Growth Response of Some Tree Species Irrigated with Treated Sewage Water to Mycorrhiza and Soil Conditioner

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ABSTRACT

Growth response of four tree species *Tectona grandis* , *Gmelina arborea*, *Corymbia citriodora* and *Khaya senegalensis*, were examined to adding exotic vascular arbuscular mycorrhiza (VAM) and soil conditioner "REVITA.SAN" to sandy soil in Serabioum plantation at Ismailia government, that irrigated with treated sewage water to enhance soil properties and moisture, from 2013 to the end of 2015. Results showed that treatments included soil conditioner such as soil conditioner (Sc) and soil conditioner and mycorrhiza (Sc+ M) recorded the highest values of all growth parameters for all studied species, especially with *Corymbia citriodora,* except for chlorophyll (a+b) that recorded the highest values with (M) treatment in *Tectona grandis*. Moreover, all examined roots of all studied species that have previously inoculated with VAM have been colonized with mycorrhizal structures e.g., internal hyphae and vesicules.

Keywords: Mycorrhiza, Soil conditioner, *Tectona grandis*, *Gmelina arborea*, *Corymbia citriodora* and *Khaya senegalensis.*

INTRODUCTION

Soil management is necessary for improving structure and physical properties by increasing organic matter content and water retention and permeability.Traditional methods of soil management can be enhanced by special synthetic preparations, like macromolecular polymers and agro gels (Leciejewski, 2008).These products, also called soil conditioners, they able to bound elementary molecules into waterproof soil aggregates. Agro gel is a non-toxic polymer of acrylic acid.Polyvinyl alcohol has a strong absorption and accumulation properties of water solutions such as fertilizers or pesticides and of water itself.Polymers induced a higher yields of plants by a several tens percent. Permanent aggregates can affect soil, water – air conditions, physical, chemical and biological properties of the soil (Paluszek, 2003).

Organic mulches reduce water loses from the soil. Water retention in the soil increases according to the increase in organic residues on soil surface. Also, the content of mineral components and their accessibility for plants enhanced (Licznar*et al*., 2000 and Szewczuk, 2004).

Mycorrhiza is a cooperative mediator between fungi and plant roots .where, it takes carbon from plant and mycorrhiza improve mineral nutrients uptake. Vesicular-arbuscular mycorrhiza (VAM) is the most numerous and widespread type to use, it plays an important role in soil stabilization and development.Also, it helps plants in up taking nutrients especially phosphorus (Forster and Nicolson,1981, Harley and Smith1983)

Eucalyptus deglupta, *Tectona grandis*, *Acacia mangium*, and *Gmelina arborea* are commonly used species at lowland tropics because of its rapid growth and easy establishment (Lamb,1968).

Teak (*Tectona grandis* L. f) is one of the most valuable timber species in tropical regions, it hasbeen planted in various countries (Tewari, 1992). It is a large deciduous tree that reaches maximum heights of 30 to 40 m and diameters of 2 m (Chanda, 1977). Teak tolerates a wide range of climates, but grows best in a warm, moist, tropical climate, with dry season of 3 to 6 months (Webb *et al*., 1984).It grows in a wide variety of soils ,but it prefers deep, moist, well-drained sandy loam soil (Tewari, 1992 and Watanabe *et al*., 2010).

Gmelina arborea Roxb. Family Verbenaceae, is a medium-sized deciduous and fast growing tree planted to produce wood for light construction, crafts, decorative purposes, pulp, fuel and charcoal. *Gmelina* grows best on deep, well drained loamy, calcareous, moist with 5-8 pH (Fred, 1994 and Jensen, 1995). It is adapted to regions, where temperatures range from near zero to 48^{o}C and rainfalls from 800 to 5000 mm (Lamb, 1970). *Gmelina arborea* is a medium-sized deciduous and fast growing tree (Jensen, 1995). Gmelina produces an average volume of about 25 m^{3}/ha/year on clayey loam soils with suitable moisture,in Indonesia (Wong and Jones 1986).

