 8x26cm	Mean
K.senegalensis	1.52	1.72	2.28	2.79	2.08	0.19	0.26	0.26	0.34	0.26	0.66	0.66	0.70	0.84	0.72
K. ivorensis	1.55	1.60	1.72	2.15	1.76	0.16	0.19	0.24	0.33	0.23	0.61	0.63	0.62	0.75	0.65
S. mahagoni	1.03	1.20	1.69	1.83	1.44	0.27	0.28	0.30	0.37	0.31	0.56	0.60	0.65	0.70	0.63
S. macrophylla	1.66	1.95	2.18	2.55	2.09	0.26	0.28	0.30	0.35	0.30	0.70	0.75	0.77	0.80	0.76
Mean	1.44	1.62	1.97	2.33		0.22	0.25	0.28	0.35		0.63	0.66	0.69	0.77	

K. ivorensis (0.60 and 0.59 gm in the two seasons, respectively) as compared to other tree species. As for the effect of nursery container types the same data cleared that, sowing seeds in polybags of 8x26 and 8x15cm size significantly increased root fresh weight (1.49, 1.35 and 1.43, 1.30 gm in the two seasons, respectively) as compared to other nursery container types. Regarding the interaction between tree species and nursery container types, sowing seeds of *K. senegalensis* in polybags of 8x26 cm size significantly increased roots fresh weight (2.50 and 2.44 gm in the two seasons respectively) as compared to other interactions.

Also, for roots dry weight, data in the same Table indicated that, *K.senegalensis* significantly gave the heaviest root dry weight (0.47 and 0.37 gm in the two seasons respectively) as compared to other tree species, with the exception of root dry weight of *S. macrophylla* in the second season only. However, roots dry weight of *K. ivorensis* significantly gave the lowest dry weight of roots (0.18 and 0.17 gm in the two seasons, respectively) as compared to other tree species. As for the effect of nursery container types, sowing seeds in polybags of 8x26 and 8x15 cm size significantly increased roots dry weight (0.45and 0.42 gm) and (0.37 and 0.39 gm) in the two seasons, respectively as compared to other nursery container types. Concerning the interaction between tree species and nursery container types, sowing seeds of *K. senegalensis* in polybags of 8x26 cm size significantly increased root dry weight (0.81 and 0.64 gm in the two seasons, respectively) as compared to other interactions.

Effect of Tree Seed Species and Nursery Container Types on Nitrogen, Phosphorus and Potassium % in the Leaves after Six Months from Seeds Sowing Seeds of Some Meliaceae Tree Species: Table (8) shows the effect of container types and different tree species seed of Family Meliaceae on leaves N, P and K percentages. Thehighest values of nitrogen percentage in leaves were in *S. macrophylla* and *K. senegalensis* (2.09 and 2.08% respectively), while the lowest N% was in *S. mahagoni*

Table 9: Effect of tree species and nursery container types on plant height (cm) and root collar diameter (cm) during one and two years from planting in the field

	One year from sowing					Two years from sowing				
	Container types (B)					Container types (B)				
Tree species (A)	Trays	Beds	bags 8x15cm	Bags 8x26cm	Mean (A)	Trays	Beds	bags 8x 15cm	bags 8 x 26cm	Mean (A)
					Plant height (cm)					
Khaya senegalensis	60.80	84.67	81.00	137.33	90.95	107.00	145.56	131.00	211.22	148.70
K. ivorensis	23.33	27.33	92.00	50.00	48.17	44.00	36.44	213.00	114.00	101.86
Swietenia mahagoni	141.33	122.67	132.67	157.33	138.50	223.31	195.00	185.00	243.11	211.61
S. macrophylla	56.83	119.83	48.00	169.00	98.42	91.52	207.00	70.00	259.89	157.10
Mean(B)	70.58	88.63	88.42	128.42		116.46	146.00	149.75	207.06	
LSD (0.05)	A: 3.15		B: 3.15	AB:6.31		A: 3.36		B: 3.36	AB:6.72	
					Root collar diameter (cm)					
Khaya senegalensis	2.45	2.93	2.29	4.65	3.08	3.67	4.92	3.11	6.03	4.43
K. ivorensis	1.03	1.30	3.98	2.30	2.15	1.92	2.40	7.11	4.30	3.93
Swietenia mahagoni	2.38	1.73	2.50	2.62	2.31	3.71	2.40	3.63	2.90	3.16
S. macrophylla	1.60	2.50	1.30	3.03	2.11	2.25	4.07	1.78	4.09	3.05
Mean (B)	1.87	2.12	2.52	3.15		2.89	3.45	3.91	4.33	1.87
LSD (0.05)	A: 0.10		B: 0.10	AB:0.20		A:0.20		B: 0.20	AB:0.40	

(1.44%). The highest nitrogen percentages were obtaineddue to sowing seeds in polybags of 8x26cm size (2.33%), while the lowest was in the case of sowing in tray containers (1.44%). However,the highest values of phosphorus percentages in the leaves were associated with *S. mahagoni* and *S. macrophylla* (0.31 and 0.30%, respectively), while the lowest P% was in the case of the *K. ivorensis* (0.23%). Using polybags of 8 x 26 cm size as nursery container types resulted in the highest values of phosphorus in leaves (0.35%), while the lowest one was in trays as container (0.22%). Regarding to potassium in the leaves, it is clear that, the highest values were obtained in the leaves of *S. macrophylla* and *K. senegalensis* (0.76 and 0.72%), respectively, while the lowest percentage was obtained in *S. mahagoni* leaves (0.63%). Sowing seeds in polybags of 8 x 26 cm gave the highest values of potassium percentage in the seedling leaves(0.77%), while sowing seeds in trays as nursery containers gave the lowest potassium% in seedling leaves(0.63%).

