

Effects of Sewage Sludge and Endo- mycorrhizal on Growth, Chemical Content and Some Physical Properties of *Swietenia mahagoni* seedling

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Abstract

This work was carried out during two seasons of 2012/2013 and 2013/2014 in the agricultural research center in El Khassasen .The aim of the this study was to investigate the effect of arbuscular mycorrhizal (AM) fungi inoculation with sewage sludge on the growth of *Swietenia mahagoni*, seedlings. The AM fungi were used as a mixed culture from species of *Glomus mosseae*, *G. etunicatum* and *G. clarum*..The factorial pot experiment was designed in six amount from sewage sludge (control, 250, 500, 750, 100 and 1250 g plant⁻¹) with four levels of AM fungi (zero, 150, 300 and 450±10 spores plant⁻¹). The results shown that, the maximum values in all plant growth parameter were recorded in the plant treated with 500g sewage sludge with AM fungi inoculation rate 300, 450 spores/ plant and NPK % in plants leaves was obtained from 500g with 300 and 450 spores/plant of AM fungi inoculation. The maximum amount of plant chlorophyll a, chlorophyll b and carotenoids were found at plants treated with AM fungi by rate 300 spores/ plant with 500g sewage sludge. The addition of AM fungi to sewage sludge had better growth effect and NPK uptake when comparison between treatments. This is due to the mutual positive action of *S. mahagoni* and AM fungi species that helped to absorb more NPK fertilization from soil.

Key Words: Woody trees, AM fungi, Bio-fertilization, Mahogany, sewage sludge

Introduction

Swietenia mahagoni (L.) Jacq , is one of the most highly valued timbers in the world, belong to Family Meliaceae. *S. mahagoni* is a tall tree, up to 30 m high, with a short, buttressing base, up to 1 m in diameter and a large, spherical crown, many heavy branches and dense shade. (Orwa et al., 2009; Sahgal et al., 2009; Panda et al., 2010 and Bhurat et al., 2011). Sewage sludge a product of wastewater is a valuable fertilizer which can be beneficially applied to many crops. Its use in agriculture as well, but it is comparatively recently that its potential as a forest fertilizer has been recognized Koulombosa et al., (2008). Trees are suitable for sludge amended soils because they are not significant food source (and because of their large biomass). (Spinosa, 2007). Vesicular-arbuscular mycorrhizae (VAM) are phycomycetous fungi belong to the order Glomerales, family Glomeraceae and class glomeromycetes. The genera that contain species known to form VAM are *Glomus*, *Gigaspora*, *Acaulospora*, *Sclerocystis* and *Entrophospora* (Trappe, 1982). The plants form symbiotic association with VAM which penetrate the root and form characteristic arbuscules and vesicles within the cortex. The aim of this experiment was to evaluate sewage sludge at six rate (control "withou" ,

250 ,500 ,750 ,1000 and 1250 (g/plant) besides four quantities of endo –mycorrhiza fungi under sandy soil condition.

Materials And Methods

The experiments were carried out at El-Kassasin Horticultural Research Station, Egypt. During two successive seasons of 2012 /2013 and 2013/2014.

Plant materials :

One year old transplants of *Swietenia mahagoni* (L.) Jacq were brought from the Horticultural Research Institute nurseries. The measurements of seedlings averaged 30 cm. in height and 0.35 cm in diameter (at 5 cm. above ground). Seedlings were grown in poly bags 40 cm in diameter, when open 45 cm in height in 15th of March 2012 and 2013 seasons. Each bag contains 20 kg.of sandy soil.

Sewage sludge treatments

The sewage sludge bulk samples were taken from Ismailia Waste Water Treatment Plant (I.W.W.T.P.) at Sarabium. The chemical analysis of the sewage sludge was carried at the table (1). Seedlings were treated with sewage sludge (zero,250,500,750,1000 and 1250 g pot⁻¹).

Table 1. Chemical analysis of the sewage sludge from Ismailia waste water station Preparation of mycorrhizal inoculums

Parameter	Sewage sludge		
	Value	Total heavy metals (ppm)	
Organic matter	23.69 %	Fe	94.50
Organic carbon	12.26 %	Mn	170.00
Total nitrogen (N)	2.75 %	Zn	254.00
C/N ratio	6.81 %	Cu	750.00
Available phosphorus (p)	0.46 %	Cd	3.00
Total potassium (K)	0.13 %	Ni	45.00
pH (1 : 2.5 sludge : water)	7.5	Pb	201.06
E. C. (1:1 sludge : water. d s/m)	3.8		

The AM fungi were used in this study as a mixed culture from species of *Glomus mosseae* G. *clarum* 27% supplied from microbiology Lab. Faculty of Agriculture, Suez Canal University, Ismailia, Egypt. The inoculums were calculated based on number of spores present in 1g of dry roots (150 spore's g⁻¹). The inoculums prepared in three levels Low (150 spores plant⁻¹), medium (300 spores plant⁻¹) and High (450 spores plant⁻¹) in addition to the fourth level which included 1g autoclaved dry root as a check treatment (zero spores g⁻¹).

Seedlings irrigation

It was determining the amount of irrigation water based on field capacity of the soil. Each seedling was irrigated two times weekly in summer and one time weekly in winter using 2000 ml (tap water)

The following data were recorded:

Vegative growth

Height increment: The measurement was done twice (at planting time, and end of season) to calculate the annually height increment % of seedlings

Diameter increment% of stem at a height 5cm: The stem diameter measure was done twice at planting time and the end of season

Fresh and dry weight of tree portions: Fresh weight of roots, stem, and leaves were calculated by weighting each portion individually then those portions were drayed at 72 °C to the oven till constant weight and dry weight of each portion was recorded for each treatment in both two seasons. (Landolt and Kandeler, 1987).