African mahogany (*Khaya senegalensis* Desr.), Family Meliaceae, is a high value hardwood species. It occurs over a wide range of climatic, altitudinal, and ecological conditions in the tropics. It adapted to a wide variety of sites and soil types (Anon.1988, and Anon. 2004). *Corymbia citriodora* 4.7 years old, *Khaya senegalensis* aged 11 years and *Casuarina equisetifolia* 6.7 years old, are fast growing trees in Egypt, planted in

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large areas at different plantations. Serapium plantation is an example of successful plantation and the growth rate of these species were 31.6 m^3/ha, 102.5 m^3/ha and 25.0 m^3/ha, respectively (FAO, 2012).

The aim of the study is to examine the effect of exotic mycorrhiza and soil conditioner on survival, growth, leaf area and chlorophyll content of some domestic and exotic tree species. Also, to test the adaptation and growth of exotic mychorrhiza on studied soil and plants.

MATERIALS AND METHODS

Experimental location

This experiment was carried out from November 2013 to the end of 2015 at Serapium plantation located in north eastern Egypt,(30° 28' 49.14"N - 32° 13' 29.86"E) within the Governorate of Ismailia. The experiment was a part of the project "Establishment of plantation forests and development of sustainable forestry in desert lands of Egypt using sewage water education and research project" and continued for two years.

Experimental design and treatments:

Seedlings aged three months of four tree species namely, *Tectona grandis* , *Gmelina arborea*, *Corymbia citriodora* and *Khaya senegalensis*, were planted. Each experimental unit is 12,5m x 12,5m in area, with 16 replicates.Seedlings were irrigated with dripping irrigation system. Planted seedling were treated with four treatments [Control (C), Mycorrhiza (M), Soil conditioner (Sc) and Mycorrhiz & Soil conditioner (Sc+M)], where:

(C): no treatment.

(M): 1.5 g of vascular arbuscular mycorrhiza " *Glomus fasciculatum* " was added to the plant hole at the rizosphere, about 12cm depth.

(Sc): 240 g of "REVITA.SAN" as soil conditioner was used (160 g was adding to plants holes ,two to three days before planting and 80 g after planting).

(Sc+ M): both of VAM & soil conditioner

Growth Parameters determined:

Total height, root collar diameter, crown width were measured twice a year for two years. Moreover, diameter at breast height (dbh), volume index, leaf area and chlorophyll (a +b) were determined for each plant at the end of the experimental period.

Leaf area measurements:

Leaf area was measured as following: A regular geometric discswere removed from the leaf. The weight/area ratio of the leaf discs is equal to the weight/area ratio of the whole leaf (Watson & Watson, 1953).

Volume index (VI) (cm^3):

Volume index was estimated according to (South *et al*, 1988 & Hreinn and Brynleyfsdottir, 2009),using the following equation:

$V I= d^2*h$, where:

d: is root collar diameter (cm), h : is total height (cm)

Mycorrihzal Infected root:

The staining method of Phillips and Hayman (1970) was used for preparing root samples for microscopic observations. Also, the gridlines intersect method was used to calculate VAM infection % according to Giovannetti and Mosse (1980) where:

$$\text{VAM infected roots\%} = \frac{\text{No. of positiveintersects point}}{\text{Total number of observed intersect}} \times 100$$

Chlorophyll analysis

Chlorophyll content was determined according to Moran and Porath, (1980).

Chlorophyll (A+B) = (5.134*E. 662)+(20.436*E.644)*X = mg/100g.

Where:

X = (V.*100)÷(W.*1000)

V = Volume sample.

W= Weight of the sample

E= Optical density of the wave length indicated.

Soil and water analysis:

Water and soil samples were collected and analyzed, results were summarizedin (Table 1, 2).

Table 1. Soil physical and chemical analysis

Depth cm	Texture	ECdS/m	pH	N ppm	P ppm
15	Sandy	0.34	7.8	252	6054

Table 2. Physical and chemical analysis for treated wastewater (TWW)

TSS (mg/L)	pH	TN mg/l	phosphate (mg/l)
193.000	6.5	0.009	0.14

Statistical analysis:

Data was analyzed by split plot design, where tree species were the main plot, while subplot was treatments with 16 replicates for each treatment. In addition, F-test and the least significant differences at 95% level of confidence ($LSD_{0.05}$) were calculated and used to determine the significant differences between means of each parameter using SAS 9.1 system software, (Snedecor and Cochran, 1974).

