Journal

J. Biol. Chem. Environ. Sci., 2012, Vol. 7(I): 1-16
www.acepsag.org

IMPROVEMENT TOLERANCE OF *FICUS RETUSA L.* PLANT TO SALINE WATER STRESS BY VESICULAR-ARBUSCULAR MYCORRHIZA (VAM, *Glomus sp.)*

Gehan[(1)] H. Abdel-Fattah , S.M. Shahin[(1)] And Azza M. Abd El-Moniem[(2)]

[(1)] Bot.Gars. Res. Dept., Hort. Res. Inst, ARC, Giza, Egypt.
[(2)] Flori. Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt.

ABSTRACT

Ficus retusa L is considered one of the most popular tree used for shading in egypt. It gives a huge and dense growth during spring and summer months, but it sheds most of its leaves during winter, especially under salinity stress. So, it is very important to explore a permanent treatment for its nutrition and keeping its vitality without exerting more effort and expenses**.** These fore, set of pot experiments was achieved at the nursery of Hort. Res. Inst., Giza, Egypt throughout 2010 and 2011 seasons to detect how far soil mycorrhization with vesicular-arbuscular mycorrhizae (VAM, *Glomus sp*.) at the rates of 0, 50 and 100ml/plant, applied three times with three weeks interval can help one-year-old transplants of Indian Laurel (*Ficus retusa L*.) to resist salinity of irrigation water at the levels of 0, 2000, 4000, 6000, 8000 and 10000 ppm when grown in 30-cm-diameter black polyethylene bags filled with about 7 kg of an equal mixture of sand and clay (1:1, v/v).

The results revealed that no mortality was noticed among ficus plants subjected to either salinity levels employed in this trial, regardless of colonization with VAM or not. In general, all vegetative and root growth parameters were progressively decreased with increasing salinity concentration, but were markedly improved by mycorrhizae inoculation treatments with the mastery of 100ml/plant level. The percent of salt resistance index (SRI%) was increased in response to low salinity levels, but was declined by highest ones. Inoculation with VAM, however caused a pronounced improve in such index under the different salinity levels. Saline water treatments

induced a gradual decrement in the leaves content of chlorophylls a and b, N, P and K, but significantly raised the content of carotenoids, Na, Cl and proline. Mycorrhizal colonization, on the other hand adjusted the content of various constituents for the benefit of the plant, as it increased chlorophylls a and b, as well as N, P and K content, which was accompanied with a clear decrement in Na, Cl and proline content.

So, in order to get the best growth and performance from one-year-old transplants of Indian Laurel (*Ficus retusa L.*) grown in 30-cm-diameter container and irrigated with saline water up to 10000ppm, it is preferably to inoculated them with 100ml of vesicular-arbuscular mycorrhizae (VAM, *Glomus sp.*) /plant, three times with three weeks interval through the active growing period.

INTRODUCTION

Ficus retusa L. (*F. nitida* Thunb.), Indian Laurel is one of the most common tree of the Moraceae family. It is a popular shade tree in Egypt, used as a specimen or in groups on lawns, in streets and for landscape architecture because of its attractive vegetative growth, bright green colour, and cutable into cubic, cylindrical or pyramidal shape (**El-Hadidi and Boulous, 1979**). However, such tree gives a huge and dense growth through spring and summer months, but it sheds most of its leaves during winter, especially under salinity stress (**Hattatt, 2001**). Hence, it is very important to find out a permanent treatment for its nutrition and keeping its vitality without exerting more effort and expenses.

Mycorrhizae are mutually beneficial (symbiotic) relationships between fungi and plant roots. The plant roots transmit substances to the fungi, and the fungi aid in transmitting nutrients and water to the plant roots. The fungal hyphae may extend the root lengths 100-fold. The hyphae reach into additional and wetter soil areas and help plants absorb many nutrients, particularly the less available minerals such as P, Zn, Cu, Mn and Mo. Some fungi form a kind of sheath around the root, sometimes giving it a hairy, cottony appearance. Because they provide a protective cover, mycorrhizae increase plant tolerance to drought, high temperatures, infections by diseases and even to extreme acidity and salinity (**Chen, 2006**). In this regard, **Rao *et al.* (2005)** observed that the mycorrhizal *Dalbergia sissoo* tree