Chemical continent

Mineral contents in dried leaves.

Nitrogen in plant samples were determined by Kjeldahl. Phosphorus concentration in plant leaves was determined by the molybdate blue ascorbic acid method. Potassium was determined according to the procedure described by Mazumdar and Majumder (2003).

Same heavy metals: Cd, Ni and Pb were measured by Atomic Absorption Spectrophotometer (Page et al., 1982)

Pigments determinations:

Chlorophyll a, b and carotenoids content in the fresh leaves Chlorophyll a, b and carotenoids were extracted from representative samples using acetone 85%. The optical density of the samples was then measured at wavelength 662, 644 and 440.5 nm using a Beckman Dk-2 spectrophotometer.

Wood properties

Moisture content%: The strip assigned for moisture content was weighted immediately after cutting, oven dried at 103 ± 2 °C to constant weight. Moisture content for the disk before machining and moisture content of strip after drying was considered the moisture content of the:

$$MC = \frac{wtf - wtd}{wtd} \times 100$$

Where MC = Moisture content, wtf = Fresh weight and wtd = Dry weight

Specific gravity g/cm³

Specific gravity was determined based on the fresh volume and oven – dry weight. The volume was determined by water displacement according to American Standard Testing Methods (ASTMD, 1989)

$$SG = \frac{OD}{V}$$

Where: SG = Specific gravity, OD = Oven dry weight, V = Volume of sample

Statistical analysis:

A factorial experiment with three replicates, one seedling in each replicate Data for each experiment was statistically analyzed using computer program (SPSS version 8) copyright by SPSS Inc. 1989-1997 Significant differences among the mean of different

treatments were carried out by Dancań's multiple range test (Sndecor and Cochran 1967).

Results

Vegtative growth

Height increment % of seedlings: Data presented in Table (2) shows that ,The highest mean value of height increment was obtained from 500 g/plant for first and second seasons, (88.21and 102.22% respectively. The highest significant mean value was recorded at plant treated with 300 spores/ plant AM fungi on the first season by rate 71.51% and 77.98% for second season. Sewage sludge at 500g/plant gave the tallest seedlings (99.83% and 123.65% respectively) during the first and second seasons respectively with 300 spores/plant of AM fungi.

Diameter increment% for seedling stem at height 5cm: Highest mean value (105.66% and 147.24%) in both season was recorded from500g/plant. The highest mean value (84.27% and113.87%) was obtained at300 spores/ plant in first season and second season. AM fungi at 450 spores /plant with 500g/plant gave highest mean value 117.17and 165.62% on both seasons respectively. Table (2)

Fresh weight of leaves: The higher mean value of leaves fresh weight 40.79g/plant, which was recorded at 500g/plant on the first season. Also from, 500g/plant the large mean value 44.66g/plant of leaves fresh weight in second season. The effect of endomycorrhizal on fresh weight of leaves, indicated that, the highest mean value obtained from 300 spores/plant for first and second seasons 33.97and 34.79g/plant respectively .On the other hand the 450 spores/plant of endo –mycorrhizal with 500g/plant of sewage sludge recorded the heaviest mean value on 69.70 g/plant and 34.13 g/plant for first season and second season respectively.

Fresh weight of stem: Data presented in Table (3) showed that, the highest mean value on fresh weight of stem was obtained from 500g/plant of sewage sludge (66.83 g/plant and 59.26 g/plant) on both seasons respectively. Endomycorrhizal fungi treatments were generally increased the fresh weight of stem and this effect reached the higher mean value54.81g/plant and 52.21 g/plant with 300 spores/plant in both second seasons. , the sewage sludge as 500g/ plant with 450 spores/plant of AM fungi for both seasons were gave the large mean value (70.50/plant and 68.33g/plant respectively) on fresh weight of stem.

Fresh weight of root: Data showed, that the sewage sludge treatment by 500g/plant was produced the largest mean value (24.16g/plant and 21.26/plant) for both seasons. The plant was treated by 450 spores/plant recorded a largest mean value (24.36 g/plant and18.13g/plant) on both seasons

respectively. The sewage sludge at 500g/plant recorded higher mean (26.83g/plant and 25.60g/plant) with mycorrhial fungi 450 spores/plant of AM fungi on first season and second season.

Dry weight of leaves Data presented in Table (4) indicate that, the higher mean value (30.79g/plant and 12.01g/plant) obtained from addition 500g sewage sludge on both seasons and showed that planted treated with300spores/plant gives the highest value (23.97g/plant and 8.60 g/plant) during the two seasons. However, sewage sludge at500g/plant with 300 spores/plant of AM fungi gave the highest mean value (34.33g/plant and 12.33g/plant) on first season and second season.

Dry weight of stem: The highest mean value (54.83g/plant and 47.77g /plant) of was obtained from 500g sewage sludge during both season respectively .Also, the largest mean value (42.80g/plant and 40.52g/plant) recorded with 300 spores/plant during tow season respectively.. However, 450spores/plant of AM fungi with 500g/plant gave the highest values 60.33/plant and 54.33g/ plant for two second season. Table (4)

Dry weight of root (g/plant) of seedlings

Data in Table (4) shows that, seedling that has been trated by 500g/plant of sewage sludge gave the highest mean value (12.16g/plant and12.68g/ plant) respectively at both seasons. The 300spores/plant of AM fungi gave the largest mean value (12.36/plant and10.25g/plant) on both seasons. The AM fungi at300spores/plant of with 500g/plant recorded higher mean value14.83g/plant and 15.93g/plant on dry weight of root on two respectively.