RERSULTS AND DISCUSSION

Growth parameters:

1- Total height (cm):

Overviewing the statistical analysis presented in (Table3), total height showed a highly significant response to the treatments, among the tree species and for the interaction between them .whereas the treatments of (Sc) and (Sc+ M) were the highest in values 406.36 and 395.64 cm, respectively. On the other hand *Corymbia citriodora* gave the highest value 704.5 cm. while, *Khaya senegalensis* was the lowest in total height 189.7 cm. Furthermore, the interaction between treatments and species illustrate that (Sc +M) and (Sc) treatments with *Corymbia citriodora* recorded the highest value 836.9 and781.25 cm, respectively with no significant differences between each other. While, treatments had no significant effect on total height with *Tectona grandis* and *Khaya senegalensis* as presented in (Table 5).

2- Root collar diameter (mm):

Statistical analysis in (Table 3) showed highly significant differences among all variance. Both of (SC) and (SC+M) treatments recorded the highest values 85.35 mm and 84.51 mm , respectively, followed by (M) treatment 71.1 mm. Also, *Corymbia citriodora* was the highest in root collar diameter 108.7 mm .At the same time interaction analysis referred to the same result, where, the highest values were obtained in (SC+M) and (Sc) treatments with *Corymbia citriodora* as well as (M) with *Gmelina arborea* with no significant differences between them 127.25mm, 125.9 mm and 113.9 mm ,respectively (Table 6).

3- DBH (mm):

The same trend was observed with dbh. All the variance showed highly significant differences (Table 3). Treatment (SC) was the highest 42.33mm followed by (Sc+M) treatment 37.54 mm. Among species *Corymbia citriodora* surpassed 64.78 mm, then *Gmelina arborea* 38.21mm, while both of *Khaya senegalensis* and *Tectona grandis* had the lowest values 20.3mm and 18.36mm, respectively with no significant differences . According to the interaction means presented in (Table 7) , both of (Sc) and (Sc+M) treatments with *Corymbia citriodora* had the highest values 81.16 mm and 76.06 mm, consecutively without significant differences, at the same time treatments showed no significant impact on dbh with *Tectona grandis* as with *Khaya senegalensis*.

4- Crown width (cm):

Crown width measurement showed highly significant differences within tree species and the interaction between treatments and tree species .while, treatments had no significant differences on crown width, as presented in Table 3. Thus, it showed that *Gmelina arborea* and *Corymbia citriodora* had the widest crown 259.34 cm and 244.77 cm, respectively. The highest interaction mean value 294.75 cm showed by (Sc+ M) treatment with *Corymbia citriodora* species, moreover, this value had no significant differences with *Gmelina arborea* species with all treatments which recorded 273.0 cm, 262.63 cm, 253.0 cm and 248.75 cm with (M), (Sc), (Sc+ M) and (C), respectively (Table 8).

5- Volume index (cm^3):

At the same behavior of the previous parameters both of treatments, tree species and the interaction between them showed highly significant differences, Table3. Whereas, treatments (Sc) and (Sc+M) were the highest 52188.58 cm^3 and 50266.51cm^3, respectively. Noticeable, *Corymbia citriodora* had the highest volume 98899.1 cm^3 followed by *Gmelina arborea* 44415.8 cm^3, while *Khaya senegalensis* and *Tectona grandis* recorded the lowest values 7753.02 cm^3 and 6711.3 cm^3 with no significant differences. Moreover, (Table 9) showed that the highest interaction values 140740.94 cm^3 and 134619.4 cm^3were, on (Sc+ M) and (Sc) treatments, respectively with *Corymbia citriodora* species. On the other hand, treatments had no significant impact on volume index for *Khaya senegalensis* and *Tectona grandis* that recorded the lowest volume index values.