(inoculated with *Glomus fasciculatum*) performed better in the increasing salinity levels compared to non-mycorrhizal ones. These observations suggested a protective role of AM fungi (*G. fasciculatum*) in preventing the injurious effects of salinity in the test plants due to enhanced water and nutrients uptake, thereby promoting growth, nodulation and N fixation of the tree under study. Likewise, **Sarhan *et al.* (2006)** found that inoculation of vesicular arbuscular mycorrhizae (VAM, *Glomus sp*.) at 100 or 200ml/pot significantly improved survival (%), height, diameter and root length of African mahogany (*Khaya senegalensis*) under various salinity levels of irrigation water. On poplar (*Populus canescens*), **Langenfeld-Heyser *et al.* (2007)** indicated that total biomass of mycorrhizal plants was greater and leaves accumulated less Na than non-mycorrhizal plants. The hyphal mantle did not diminish salt accumulation in root cell walls, indicating that mycorrhization did not provide a physical barrier against excess salinity. Element analyses suggest that improved performance of mycorrhizal poplar under salt stress may result from diminished xylem loading of Na and increased supply with K. In addition, **Giri *et al.* (2007)** postulated that mycorrhizal *Acacia nilotica* plants maintained greater root and shoot biomass at all salinity levels (1.2, 4.0, 6.5 and 9.5ds/m) compared to nonmycorrhizal ones. AM-inoculated plants had higher P, Zn, Mn and Cu concentrations than uninoculated plants. In mycorrhizal plants, nutrient concentrations decreased with increasing levels of salinity, but were higher than those of the nonmycorrhizal plants. Mycorrhizal plants had greater Na concentration at low salinity levels (1.2 and 4.0ds/m), which lowered as salinity levels increased (6.5 and 9.5ds/m), whereas Na concentration increased in control plants. Unlike Na, the uptake of K increased in shoot tissues of mycorrhizal plants with the increasing levels of salinity. The previous results indicate that mycorrhizal fungus alleviates deleterious effects of saline soils on plant growth that could be primarily related to improve P nutrition. The improved K/Na ratios in root and shoot tissues of mycorrhizal plants may help in protecting disruption of K-mediated enzymatic processes under salt stress conditions.

Similarly, were those results attained by **Grzybawaska (2004)** on *Lotus sp*., *Ranunculus repens* and *Matricaria chamomilla*, **Sharma *et al.* (2005)** on *Morus alba*, **Abbaspour *et al.* (2004)** on *Pistacia*

vera, **Kumar and Ghose (2006)** on some mangroves and **Sannazzaro *et al.* (2007)** on *Lotus glaber*.

Therefore, the main target of this work is to detect the role of supplying with mycorrhizae on attenuate stress of saline irrigation water in *Ficus retusa* transplants.

MATERIALS AND METHODS

A set of pot experiments was carried out at the nursery of Hort. Res. Inst., Giza, Egypt during the two successive seasons of 2010 and 2011 to study the effects of saline water, mycorrhizae inoculation and their interaction on growth behaviour and chemical composition of Indian Laurel (*Ficus retusa L.*) transplants, as well as to determine the suitable mycorrhizae treatment necessary for alleviating salt stress in such plant.

Hence, one-year-old transplants of *Ficus retusa L.* with initial height of 20-25cm and 5±1 branches carry about 50±5 leaves were planted on February, 15th for each season in 30-cm-diameter black polyethylene bags (one transplant/bag) filled with about 7kg/bag of an equal mixture of sand and clay by volume (1:1, v/v). The physical and chemical properties of the used sand and clay in the two seasons are given in Table (a), whereas microbial analysis of the soil mixture are shown in Table (b). After planting, the transplants were irrigated once every three days with 750 ml of fresh water/bag until mid of March, as they were subjected to the following treatments:

Table (a): Some physical and chemical properties of the used sand and clay during 2010 and 2011 seasons.