Mineral contents in dried leaves

Nitrogen %:

table (5) indicates that the highest percentage value for the nitrogen was produced from250,500,750g/plant of sewage sludge as 2.15% and in the second season from 500g/plant of sewage sludge as2.33 %.The highest percentage value(2.12 % and 2.03%) record from 450spores/plant in both seasons . the 300 spores/ plant of AM fungi with 500g/plant of sewage sludge obtained the highest percentage value (2.55 and 2.58%) in both season from.

Phosphorus %:

Data in table (5) it was no different between sewage sludge treatment in first season. Higher Phosphorus percentage value0.58% recorded with 500g/plant sewage sludge on second season. No differences on effects of AM fungi levels in first season. AMfungi at 300 and, 450spres/ plant gives the highest concentration of phosphorus in second season (0. 0.46% and0.48%). In general, 500g/plant with 450spores/plant of AM fungi were the best to increase the concentration of phosphorus (0.49% and

0.68 respectively) in the leaves of seedlings in both seasons.

Potassium %

Resulted in table(5) indicates that the highest percentage value for the potassium was produced from 500g/plant as 0.82% and 0.77% in both second season. The best treatment that showed a high value for the increase potassium percentage is treatment 300spores/plant during both season (0.71% and 0.72% respectively). As for interaction effect, However, 500g/plant with 300spores/plant of AM fungi gave the highest mean value (0.94% and 0.86%) on first season and second season respectively.

Chlorophyll a (mg/ g FW) Table (7) showed that, the treatment at 500g/plant gave highest value 1.77 and 2.02 in both seasons. Also, indicated that, the highest significant mean value 1.73 and 1.77 of chlorophyll a from 300spores/plant fungi levels. The large mean value (2.07 and 2.08) recorded from 500g/plant under 300spores/plant on first season and second season.

Chlorophyll b (mg/ g FW): Tabulated results in table (6) showed that, sewage sludge recorded higher mean value (0.83 and 0.69) at 500g/plant of sewage sludge on two seasons. On the first season, 300 and 450spores/plant of AM fungi gave higher mean value (0.82 and 0.84%) and highest mean value (0.60 and 0.62%) in second season. AM fungi at 300 spores/plants with 500g/plant of sewage sludge the heaviest mean value (0.91 and 0.71) of chlorophyll b during both seasons respectively.

Carotenoids (mg/ g FW): Sewage sludge treatment indicated the highest mean value (2.32 and 2.25) was obtained from 500g/plant during tow season. The largest mean value (2.21 and 2.26) recorded with 300 spores/ plant in both seasons. However, 300 spores/plants of AM fungi with 500g/ sewage sludge the highest values (2.41 and 2.37%) for first season and second season.

Heavy metals on leaves and root

Data indicted in **Table (7)** show the effect of different levels sewage sludge and AM fungi on concentration of some heavy metals on leaves and root. The highest value of Pb (56.04ppm) on leaves gives from high level of AM fungi and 1250g sewage sludge on leaves. On root the largest value recorded from medium level of AM fungi with 1250g sewage sludge. On the other hand, the highest concentration of Ni gives on leaves from medium level of AM fungi with 1000g sewage sludge and from high level with 1000g of sewage sludge on root. Also, the large amount of Cd obtain from 1250 g sewage sludge with high level (450 spores

Wood properties:

Moisture content of stem % : Table (8) shows that, the resulted indicted that, the highest mean value 46.36 and 37.43% of moisture content with control

plants on both seasons. The largest mean value 40.44 and 29.69 % moisture content of recorded with untreated seedlings in two season Also, indicated that, untreated plants of AM fungi with control plant recorded the heaviest mean value 64.61 and 41.73% of moisture content during two season.

Specific gravity of stem (g/cm³): Resulted indicted that, 300spores/ plant gave the largest mean value 0.36 and 0.46 of specific gravity of stem at first and second season In general, treated plants with 450spores/plant of AM fungi gave the highest value on first season but on second season, it was significantly differs with treatments and 500g sewage sludge/plant under 450spores/plant gave biggest mean value 0.53g/m³ of specific gravity. Table (8)

Discussion

The successful association between plants and AM fungi constitutes a strategy to improve the nutritional status of both associates and reduces the use of fertilizers specially phosphorus nutrition (**Almagrabi and Abdelmoneim, 2012**). Mycorrhizal symbioses facilitate plant uptake of nutrient resources and water (**Allen, 1991, Newsham et al., 1995, Zobel et al., 1997**). Most studies have investigated P, but mycorrhizas have been implicated in the uptake of most essential nutrients. Plants colonized by AM fungi have greater ability to absorb nutrients like P, N, K, Ca and Mg which results in better survival under stressed conditions (**Auge and Stodola, 1990**). A notable exception is the element boron which is often the main micronutrient limiting growth in soil (**Dell and Malajczuk, 1994; Marschner and Dell, 1994; Clark and Zeto, 2000**). Dried sewage sludge can be useful in stimulating seedling growth for the reclamation of nutrient deficient sites. Such increase might reflect the improvement of sandy soil characters (physiological, biological and chemical properties) as well as increase of available water and nutrients by increasing organic matter, which cause an increase in the vegetative growth of plants. In conclusion, the results obtained explain that increasing plant growth, mineral content and some wood properties was recorded at plants treated with sewage sludge with AM fungi inoculation. The results are in agreement with **El-Baha (2001), Ya et al (2001), Carlot et al., (2002)** and **Bose et al., (2008)**, they found the similar results on plant growth.