Table 3. Analysis of variance of tree growth parameters for different treatments and treespecies

s.o.v.	d.f.	Mean Square				
		Total height (cm)	Root collar diameter (mm)	Dbh (mm)	Crown width (cm)	Volume index (cm^3)
Rep	15	7648.8906 n.s.	441.34533n.s.	88.344602n.s.	4034.6156n.s.	4.20931e8 n.s.
Species (a)	3	3609315.4**	58912.372**	29633.044**	190528.47**	1.2022e11 **
Error a	45	9039.5045	542.90499	103.11255	3402.4387	5.84243e8
Treatments (b)	3	02361.36**	4265.919**	2398.7512**	4216.2654 n.s.	1.2101e10**
(a X b)	9	105605.01**	4662.5126**	1464.0312**	15442.66**	1.0806e10**
Error b	180	8670.5323	576.53124	118.37279	4772.3163	8.00067e8
Total	255					

n.s. Not significant * : Significant at 0.05 level of probability. ** : Significant at 0.01 level of probability.

Table 4. Analysis of variance of Leaf area (cm^2) and chlorophyll a+b (mg/100g) for studied species under different treatments

s.o.v.	d.f	Mean Square	
		Leaf area (cm^2)	Chlorophyll (a+b) (mg/100g)
Rep	2	15141.44 n.s.	0.0067771 n.s.
Species (a)	3	4116317.3**	2.1219854**
Error a	6	24302.485	0.0027687
Treatments (b)	3	90776.992 n.s.	0.1681743 *
(a X b)	9	224887.71**	0.3641354 **
Error b	24	34894.267	0.0378764
Total	47		

n.s. Not significant - * : Significant at 0.05 level of probability. , ** : Significant at 0.01 level of probability.

Table 5. Total height means (cm) for studied species , treatments and their interaction

Treatments / Species	Control	Mycorrhiza	Soil conditioner	Myco. & Soil cond.	Mean
Tectona grandis	189.9 g	248.13 fg	227.19 g	185.19 g	212.59 C
Gmelina arborea	318.7 f	384.06 e	422.6 d	346.4 ef	367.94 B
Corymbia citriodora	705.6 b	494.4 c	781.25ab	836.9 a	704.5 A
Khaya senegalensis	198.7 g	151.7 g	194.4 g	214.13 g	189.7 C
Mean	353.22 B	319.56 C	406.36 A	395.64 A	
LSD.0.05 Treatment			32.48		
LSD.0.05 Species			33.85		
LSD.0.05 Interaction			99.39		

Means with the same Letters are not significant, Capital Letters for species and treatments.

Table 6. Root collar means (mm) for studied species , treatments and their interaction

Treatments / Species	Control	Mycorrhiza	Soil conditioner	Myco. & Soil cond.	Mean
Tectona grandis	45.96 d	56.34 cd	49.7 cd	44.74 d	49.18 C
Gmelina arborea	69.94 c	113.9 a	108.9 b	103.2 b	98.97 B
Corymbia citriodora	108.19 b	73.5 c	125.91a	127.25 a	108.7 A
Khaya senegalensis	57.99 c	40.63 d	56.94 cd	62.85 c	54.6 C
Mean	70.52 B	71.1 B	85.35 A	84.51 A	
LSD.0.05 Treatment			8.38		
LSD.0.05 Species			8.3		
LSD.0.05 Interaction			16.29		

Means with the same Letters are not significant, Capital Letters for species and treatments.

6- Leaf area (cm^2):

Overviewing, Table 4 both of species and interaction between species and treatments had highly significant differences .while, treatments were not significant. So, *Tectona grandis* was the highest at leaf area 1287.63cm^2 followed by *Khaya senegalensis*, 986.81cm^2 while, *Corymbia citriodora* had the lowest leaf area 27.97 cm^2. However, Table 10, presented the interaction means whereas, *Tectona grandis* recorded the highest value 1807.30 cm^2 with (M) treatment, then (Sc) and (Sc + M) treatments with *Tectona grandis* and *Khaya senegalensis* without significant differences between them.