Soil texture	Seasons	Particle size distribution (%)				S.P.	pH	E.C. (ds/m)	Cations (meq/L)				Anions (meq/L)		
		Coarse sand	Fine sand	Silt	Clay				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Sand	2010	89.03	2.05	0.40	8.52	23.00	7.92	3.72	7.50	1.63	33.60	0.50	3.20	22.00	18.03
	2011	90.10	1.95	0.50	7.45	22.86	7.89	3.75	19.42	8.33	7.20	0.75	1.60	7.00	27.10
Clay	2010	7.54	22.28	30.55	39.63	55.00	8.17	2.26	7.82	2.12	15.40	0.75	6.60	8.20	11.29
	2011	7.64	22.50	30.15	39.71	51.00	8.09	2.38	7.50	2.20	15.50	0.75	6.78	8.02	11.15

Table (b) Microbial analysis of the soil mixture (Counts/g soil)

Azotobacter sp.	3.0×10^5
B. megaterium	4.0×10^5
Azospirillum sp.	1.6×10^5
Total count	1.4×10^7

A. Saline water treatments:

A pure salt of NaCl was mixed well with $CaCl_2$ pure salt at the ratio of 1:1 by weight. Saline water was then prepared from the salts mixture at the levels of 0, 2000, 4000, 6000, 8000 and 10000 ppm. Each bag was irrigated with 750ml of different saline water treatments twice a week till the end of the experiment on October, 15th.

B. Mycorrhizae treatments:

As the soil mixture was inoculated with vesicular-arbuscular mycorrhiza (VAM, *Glomus sp*.) at the rates of 0, 50 and 100ml/bag (plant) according to the method of **Menge *et al*. (1980).** The inoculation was done three tines commencing from April, 1st (after irrigation with saline water by two weeks), with three weeks interval.

C. Saline water and mycorrhizae interaction treatments:

As each treatment of saline water was combined with each one of mycorrhizae to form eighteen interaction treatments.

The transplants were fertilized three times throughout the course of the study with 5g/bag of a compound chemical fertilizer (NPK, 1:1:1); as the first batch was added after two months from planting. The second and third ones were added each two months afterwards. The layout of the experiment in the two seasons was a complete randomized design of three replicates with six transplants per replicate **(Mead *et al*., 1993).** At the end of the experiment, the following data were recorded: survival (%), plant height (cm), stem diameter at the base (cm), No. branches and leaves/plant, leaf area (cm^2), the longest root length (cm), No. lateral roots/plant and fresh and dry weights of aerial parts and roots (g). A salt resistance index (SRI%), as a real

indicator for salt tolerance was calculated as described by **Wu and Huff (1983)** from the following equation:
SRI % = Mean root length of the longest root in salt treated plant/ Mean root length of the longest root in control x 100.

In fresh leaf samples taken from the middle parts of plants, the pigments content (Chlorophyll a, b and carotenoids, mg/g F.W.) was determined according to **Moran (1982),** while in dry samples, the percentages of nitrogen **(Pregl, 1945),** phosphorus **(Luatanab and Olsen, 1965),** potassium **(Jackson, 1973),** sodium (using

Flam-photometer set) and chloride (by titration method indicated by **Jackson, 1973)** were measured. Moreover, content of free proline as mg/g F.W. was assessed in fresh leaf samples according to the method of **Bates *et al.* (1973).**

Data were then tabulated and statistically analyzed according to **SAS program (1994)** using **Duncan's Multiple Range Test (1955)** for elucidating the significancy level among the means of various treatments.

RESULTS AND DISCUSSION

Effect of saline water, mycorrhizae and their interaction on:

A. Vegetative and root growth parameters:

Data in Table (1) show that no mortality was observed in the two seasons among ficus transplants irrigated with saline water at various levels, even in the absence of mycorrhizae fungi, indicating the ability of such plant to survive under salinity conditions up to 10000 ppm (the highest concentration applied in the present work). However, the means of all vegetative and root growth parameters registered in Tables (1, 2 and 3) were progressively decreased as salinity level increased with significant differences compared to control means in both seasons. So, the least records was found due to saline water treatment at the rate of 10000 ppm. This may be attributed to a decrease in all volume at a constant cell number caused by salinity **(Handreck and Black, 2002).** Inoculation with mycorrhizae fungi, on the other hand, significantly improved all vegetative and root growth traits with the superiority of 100ml/bag treatment, which caused a marked increment in all measured characters comparing with either non-inoculated one or inoculation at 50ml/bag. Therefore, the best and

healthy growth was gained from transplants irrigated with fresh or saline water at 2000 ppm and inoculated with mycorrhizae at 100ml/bag. In general, mycorrhizae inoculation attenuated the deleterious effects of irrigation with saline water, and consequently improvement tolerance of Indian Laurel pants to salt stress. This may be ascribed to fungi ability in transmitting nutrients and water to the plant roots **(Chen, 2006),** thereby promoting growth, nodulation and N fixation of the plants **(Rao *et al*., 2005).** Because mycorrhizae provide a protective cover in the form of a sheath around the roots, it greatly increases plant tolerance to extreme salinity **(Chen, 2006).** These findings, however are in parallel with those of **Sharma *et al.* (2005)** on *Morus alba*, **Kumar and Ghose (2006)** on mangroves, **Sarhan *et al.* (2006)** on *Khaya senegalensis* and **Langenfeld-Heyser *et al.* (2007)** on poplar.

As for salt resistance index (SRI%), data in Table (2) reveale that low salinity level (2000 and 4000ppm), as well as mycorrhizae treatments under all salinity levels were significantly elevated SRI means in both seasons, while moderate and high salinity rates (6000, 8000 and 10000 ppm) gradually declined it, especially in plants cultivated in soil mixture free from mycorrhizae fungi, as the average of this character reduced to 50.6 and 50.3% for 8000 and 10000 ppm saline water treatments, respectively.

According to survival (%) and SRI (%) mentioned before, it is clear that Indian Laurel (*Ficus retusa* L.) plant can tolerate irrigation with saline water up to 10000 ppm with good performance and healthy growth if the soil inoculated with 100ml of mycorrhizae fungi/plant.

Table (1) Effect of saline water, micorrhizae and their interaction on some vegetative growth parameters of *Ficus retusa* L. plant during 2010 and 2011 seasons.