Recommendation:

It could be concluded that the addition of Endo-mycorrhizal fungi rates by 300 and 450 spores of plant with the 500g/plant of sewage sludge for sandy soil increased the vegetative growth ,chemical content and physical properties of *Swietenia mahagani* seedling

Table 2. Effects of interaction between sewage sludge and inoculation by endomycorrhizal fungi on height increment% and diameter of *Swietenia mahagoni* seedlings during the two seasons (2012-2013) and (2013-2014)

Spores/plant Sewage sludge (g/pot)	1 st year								2 nd year									
	Untreated	150	300	450	Mean	Untreated	150	300	450	Mean								
	Height increment %																	
Control	15.33	k	40.00	37.16	j	24.27	k	29.19 F	17.25	mn	37.02	k-	58.98	hi	24.27	mn	34.38 e	
250	70.67	d	78.50	72.67	cd	91.04	b	78.22 B	72.64	gh	72.88	f-h	64.42	hi	60.57	hi	80.65 b	
500	60.00	e	93.67	ab	99.83	a	99.33	a	88.21 A	52.61	il	112.19	a-	120.42	ab	123.65	a	102.22 a
750	45.16	hi	68.50	d	48.33	gh	91.16	b	63.29 C	51.24	l-k	87.04	ef	55.976	ij	105.64	cd	74.97 b
1000	56.83	ef	59.33	ef	46.67	g-i	70.17	d	58.25 D	50.33	i-l	36.78	lm	37.18	k-m	62.35	hi	67.63 c
1250	40.00	ij	45.16	hi	35.17	j	53.09	fg	43.35 E	41.82	i-l	82.85	e-	106.53	bc	91.39	de	46.66 d
Mean	48.00 D		65.22 B	71.51A		55.61c			47.65 B		72.83 A		77.98 A		72.54 A			
	Diameter increment %																	
Control	25.00	n	56.00	kl	51.50	lm	35.83	n	42.08 E	67.32	ij	48.53	k	51.98	k	60.64	jk	57.12 E
250	79.66	g	87.67	f	107.33	b	94.50	ef	94.5 B	97.92	ef	71.90	ij	122.32	c	106.11	de	111.55 B
500	92.00	ef	106.17	bc	116.17	a	117.17	a	105.6 A	126.47	c	152.21	ab	144.65	b	165.62	a	147.24 A
750	103.00	b-d	98.50	de	99.33	c-e	107.83	b	102.16 A	106.02	de	118.56	cd	69.12	ij	140.65	b	108.59 B
1000	62.50	jk	76.83	gh	69.17	ij	62.83	jk	67.83 C	77.91	g-i	68.86	ij	73.82	h-j	88.34	fg	99.56 C
1250	71.50	hi	58.83	kl	62.17	jk	47.67	m	60.04 D	86.07	f-h	92.48	f	145.80	b	121.83	c	77.23 D
Mean	72.27 C		80.66 B	84.27 A		77.63 B			93.62 C		92.09 C		113.87 A		101.28 B			

Table 3. Effects of interaction between sewage sludge and inoculation by endomycorrhizal fungi on fresh weight (FW) of leaves, stem and root of *Swietenia mahagoni* seedlings during the two seasons (2012-2013) and (2013-2014)