7- Chlorophyll content(mg/100g):

Chlorophyll content distinctly, showed the same behavior in statistical analysis. All of tree species, treatments and the interaction between them recorded highly significant differences, (Table 4), where, (M) treatment gave the highest chlorophyll content 2.21 mg/100g, followed by (Sc) treatment 2.16 mg/100g, then (Sc+M) treatment 2.12 mg/100g with no significant differences. Among tree species both of *Gmelina arborea* and *Tectona grandis* recorded the highest values, 2.45 mg/100g and 2.40 mg/100g, respectively with no significant differences. Moreover the interaction between variances showed that (Sc) treatment with *Tectona grandis* had the highest chlorophyll content 3.07mg/100g,followed by (M) treatment with *Gmelina arborea* and *Tectona grandis* 2.65 mg/100g and 2.42 mg/100g, in order, and (Sc+M) treatment with *Gmelina arborea* 2.56 mg/100g, with no significant differences, (Table 11).

Table 7. DBH means (mm) for studied species , treatments and their interaction

Treatment / Species	Control	Mycorrhiza	Soil conditioner	Myco. & Soil cond.	Mean
Tectona grandis	18.35 f	18.44 f	19.22 f	17.44 f	18.36 C
Gmelina arborea	30.13 de	39.77 cd	45.6 c	37.34 d	38.21 B
Corymbia citriodora	63.5 b	38.43 cd	81.16a	76.06 a	64.78 A
Khaya senegalensis	23.99 ef	14.6 f	23.38 ef	19.3 f	20.30 C
Mean	33.98 B	27.8 C	42.33 A	37.54 B	
LSD.0.05 Treatment			3.8		
LSD.0.05 Species			3.62		
LSD.0.05 Interaction			7.45		

Means with the same Letters are not significant, Capital Letters for species and treatments.

Table 8. Means of crown width (cm) for studied species , treatments and their interaction

Treatment / Species	Control	Mycorrhiza	Soil conditioner	Myco. & Soil cond.	Mean
Tectona grandis	148.81 cd	195.0 c	192.75 c	132.6 d	167.3 B
Gmelina arborea	248.75 ab	273.0 ab	262.63 ab	253.0 ab	259.34 A
Corymbia citriodora	246.6 b	193.75 c	244.06 b	294.75 a	244.77 A
Khaya senegalensis	159.50 cd	115.33 d	151.6 cd	165.88 cd	150.14 B
Mean	200.91	197.08	212.75	211.55	
LSD.0.05 Treatment			n.s. = not significant		
LSD.0.05 Species			20.93		
LSD.0.05 Interaction			46.36		

Means with the same Letters are not significant, Capital Letters for species and treatments

Table 9. Means of volume index (cm3) for studied species , treatments and their interaction

Treatment / Species	Control	Mycorrhiza	Soil conditioner	Myco. & Soil cond.	Mean
Tectona grandis	5641.81 f	8532.56 f	7290.10 f	5380.71 f	6711.3 C
Gmelina arborea	19192.56 ef	55943.44 c	56958.52c	45568.56 cd	44415.8 B
Corymbia citriodora	86078.56 b	34157.50 de	134619.4 a	140740.94 a	98899.1 A
Khaya senegalensis	8693.74 f	3056.21 f	9886.31 f	9375.81 f	7753.02 C
Mean	29901.67 B	25422.43 B	52188.58 A	50266.51 A	
LSD.0.05 Treatment			9866.57		
LSD.0.05 Species			8606.04		
LSD.0.05 Interaction			19024.9		

Means with the same Letters are not significant, Capital Letters for species and treatments

Table 10. Means of leaf area (cm^2) for studied species , treatments and their interaction

Treatment / Species	Control	Mycorrhiza	Soil conditioner	Myco. & Soil cond.	Mean
Tectona grandis	1007.34 b	1807.30 a	1205.85 b	1130.03 b	1287.63 A
Gmelina arborea	294.00 de	270.16 e	325.03 de	312.81 de	300.5 C
Corymbia citriodora	25.15 e	32.48 e	28.42e	25.83 e	27.97 D
Khaya senegalensis	760.72 c	603.72 cd	1284.1 b	1298.72 b	986.81 B
Mean	521.8	678.4	710.85	691.85	
LSD.0.05 Treatment			n.s. = not significant		
LSD.0.05 Species			155.73		
LSD.0.05 Interaction			312.3		

Means with the same Letters are not significant, Capital Letters for species and treatments

Table 11. Means of chlorophyll a+b content (mg/100g) for studied species , treatments and their interaction