Saline water treatments (ppm)	Survival (%)				Plant height (cm)				Stem diameter (cm)				No. branches/plant				No. leaves/plant				Leaf area (cm^2)			
	M	M1	M2	Mean	M	M1	M2	Mean	M	M1	M2	Mean	M	M1	M2	Mean	M	M1	M2	Mean	M	M1	M2	Mean
First season: 2010																								
Control	100.00	100.00	100.00	100.00	58.40e	61.10d	73.60a	64.37a	1.20bc	1.31ab	1.62a	1.38a	15.3cd	16.0c	18.3a	16.5a	150.1d	173.2b	183.3a	168.9a	11.5de	12.2bc	13.9a	12.5a
2000	100.00	100.00	100.00	100.00	56.30fg	58.20e	69.10b	61.20b	1.13cd	1.31ab	1.60a	1.35a	14.4de	15.5c	17.0b	15.6b	141.5e	153.1d	163.1c	152.6b	11.1ef	12.0bc	13.5a	12.2a
4000	100.00	100.00	100.00	100.00	50.10hi	55.20g	64.40c	56.57c	0.81fg	0.96ef	1.23bc	1.00b	11.9gh	13.1f	14.2e	13.1c	117.0g	125.1f	137.9e	126.7c	10.6fg	11.5de	12.7b	11.6b
6000	100.00	100.00	100.00	100.00	46.30j	49.90i	57.60ef	51.27d	0.69g	0.77fg	1.10de	0.85bc	11.0hi	12.0g	12.7fg	11.9d	109.2i	116.0gh	122.6f	115.9d	10.0gh	11.2ef	12.1bc	11.1c
8000	100.00	100.00	100.00	100.00	40.10m	43.90k	51.60h	45.20e	0.61g	0.70fg	0.91ef	0.74cd	9.4jk	10.3ij	11.8gh	10.5e	100.1j	109.7i	112.4hi	107.4e	9.7h	11.2ef	12.0bc	11.0cd
10000	100.00	100.00	100.00	100.00	35.70o	38.00n	42.20l	38.63f	0.55g	0.59g	0.79fg	0.65d	8.0l	8.6kl	10.0j	8.9f	79.6l	87.1k	96.2j	87.6f	9.3h	10.8ef	11.6cd	10.6d
Mean	100.00	100.00	100.00		47.82c	51.05b	59.75a		0.84b	0.94b	1.21a		11.7c	12.6b	14.0a		116.3c	127.4b	135.9a		10.37c	11.48b	12.63a	
	Second season:2011																							
Control	100.00	100.00	100.00	100.00	61.50cd	66.90b	73.10a	67.17a	1.21cd	1.42ba	1.63a	1.42a	15.8bc	16.7b	19.0a	17.2a	152.3d	176.2b	188.0a	172.2a	12.2bc	12.6abc	13.5ab	12.8a
2000	100.00	100.00	100.00	100.00	57.33ef	63.50bc	71.40a	64.08b	1.04ef	1.39b	1.64a	1.36a	14.8cd	16.0bc	18.0a	16.3b	143.2e	156.3d	167.2c	155.6b	12.1bc	12.6abc	13.8a	12.8a
4000	100.00	100.00	100.00	100.00	54.00gh	57.30ef	65.30bc	58.87c	0.83gh	0.99f	1.34bc	1.05b	11.6f	13.0e	14.5d	13.1c	123.2g	131.0f	139.9e	131.4c	11.8cd	12.1bc	13.3ab	12.4a
6000	100.00	100.00	100.00	100.00	50.60hi	52.90gh	63.30bc	55.60d	0.68jk	0.79hi	1.16e	0.88c	10.9fg	12.0ef	13.2e	12.1d	106.4j	110.2ij	120.3gh	112.3d	11.3de	11.8cd	12.9abc	12.0ab
8000	100.00	100.00	100.00	100.00	47.10i	51.10h	59.00de	52.40e	0.63jk	0.71hi	0.94fg	0.76d	9.9gh	10.8fg	12.0ef	10.9e	99.3k	109.7j	115.3hi	108.1e	10.5fg	11.0ef	12.1bc	11.2bc
10000	100.00	100.00	100.00	100.00	42.80j	46.90i	56.67fg	48.79f	0.57k	0.60k	0.83gh	0.67e	8.0i	9.0hi	10.2g	9.1f	81.6m	88.7l	99.6k	89.9f	9.9g	10.7fg	11.1ef	10.6c
Mean	100.00	100.00	100.00		52.22c	56.43b	64.79a		0.83c	0.98b	1.26a		11.9c	12.9b	14.5a		117.7c	128.7b	138.4a		11.3b	11.8b	12.8a	

- M= Micorrhizae free, M1 = micorrhizae at 50ml/bag and M2 = micorrhizae at 100ml/bag.
- Means within column or row having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Table (2) Effect of saline water, microrrhizae and their interaction on root parameters and S.R.I. of *Ficus retusa* L. plant during 2010 and 2011 seasons.