Effect of Tree Species and Nursery Container Types on Plant Height and Root Collar Diameter (cm) after One and Two Years from Planting in Field: Data presented in Table (9) indicated that, plant height was significantly decreased in a descending order as seed species were *S. mahagoni, S. macrophylla, K. senegalensis* and *K. ivorensis*, as the value were (138.50, 98.42, 90.95 and 48.17 cm) for one year old seedling and 211.61, 157.10, 148.70 and 101.86 cm for two years old plant. Concerning the effect of nursery container type the same data showed that, sowing seeds in polybags of 8x26 cm size significantly increased seedling height (128.42 and 207.06 cm in the two seasons, respectively) as compared to other nursery container types, while sowing seeds in trays significantly decreased seedling height (70.58 and 116.46 cm in the two seasons, respectively). As for the interaction between tree species and nursery container types, *S. macrophylla* sowing seeds in polybags of8x 26 cm significantly increased seedling height (169.00 an 259.89 cm) after one and two years from planting in field, respectively as compared to other interactions.

The effect of the tested seeds of tree species and nursery container type onroot collar diameter one and two years from transplanting in the field was shown in Table (9). There were significant differences in the values of diameter of the tested seedlings grown in the different types of nursery containers. Root collar diameter was surpassed with *K. senegalensis* seedlings (3.08 and 4.43 cm after one and two years, respectively) as compared to other tree species.Concerning the effect of the container types on the characteristics of root collar diameter of the transplants after one and two years from sowing, it is shown that, the highest values of these attributes was a result of sowing in polybags of 8x 26cm(3.15 and 4.33 cm for the two seasons, respectively). Regarding to the interaction between nursery container types and the tested tree species, it is clear that sowing of *K. senegalensis* in 8x26 cm type of container gave the highest values of the root collar diameter (4.65 and 6.03 cm after one and two years, respectively) as compared to other interactions.

In nursery, the seedling quality reflects the combination of a multitude of physiological and morphological characteristics of the seedling. Also, the choice of seedling size and container type and their effects on post-planting performance are of economic importance to produce forestry seedling [1]. Our results showed that, both container type and tree species significantly affected the growth, biomass and root morphological characteristics of the tested tree seedlings during the two seasons. However, the container type affected early growth of the seedlings. However, this effect appears to be more related to the container size and type. It is also worthy to mention that, sowing in the black plastic container resulted in the highest values of seedling growth, biomass and root morphological characteristics than those grown in the other containers. The non-woven container is permeable and allows water and soluble nutrients to move laterally, which could affect the water and nutrients availability for the seedlings and thus impacts the growth. Also, the black plastic containers may absorb more solar radiation, which can increase the root temperature during early spring [33]. However, Gera *et al.* [34] observed that when *Dalbergia sissoo* were grown in polybags of sizes 23 x 11 cm, 14 x 9 cm and 11 x 6 cm, the largest plant height, collar diameter, root length and number of roots was resulted in 23 x 11 cm size polybag. Swanson [35] observed that, the effects of container size on roots are related to container geometry and to volume of substrate. Container volume has been reported to limit basic plant growth requirements of space, water, air and nutrients. The increase in the growth characters recorded in the tested trees might be due to availability of space and potting media for good growth of roots which might have reflected in increasing the vegetative growth and leaves content of N, P and K. Also, the increase in girth at collar recorded in our findings might be due to good growth of roots which might have reflected in more uptakes of nutrient as well as water from media and thus, resulting in rapid division and multiplication of cells, which increased the girth at collar [36, 37]. Our study showed that a more closed relationship was found between root-collar diameter and seedling biomass, which agrees with the result reported by Ning *et al.* [38].

CONCLUSIONS

The best date for sowing seeds of four species (*Khaya senegalensis, K. ivorensis, Swietenia mahagoni* and *Swietenia macrophylla*) is June. Nursery container types and the tree species significantly affected the seed germination percentage of the tested tree species. In order to obtain the highest germination for these trees in polybags of 8 x26cm. Also, the seeds of *K. senegalensis* followed by *S. mahagoni* and *S. macrophylla* gave the highest values of germination %, while *K. ivorensis* tree species was the least. It is clear from our experiment that, the production of seedlings in the nursery by sowing seeds in plastic bags of 8 x 26cm size is the best for producing good seedlings in the sustainable land. However, the recommendations include sowing seeds of the family Meliaceae in June date and the use of a polybags of 8 x 26cm as container.

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