Treatment / Species	Control	Mycorrhiza	Soil conditioner	Myco. & Soil cond.	Mean
Tectona grandis	2.19 cd	2.42 b	3.07 a	1.94 d	2.40 A
Gmelina arborea	2.37 bc	2.65 b	2.2 cd	2.56 b	2.45 A
Corymbia citriodora	1.92 d	1.99 d	2.19 cd	2.04 d	2.04 B
Khaya senegalensis	1.27 e	1.78 d	1.19 e	1.92 d	1.54 C
Mean	1.94 B	2.21 A	2.16 A	2.12 A	
LSD.0.05 Treatment			0.16		
LSD.0.05 Species			0.05		
LSD.0.05 Interaction			0.29		

Means with the same Letters are not significant, Capital Letters for species and treatments.

Mycorrhiza Infected roots %:

According to the results presented in (Fig 1) roots of all studied species gave no mycorrhizal structures at (C) and (Sc) treatments , whereas *Gmelina arborea* recorded the highest percentage (29%) with (Sc+ M) treatment ,followed by *Tectona grandis* and *Khaya senegalensis* that gave 25%, 24% of infected roots with (M) treatment, respectively. At the same time *Tecto*na *grandis* and *Corymbia citriodora* gave the same percentage with (Sc+M) treatment (12%). When, the lowest percentage of infected roots (8%) with (M) treatment recorded by *Corymbia citriodora*. Photos of infected roots were presented in (fig 2).

Results clearly showed that both of (SC) and (Sc+ M) treatments improved total height, root collar diameter, dbh, crown width, volume index for all studied species. Moreover, *Tectona grandis* gave the highest leaf area .Also, *Tectona grandis* and *Gmelina arborea* contain the highest value of chlorophyll content with (M) treatment. Results are agreeable with (Ewelina and Szewezuk, 2011) who found that the use of polymer super sorbents improves the growth and yield of apple trees. This is because synthetic mulches reduce evaporation from thesoil, resulting from that increasingwater content in the soil, increasing accessibility of mineral components, and the activity of soil enzyme increase. Moreover, nitrogen level in the soil enhanced, (Bielinska and Lipecki,1998).

Also, Leroy *et al.* (2007), Masazumi, *et al*. (2016), found that adding charcoal to sandy soils improve the growth of teak seedlings,which recorded the highest value of basal diameter, leaf area, photosynthetic rate, total chlorophyll concentration, inasmuch as water content in the soil was increased. Furthermore, Hussein and Fawy, (2007) mentioned that using soil conditioner application in sand and loamy sand soils, lowered soil pH and increased soil EC, CEC, OM, and available NPK of both soils. It also, increased of the emergence, chlorophyll a and b and yield parameters of barley in both soils. But, soil conditioner was higher in the sandy soil than in the sandy loam one.On the oboist with this results (Henderson-Cole and Hensley 1992).Found that adding hydrophilic gel, peat, and slow-release fertilizer in grown container of green ash seedling, in the nursery, had a little effect on growth.

The differences in infected root percentage within tree species and high variability in plant-growth response, may be due to the combination of plant and fungal species.Whereas, the range of responses was the greatest when using local plants and fungi. Noticeable that extreme response are more commonwhen using locally adapted plants and fungi. While, mostVAM species are known to be non-specific for host plant species. Therefore, a mixture of different VAM species may associate with a plant species and even an individual plant at any one time in nature. So, the relationship between fungi and host plant differs depending on plant species, and these differences could reflect the structure and pattern of colonization (Eom*et al*. 2000 ;John, 2003 and Parniske,2008).

Furthermore, low percentage of infected roots may be due to the high level of Phosphorus in the soil as showed by soil analysis. According to ((Nagahashi *et al*. 1996; Nagahashi and Douds,2000) they explain that exudation from host plant roots of signal molecules that encourage hyphal branching is enhancedby P limitation in host roots. Therefore, increasing P level of the root may reduce the excretion of these signal molecules, whereas, hyphal branching and mycorrhizal association reduced. Moreover, Phosphorus status of the root may affect membrane phospholipids, thus influencing membrane permeability and the release from the roots of carbohydrates that supply the fungi (Graham *et al*. 1981; Schwab *et al*. 1991).