Saline water treatments (ppm)	Root length (cm)				No. lateral roots/plant				S.R.I (%)			
	M	M1	M2	Mean	M	M1	M2	Mean	M	M1	M2	Mean
	First season: 2010											
Control	23.9fg	31.8c	44.9a	33.5a	9.5cd	10.0bc	11.3a	10.3a	100.0e	133.2c	188.2a	140.5a
2000	21.1h	27.5e	37.3b	28.6b	8.4ef	9.2de	11.0ab	9.5b	88.4fg	115.2d	156.2b	119.9b
4000	19.0i	24.6f	30.3d	24.6c	7.7fg	8.0fg	9.2de	8.3c	79.6gh	103.0e	126.8c	103.1c
6000	17.3j	22.7g	30.2d	23.4d	6.9hi	7.1gh	8.0fg	7.4d	72.5h	95.1ef	126.4c	98.0c
8000	21.1k	17.9ij	20.6h	16.9e	5.0jk	5.9ij	6.9hi	5.9e	50.6i	74.7h	86.2fg	70.5d
10000	12.0k	13.2k	17.0j	14.1f	4.1k	4.9jk	5.7ij	4.9f	50.3i	55.3i	71.2h	58.9e
Mean	17.6c	23.0b	30.1a		6.9c	7.5b	8.7a		73.6c	96.1b	125.9a	
	Second season: 2011											
Control	24.0ef	32.1c	45.3a	33.8a	9.8cd	10.2bc	11.9a	10.6a	100.0fg	133.8c	188.8a	140.8a
2000	22.3fg	27.9d	38.4b	29.5b	9.0ef	9.6de	11.2ab	9.9a	92.9gh	116.3de	160.0b	123.1b
4000	19.3h	25.7e	32.1c	25.7c	7.8fg	8.1fg	10.1bc	8.7b	80.4ij	107.1ef	133.8c	107.1c
6000	16.9ij	23.5f	29.7d	23.4d	7.1gh	7.2gh	8.3fg	7.5c	70.4jk	97.9fg	123.8cd	97.4d
8000	13.9k	18.9hi	23.4f	18.7e	5.2i	5.9hi	6.8gh	6.0d	57.9L	78.8jk	97.1hi	78.1e
10000	12.7k	16.7j	20.9gh	16.8f	4.4i	4.9i	5.9hi	5.1e	52.9L	69.6k	87.1hi	69.9f
Mean	18.2c	24.1b	31.6a		7.2b	7.7b	9.0a					

- M= Micorrhizae free, M1 = micorrhizae at 50ml/bag and M2 = micorrhizae at 100ml/bag.
- Means within column or row having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Table (3) Effect of saline water, micorrhizae and their interaction on aerial parts and roots fresh and dry weights of *Ficus retusa* L. plant during 2010 and 2011 seasons.

Saline water treatments (ppm)	Aerial parts fresh weight (g)				Aerial parts dry weight (g)				Roots fresh weight (g)				Roots dry weight (g)			
	M	M1	M2	Mean	M	M1	M2	Mean	M	M1	M2	Mean	M	M1	M2	Mean
	First season: 2010															
Control	169.9e	195.1b	209.3a	191.4a	69.5f	86.9c	107.4a	87.9a	35.4e	54.1b	66.5a	52.0a	19.8e	30.5b	37.2a	29.2a
2000	161.7f	176.0d	197.2b	178.3b	67.3fg	81.1d	93.5b	80.6b	31.5f	48.3c	55.7b	45.2n	18.9e	24.1c	29.4b	24.1b
4000	144.2h	160.7f	184.2c	163.0c	60.2h	70.1ef	86.1c	72.1c	30.2f	40.3d	45.8c	38.8c	15.0fg	20.0e	22.3d	19.1c
6000	131.1i	148.2g	167.1e	148.8d	51.0j	58.9h	73.2e	61.0d	25.4g	35.1e	42.8d	34.5d	13.3h	16.1f	19.6e	16.3d
8000	111.0k	128.7i	143.3h	127.7e	43.4k	53.0ij	66.2g	54.2e	21.7h	26.0g	30.4f	26.0e	10.7ij	13.4gh	15.7f	13.3e
10000	92.0l	108.8k	121.6j	107.5f	37.0l	42.1k	55.1i	44.8f	18.0i	21.9h	25.0g	21.6f	9.2j	11.3i	13.7gh	11.4f
Mean	135.0c	152.9b	170.5a		54.7c	65.4b	80.3a		27.0c	37.6b	44.4a		14.5c	19.2b	23.0a	
	Second season:2011															
Control	170.0f	195.6c	212.2a	192.6a	70.3d	89.8bc	103.5a	87.9a	33.8i	53.4c	65.3a	50.8a	20.2e	31.4b	38.5a	30.0a
2000	167.8f	178.9e	200.9b	182.5b	67.5d	83.1c	94.6b	81.7b	31.7ij	50.4d	59.3b	47.2b	19.1ef	25.3d	29.0c	24.5b
4000	147.2i	163.4g	187.8d	166.1c	60.2e	71.3d	87.0bc	72.8c	30.0jk	42.4f	52.4cd	41.6c	20.0e	20.2e	23.3d	21.2c
6000	134.7j	151.1h	170.2f	152.0d	49.9fg	58.1e	74.3d	60.7d	26.4l	37.2h	47.3e	37.0d	13.7hi	17.4fg	19.8e	16.9d
8000	114.2L	132.3j	150.4h	132.3e	44.7gh	55.5ef	67.4d	55.9e	21.0n	29.0k	39.5g	29.8e	10.4kl	13.1ij	15.6gh	13.0e
10000	89.0n	104.0m	119.8k	104.3f	39.2h	43.1gh	58.5e	47.0f	18.1o	23.8m	29.0k	23.6f	9.0L	11.3jk	13.8hi	11.4f
Mean	137.1c	154.2b	173.6a		55.9c	66.8b	80.9a		26.8c	39.4b	48.8a		15.4c	19.8b	23.3a	