Spores/plant	Untreated				150				300				450				Mean			
	1 st year								2 nd year											
Sewage sludge (g/pot)	FW of Leaves (g/plant)																			
Control	15.80	i	13.10	k	21.10	k	37.85	hi	21.00	F	18.10	j	20.53	ij	21.93	h-j	21.47	h-j	20.51	D
250	32.6	j	17.70	kl	53.30	de	34.40	j	37.29	B	17.40	j	23.73	g-i	23.67	g-i	25.13	d-h	42.83	A
500	21.90	k	37.40	h-j	65.70	ab	69.70	a	40.79	A	17.93	j	30.53	a-c	32.13	ab	34.13	a	44.66	A
750	54.70	d	35.60	ij	49.30	ef	62.00	bc	34.04	C	23.0	g-i	25.53	d-h	26.80	c-g	32.47	ab	37.95	B
1000	37.50	hi	43.00	g	62.70	bc	60.20	c	30.12	D	20.60	ij	26.73	c-g	29.27	b-e	29.93	a-	27.65	C
1250	48.05	f	38.90	g-i	40.60	gh	48.00	f	23.83	E	20.73	ij	24.27	f-i	27.33	c-g	28.73	b-f	20.91	D
Mean		27.25	C	31.02	B	33.97	A	31.02	B		29.56	C	32.34	B	34.79	A	32.80	B		
	FW of Stem (g/plant)																			
Control	39.83	gh	41.00	f-g	42.33	f-g	37.67	h	40.21	D	29.80	lm	31.00	k-m	37.93	g-j	41.60	f-g	35.08	CD
250	51.83	d	60.83	bc	61.67	bc	60.00	bc	58.58	B	41.73	f-g	50.26	de	50.93	de	58.00	bc	50.23	B
500	52.33	d	72.33	a	72.16	a	70.50	a	66.83	A	45.93	ef	60.06	b	62.73	ab	68.33	a	59.26	A
750	50.33	d	63.50	b	60.17	bc	57.83	c	57.95	B	38.20	g-i	43.60	fg	53.33	ab	61.06	b	49.05	B
1000	39.83	gh	51.67	d	47.50	de	50.83	d	47.45	C	33.66	m-i	34.53	i-l	36.13	h-k	46.46	ef	37.70	C
1250	31.00	i	43.67	e-f	45.00	ef	38.17	h	39.46	D	28.80	m	32.26	j-m	32.40	j-m	37.80	h-j	32.81	D
Mean		44.19	C	55.50	A	54.81	A	52.50	C		36.35	D	41.95	C	52.21	A	45.57	B		
	FW of Root (g/plant)																			
Control	20.33	gh	20.67	f-g	23.50	b-e	22.16	d-g	21.66	C	16.53	d-h	17.93	d-g	17.73	d-g	19.33	cd	17.88	B
250	20.83	gh	23.33	b-e	25.33	a-c	25.67	ab	23.62	AB	18.06	d-g	18.53	de	19.46	cd	23.60	ab	19.91	A
500	20.16	gh	24.50	b-e	24.50	a-d	26.83	a	24.16	A	17.26	d-g	23.53	ab	19.46	cd	25.60	a	21.26	A
750	18.83	h	23.00	c-f	23.33	b-e	23.50	b-e	22.16	C	17.00	d-h	20.20	b-d	14.16	g-i	17.20	d-h	17.14	B
1000	21.50	e-g	20.17	gh	24.50	a-d	24.83	a-c	22.75	BC	14.86	e-i	12.53	i	17.20	d-h	14.73	f-i	14.83	C
1250	20.33	gh	23.00	c-f	23.50	b-e	20.83	f-g	21.91	C	12.46	i	13.46	hi	14.33	f-i	11.20	i	12.86	D
Mean		20.33	C	22.44	B	23.72	A	24.36	A		16.03	B	18.04	A	17.06	AB	18.13	A		

Table 4. Effects of interaction between sewage sludge and inoculation by endomycorrhizal fungi on Dry weight (DW) of leaves, stem and root of *Swietenia mahagoni* seedlings during the two seasons (2012-2013) and (2013-2014)

Spores/plant	Untreated	150	300	450	Mean	Untreated	150	300	450	Mean										
Sewage sludge (g/pot)						1st year					2nd year									
											DW of Leaves (g/plant)									
Control	4.67	m	12.33	j-l	15.33	i-k	11.67	kl	11.00	F	5.46	gh	5.40	gh	5.06	gh	5.80	gh	5.43	D
250	16.33	ij	24.50	e-f	34.00	ab	33.00	ab	27.29	B	8.00	e	11.13	a-c	11.86	a	11.46	ab	11.01	B
500	26.00	d-f	34.17	ab	34.33	a	30.00	b-d	30.79	A	12.13	a	12.60	a	12.33	a	12.60	a	12.01	A
750	21.50	gh	28.50	c-e	23.33	fg	22.83	fg	24.04	C	9.00	be	11.13	a-c	9.93	cd	10.20	b-d	10.06	C
1000	17.83	hi	30.50	a-c	15.17	i-k	17.00	i	13.83	D	5.60	gh	7.73	ef	5.73	gh	5.60	gh	6.16	D
1250	17.17	l	13.83	i-l	14.00	i-l	10.33	l	20.12	E	6.00	gh	4.53	h	6.40	fg	5.93	gh	5.71	D
Mean	17.25	C	21.02	B	22.47	AB	23.97	A			7.70	B	8.75	A	8.55	A	8.60	A		
											DW of Stem (g/plant)									
Control	27.83	gh	29.00	f-g	30.33	f-g	25.67	h	28.21	D	21.00	n	24.50	l-n	27.33	j-m	29.16	jk	25.5	D
250	39.83	d	48.83	bc	49.67	bc	48.00	bc	46.58	B	34.16	gh	40.00	d-f	40.60	de	46.80	bc	40.39	B
500	40.33	d	60.33	a	60.16	a	58.50	a	54.83	A	37.83	e-g	49.16	b	49.76	b	54.33	a	47.77	A
750	38.33	d	51.50	b	48.17	bc	45.83	c	45.95	B	31.00	h-j	33.93	g-i	42.43	cd	47.26	b	38.65	B
1000	27.83	gh	39.67	d	35.50	de	38.83	d	35.46	C	26.50	k-m	27.76	j-m	28.26	j-l	36.03	fg	29.64	C
1250	19.00	i	31.67	e-g	33.00	ef	26.17	h	27.45	D	23.50	mn	25.26	k-n	26.60	j-m	29.53	i-k	26.22	D
Mean	32.19	C	43.50	A	42.80	A	40.50	B			29.00	D	33.43	C	40.52	A	40.52	B		
											DW of Root (g/plant)									
Control	8.33	gh	8.67	f-h	11.50	b-e	10.16	d-g	9.60	c	8.26	c-e	9.13	c-e	9.33	c-e	6.53	e	9.48	B
250	8.83	f-h	11.33	b-e	12.53	a-d	13.67	ab	11.63	ab	10.86	b-e	12.66	a-c	12.60	a-c	12.33	a-d	12.36	A
500	8.16	gh	12.50	a-d	14.83	a	13.33	a-c	12.16	a	10.06	b-e	11.13	a-e	15.93	a	14.60	a	12.68	A
750	6.83	h	11.00	c-f	11.33	b-e	11.50	b-e	10.16	c	7.93	c-e	10.46	b-e	7.93	c-e	11.20	ab	8.78	BC
1000	9.50	e-f	8.16	gh	12.50	a-d	12.83	a-c	10.75	bc	8.46	e	6.53	e	9.33	de	8.06	c-e	8.10	CD
1250	8.33	gh	11.00	c-f	11.50	b-e	8.83	f-h	9.91	c	7.00	e	6.46	e	7.73	a-e	8.80	c-e	6.93	D
Mean	8.33	C	10.44	B	12.36	A	11.72	A			8.76	B	10.20	A	10.25	A	9.67	AB		