Subsequently, as (Marschner and Dell, 1994) pointed out mycorrhiza enhance growth through nutrient uptake by external hyphae that can reach more than 10 cm from the root. External mycelium is important for exploration of soil pores and interaction with organic matter in the soil. It is also important in establishing soil aggregates, which are important for healthy soil structure (Ridsdale, 2012).

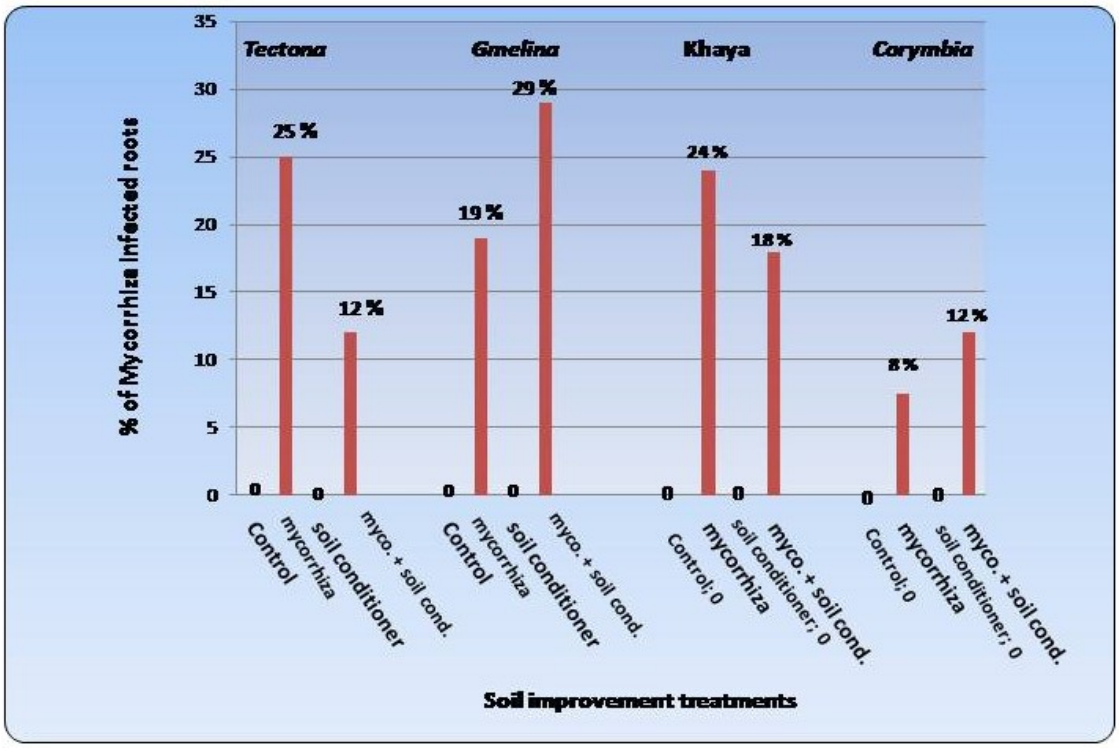

Fig. 1. percentage of Mycorrhiza infected roots for different tree species under different treatments

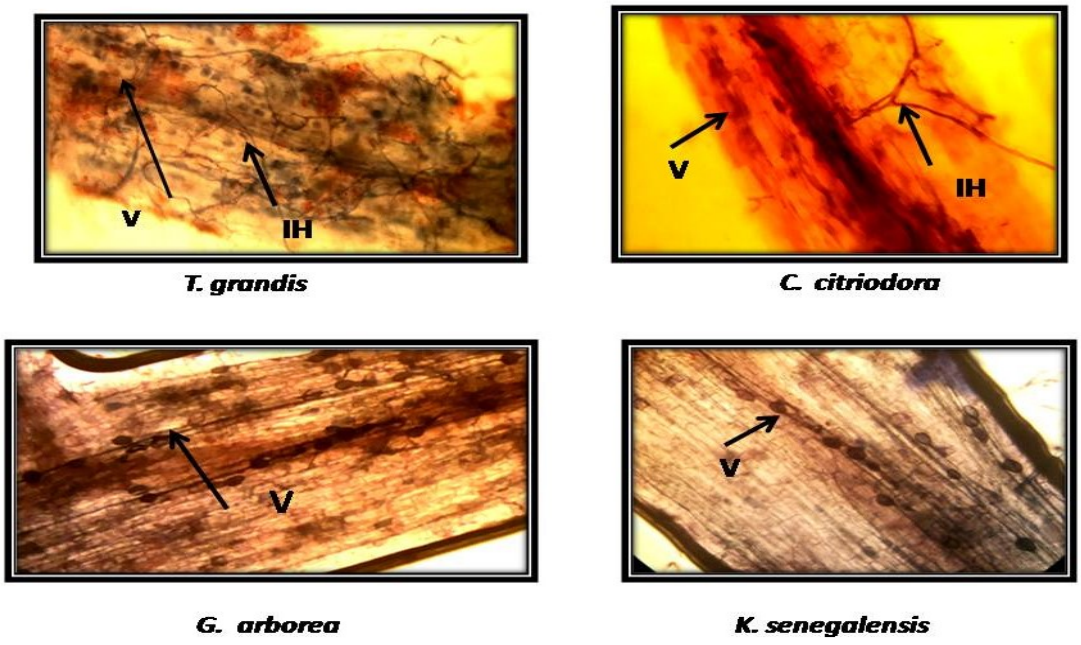

Fig. 2. Mycorrhizal structures, internal hyphae (IH) and vesicules (V) in infected roots for the studied species

CONCLUSION

Plantation establishment and renewable is very needed in Egypt to minimize the effect of climate change, Reduce timber import and reuse wastewater. Moreover Egypt weather is suitable for a wide range of wood trees species, especially the fast growing and good wood properties one such as *Corymbia citriodora*, *Gmelina arborea, Khaya senegalensis* and *Tectona grandis*.

By all the odds water is the limited factor in agriculture and forest establishment, especially in sandy soils. So, keeping the rhizosphere area always wet is very important thing to plant survival and growth. Moreover, as the results showed, adding VAM to enhance soil fertility, good results were obtained in the presence of soil conditioner, which keep soil moisture around roots and provide a suitable condition for VAM to act. Also, it can be concluded that inoculation with VAM has negative impact on total height and positive effect on root collar diameter, may be it regards to VAM works on increasing root dry matter on the expense of shoot growth at least at this stage of growth. Finally forest establishment in sandy soil irrigated with treated sewage water need urgently to a humid soil around root system, so adding polymers that hold moist in soil for a long time is very effective and needed.

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الملخص العربي

استجابة نمو بعض الأنواع الشجرية المروية بمياه الصرف الصحى المعالج لاستخدام الميكوريزا ومحسنات التربة

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أجريت تجربة حقلية فى غابة سيرابيوم– محافظة الاسماعلية التى تروى بمياه الصرف الصحى المعالج فى الفترة من نوفمبر ٢٠١٣ حتى نهاية ٢٠١٥ لاختباراستجابة نمو٤ أنواع شجرية وهى التيك، الملينا، الكافور الليمونى والكايا لاضافة كلا من الميكوريزا المستجلبة من الخارج (جنس الجلومس) ومحسن التربة (REVITA.SAN) الى تربة الزراعة الرملية و ذلك لتحسين خواص التربة ورطوبتها .وقد أظهرت النتائج ان المعاملات التى تضمنت محسن التربة و(محسن التربة+ الميكوريزا) سجلت اعلى متوسطات لكل مقاييس النمو المختبرة مع كل الانواع الشجرية تحت الدراسة بشكل عام، والكافور الليمونى بشكل خاص، باستثناء كلوروفيل(أ + ب) والذى كان اعلى تركيز له عند المعاملة بالميكوريزا مع التيك. بالاضافة لما سبق تم الكشف عن نسبة العدوى فى جذور الانواع الشجرية والتى عوملت بالميكوريزا وقد وجد ان هذه الجذور كانت تحتوى على تراكيب فطرية مثل حويصلات وهيفات داخلية.

الكلمات الكاشفة: ميكوريزا، محسن تربة. التيك، ملينا، كافور ليمونى والكايا.