Table 5. Effects of interaction between sewage sludge and inoculation by endomycorrhizal fungi on nitrogen%, phosphorus% and Potassium % contents on leaves of *Swietenia mahagoni* seedlings during the two seasons (2012-2013) and (2013-2014)

Spores/plant	Untreated	150	300	450	Mean	Untreated	150	300	450	Mean										
Sewage sludge (g/pot)	1 st year										2 nd year									
	Nitrogen %																			
Control	0.92	j	1.61	f-h	1.42	h	1.34	hi	1.44	C	0.95	i	1.13	gh	1.01	hi	1.19	g	1.07	E
250	1.05	ij	2.35	a-d	1.83	e-g	2.28	a-d	1.81	B	2.06	c-e	2.16	bc	2.23	b	2.15	bc	2.28	A
500	2.03	de	2.46	ab	2.55	a	2.47	ab	2.15	A	2.22	b	2.52	a	2.53	a	2.58	a	2.33	A
750	2.10	c-e	2.33	a-d	2.22	b-d	2.40	a-d	2.15	A	1.98	ef	2.00	d-f	2.15	bc	2.02	c-e	2.04	B
1000	1.32	hi	2.22	b-d	1.85	ef	2.13	c-e	2.13	A	1.13	gh	1.19	g	1.95	ef	2.14	b-d	1.60	C
1250	1.44	h	2.07	de	1.52	gh	2.05	de	1.82	B	1.01	hi	1.01	hi	2.01	d-f	1.87	f	1.47	D
Mean	1.48	D	1.86	C	2.02	B	2.12	A	1.56	C	1.62	B	1.99	A	2.03	A				
Phosphorus %																				
Control	0.34	hi	0.40	c-h	0.34	g-i	0.38	f-g	0.37	A	0.15	m	0.19	lm	0.23	k-m	0.26	k-m	0.22	D
250	0.39	f-h	0.42	b-f	0.41	b-f	0.41	b-f	0.43	A	0.48	d-g	0.54	b-d	0.60	a-c	0.63	ab	0.57	A
500	0.45	a-d	0.47	ab	0.46	a-c	0.49	a	0.43	A	0.52	c-e	0.51	c-f	0.65	b	0.68	a	0.58	A
750	0.42	b-f	0.43	a-f	0.45	a-d	0.41	b-f	0.43	A	0.41	f-g	0.37	g-j	0.51	c-f	0.46	d-g	0.43	B
1000	0.39	f-g	0.41	b-f	0.40	e-h	0.31	l	0.55	A	0.34	h-k	0.27	j-l	0.42	e-h	0.51	c-f	0.38	B
1250	0.37	f-g	0.38	f-g	0.39	f-g	0.29	i	0.37	A	0.26	k-m	0.28	i-l	0.34	h-k	0.38	g-i	0.32	C
Mean	0.38	B	0.41	A	0.41	A	0.41	A	0.36	B	0.36	B	0.46	A	0.48	A				
Potassium %																				
Control	0.48	ij	0.46	jk	0.42	jk	0.39	k	0.44	e	0.56	k	0.56	k	0.59	i-k	0.69	fg	0.58	E
250	0.57	gh	0.54	hi	0.77	cd	0.77	c	0.67	c	0.61	ij	0.69	fg	0.74	c-e	0.77	bc	0.74	B
500	0.60	f-g	0.93	a	0.94	a	0.88	ab	0.82	a	0.72	d-f	0.75	cd	0.86	a	0.86	a	0.77	A
750	0.70	de	0.83	bc	0.71	de	0.82	bc	0.77	b	0.69	fg	0.67	gh	0.71	e-g	0.64	hi	0.70	C
1000	0.64	e-g	0.76	cd	0.76	cd	0.78	c	0.75	b	0.58	jk	0.62	ij	0.62	i	0.59	i-k	0.64	D
1250	0.67	ef	0.57	gh	0.41	k	0.67	ef	0.58	d	0.56	k	0.58	jk	0.60	i-k	0.59	i-k	0.59	E
Mean	0.61	B	0.68	A	0.71	A	0.68	A	0.62	D	0.65	C	0.72	A	0.69	b				

Table 6. Effects of interaction between sewage sludge and inoculation by endomycorrhizal fungi on chlorophyll a (mg/g FW), chlorophyll b (mg/g FW) and carotenoids (mg/g FW) content on leaves of *Swietenia mahagoni* seedlings during two seasons (2013-2013) and (2013-2014)

Spores/plant	Untreated	150	300	450	Mean	Untreated	150	300	450	Mean	
Sewage sludge (g/pot)						1 st year					2 nd year
chlorophyll a (mg/ g FW)											
Control	1.01 h	1.33 d-f	1.37 bc	1.05 gh	1.22 C	0.80j	1.32i	1.66d-g	0.94j	1.18 E	
250	1.32 d-f	1.95 a	1.87 ab	2.10 a	1.63 A	1.99ab	2.05ab	2.08a	1.84b-d	1.99 A	
500	1.85 ab	2.01 a	2.00 a	2.07 a	1.77 A	1.98ab	2.04ab	1.98ab	2.08a	2.02 A	
750	1.38 c-f	1.36 c-f	1.30 d-g	1.54 cd	1.65 A	1.86a-d	1.95a-c	1.87a-d	1.73c-e	1.85 B	
1000	1.19 e-h	1.52 cd	1.62 bc	1.21 e-h	1.39 B	1.67d-f	1.67d-f	1.64d-h	1.56e-h	1.63 C	
1250	1.16 f-h	1.33 d-f	1.36 c-f	1.31 d-g	1.43 B	1.46f-i	1.42hi	1.43g-i	1.29i	1.40 D	
Mean	1.27 D	1.47 C	1.73 A	1.58 B		1.63 B	1.74 A	1.77 A	1.57 B		
chlorophyll b (mg/ g FW)											
Control	0.67 g	0.76 c-g	0.74 e-g	0.77 b-g	0.78 AB	0.25 k	0.30jk	0.32jk	0.31hi	0.29 D	
250	0.78 b-g	0.86 a-d	0.76 c-g	0.83 a-e	0.76 AB	0.51f-g	0.57d-f	0.74d-f	0.61ab	0.65 A	
500	0.88 ab	0.88 a-c	0.91 a	0.90 a	0.83 A	0.54f-g	0.64a-c	0.71a	0.65a	0.69 A	
750	0.73 e-f	0.83 a-d	0.81 a-f	0.82 a-f	0.80 AB	0.46g-i	0.64a-c	0.64a-e	0.58bc	0.58 B	
1000	0.74 e-f	0.80 a-e	0.73 e-g	0.76 d-g	0.82 AB	0.38ij	0.56c-e	0.66a-e	0.61c-e	0.55 B	
1250	0.71 fg	0.78 b-g	0.72 e-g	0.81 a-f	0.77 B	0.33jk	0.46e-g	0.56e-g	0.57cd	0.48 C	
Mean	0.76 B	0.77 B	0.82 A	0.84 A		0.41 C	0.53 B	0.60 A	0.62 A		
Carotenoids (mg/ g FW)											
Control	1.40 h	1.76e-h	1.99a-g	1.78d-h	1.78 c	1.71e	1.89b-e	1.97b-e	1.73de	2.0 B	
250	2.12 a-f	1.73f-g	2.32ab	2.25a-d	2.14 ab	2.01b-e	1.98b-e	2.16bc	2.19bc	2.08 B	
500	2.27 ab	2.40ab	2.41a	2.37ab	2.32 a	2.25ab	2.29ab	2.37a	2.25ab	2.25 A	
750	1.83 c-h	2.13a-f	2.31ab	2.14a-f	2.08 b	2.19bc	2.27b	2.23ab	2.00b-e	2.18 AB	
1000	1.59 gh	1.92b-g	2.23a-e	2.05a-g	2.12 ab	2.17bc	2.17bc	2.06b-e	2.21bc	2.15 B	
1250	1.99 a-g	2.12a-f	2.01a-g	1.96a-g	1.83 c	2.19bc	2.12bc	1.97c-e	2.00b-e	2.06 A	
Mean	1.87 C	2.01 BC	2.21 A	2.09 AB		1.97 C	2.12 B	2.26 A	2.13 AB		

Table 7. Effects of interaction between sewage sludge and inoculation by endomycorrhizal fungi on heavy metals on leaves and roots of *Swietenia mahagoni* seedlings

Spores/plant	Sewage sludge (g/pot)	Lead Pb (ppm)		Nickel Ni (ppm)		Cadmium Cd (ppm)	
		Leaves	Roots	Leaves	Roots	Leaves	Roots
Untreated	Control	25.00	35.50	31.00	27.23	0.00	0.01
	250	42.30	39.29	43.46	67.11	0.10	0.13
	500	36.02	50.23	44.02	52.89	0.10	0.14
	750	41.01	70.41	50.52	68.46	0.12	0.13
	1000	38.10	58.00	52.36	69.20	0.11	0.15
	1250	34.05	59.53	46.06	60.01	0.11	0.17
150	Control	20.05	20.01	34.16	25.46	0.01	0.01
	250	43.30	44.01	43.05	47.77	0.07	0.12
	500	45.66	39.96	39.15	57.01	0.11	0.14
	750	48.20	63.66	42.05	55.76	0.08	0.16
	1000	39.20	64.33	57.03	59.67	0.12	0.14
	1250	45.51	67.62	44.37	61.79	0.12	0.16
300	Control	22.36	36.02	24.71	32.21	0.02	0.10
	250	32.21	41.24	44.46	44.95	0.08	0.15
	500	45.50	43.42	44.02	42.67	0.10	0.14
	750	54.21	48.30	66.52	60.63	0.14	0.13
	1000	42.15	64.75	74.36	57.92	0.12	0.17
	1250	41.13	73.23	51.06	54.71	0.13	0.17
450	Control	20.35	33.68	28.25	36.13	0.04	0.11
	250	40.44	49.76	43.21	51.12	0.11	0.15
	500	41.20	54.99	57.80	62.48	0.11	0.14
	750	51.40	48.07	45.26	52.80	0.13	0.12
	1000	54.21	57.95	47.50	48.51	0.9	0.13
	1250	56.04	50.61	62.15	77.49	0.15	0.18

Table 8. Effects of interaction between sewage sludge and inoculation by endomycorrhizal fungi onMoisture content% and Specific gravity (g/cm³) on stem of *Swietenia mahagoni* seedlings during two seasons (2013-2013) and 2013-2014)

Spores/plant	Untreated					150					300					450					Mean				
	1 st year										2 nd year														
Sewage sludge (g/pot)	Moisture content %										Specific gravity (g/cm ³)														
	Untreated	150	300	450	Mean	Untreated	150	300	450	Mean	Untreated	150	300	450	Mean										
Control	64.61	a	41.51	b-d	39.97	c-e	47.14	b	46.36	A	41.73	a	26.59	b-f	38.82	a	42.55	a	37.43	A					
250	30.26	g-i	24.61	i-l	24.24	il	25.03	i-l	26.04	D	22.23	g-i	25.75	b-i	25.49	b-i	24.05	d-i	24.38	C					
500	29.90	g-i	19.92	l	20.02	l	20.52	kl	22.59	E	21.41	i	22.14	g-i	26.03	b-g	25.80	b-h	23.84	C					
750	34.39	bc	23.31	kl	25.01	i-l	26.21	h-k	26.48	D	23.31	e-i	28.49	bc	25.78	b-h	29.04	b	26.65	B					
1000	43.23	bc	30.31	g-i	33.97	e-g	31.40	f-g	34.73	C	27.26	b-e	24.56	c-i	27.81	b-d	28.81	bc	27.11	B					
1250	43.26	b	38.25	c-e	36.41	d-f	46.19	b	42.96	B	22.64	f-i	27.62	b-e	21.64	hi	27.90	b-d	24.95	D					
Mean	40.44	A	29.65	C-E	29.94	C	32.75	B			29.69	A	25.86	B	27.59	B	26.43	B							
Control	0.32	a-d	0.34	b-f	0.37	ab	0.36	e	0.35	A	0.31	h	0.32	gh	0.46	ab	0.38	fg	0.38	C					
250	0.31	g-i	0.39	b-i	0.36	a-c	0.28	a-d	0.34	A	0.38	ef	0.43	c-f	0.42	c-f	0.39	ef	0.41	AB					
500	0.34	i	0.36	a-c	0.36	a-d	0.40	a	0.35	A	0.39	ef	0.41	d-f	0.43	c-f	0.53	a	0.43	A					
750	0.35	e-i	0.35	a-d	0.39	a-d	0.33	b-e	0.35	A	0.32	h	0.46	ab	0.39	ef	0.43	c-f	0.40	BC					
1000	0.33	b-d	0.34	a-d	0.36	a-d	0.31	a-d	0.33	A	0.31	h	0.43	bc	0.41	c-f	0.39	ef	0.40	BC					
1250	0.33	f-i	0.35	a-d	0.34	a-d	0.33	a-d	0.34	A	0.32	gh	0.49	ab	0.39	ef	0.41	d-f	0.40	BC					
Mean	0.33	B	0.35	A	0.36	A	0.32	B			0.34	C	0.42	B	0.46	A	0.41	B							

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تأثير الحمأة وفطريات الميكورهيذا الداخلية علي النمو والمحتوي الكيماوي وبعض الصفات الفيزيائية لشتلات الماهوجنى

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** قسم البساتين - كلية زراعة - جامعة قناة السويس

اجريت هذه الدراسة في محطة بحوث البساتين التابعة لمركز البحوث الزراعية و خلال العامين ٢٠١٢-٢٠١٣ و ٢٠١٣-٢٠١٤ . الهدف من هذه الدراسة تأثير فطريات الميكورهيذا الداخلية و الحمأة علي بعض صفات الفسيولوجية لشتلات الماهوجنى الميكورهيذا المستخدمة عبارة عن خليط من عدة انواع *Glomus mosseae*, *G. etunicatum* and *G. clarum*. تم تصميم التجربة باريح مستويات من الميكورهيذا من الجراثيم / للنبات. ومع بستة معاملات من الحمأة (كنترول و ٢٥٠ و ٥٠٠ و ٧٥٠ و ١٠٠٠ و ١٢٥٠ جرام). كانت اهم النتائج، ادت المعاملة المنخفضة من الحمأة ٥٠٠ جرام/للنبات مع ٣٠٠ جرثومة/ للنبات من الميكورهيذا الي الحصول علي اعلي زيادة في ارتفاع النبات وقطر الساق والوزن الطازج والجاف لكل من الاوراق والساق والجذور بينما ادت المعاملات العالية من الحمأة الي نقص هذه الصفات خاصة مع التركيز ١٢٥٠ جرام/للنبات. كانت اعلي قيم للمحتوي الكيماوي NPK والكلورفيل ا، ب والكاروتين مع ٥٠٠ جرام حمأة مع ٣٠٠ جرثومة /للنبات من الميكورهيذا وايضا بعض الصفات الفيزيائية.

التوصية:

يمكن الحصول علي افضل نمو للماهوجنى في الارضاي الرملية باضافة الميكورهيذا بمعدل ٣٠٠ جرثومة/ للنبات مع ٥٠٠ جرام من الحمأة /نبات للحصول علي اعلي معدل نمو وتحسن المحتوي الكيماوي للنبات