- M= Micorrhizae free, M1 = micorrhizae at 50ml/bag and M2 = micorrhizae at 100ml/bag.
- Means within column or row having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

B. Chemical composition:

It is obvious from data averaged in Table (4) that chlorophylls a and b content was cumulatively declined as a result of increasing level of salinity in irrigation water, but they were significantly increased in response to inoculation with mycorrhizae fungi, especially at the rate of 100ml/bag, which gave, in general the utmost high content. The opposite was the right concerning carotenoids content, that was augmentatively increased with raising salinity rate, while decreased with elevating the rate of mycorrhizae application. This may be connected to the root absorption of NaCl from soil solution at high concentration, which causes yellowings and necroses on the leaves **(Devecchi and Remotti, 2004).** Inoculation with mycorrhizae repair, to somewhat such deficiency.

A similar trend to that of chlorophyll a and b content was also observed regarding the percentages of N, P and K (Table, 4), as they were progressively depressed with increasing salinity concentration, but were slightly improved due to mycorrhizae treatments, except for the rate of 100ml/bag, which significantly increased P content in the leaves of plants irrigated with either fresh or low and medium levels of saline water.

The percentages of Na and Cl, as well as free proline content (mg/g F.W.), on the other hand were gradually increased with elevating salinity of irrigation water to reach maximum values in the leaves of plants irrigated with 10000 ppm saline water. That is because the higher salts concentration in the nutrient medium usually leads to an increase in the uptake of some highly hydrophilic ions (e.g. Na or borate) as mentioned by **Handrc and Black (2002).** Contents of the three previous constituents, however were significantly reduced as a result of inoculation with mycorrhizae fungi. The highest reduction was recorded by the highest rate of inoculation (100ml/bag).

Improvement the content of some constituents in response to mycorrhizae treatments may be due to reaching the hyphae into additional and water soil areas and help plants absorb many nutrients, particularly the less available minerals such as P, Zn, Cu, Mn and Mo **(Chen, 2006).** In this connection, **Abbaspour *et al*. (2005)** reported that the contents of P, K, Cu and Zn were higher in mycorrhiza treated *Pistacia vera* plants than in non-mycorrhizal ones under both control and saline conditions, while the concentrations of Na and Cl in the shoots of mycorrhiza-treated plants were lower than those in non-mycorrhizal ones.

Table (4) Effect of saline water, microrrhizae and their interaction on chemical composition of *Ficus retusa* L. leaves during 2010 and 2011 seasons.

Saline water treatments (ppm)	Chlorophyll a (mg/g F.W.)				Chlorophyll b(mg/g F.W.)				Carotenoids (mg/g F.W.)			
	M	M1	M2	Mean	M	M1	M2	Mean	M	M1	M2	Mean
	First season: 2011											
Control	1.48cd	1.53bc	1.74a	1.58a	0.69ab	0.73ab	0.84a	0.75a	0.58ij	0.53ij	0.51j	0.54e
2000	1.39cd	1.43cd	1.68ab	1.50ab	0.65bc	0.65bc	0.72ab	0.67ab	0.71gh	0.67gh	0.61ij	0.66d
4000	1.33cd	1.37cd	1.49cb	1.40bc	0.57de	0.61cd	0.66bc	0.61b	0.78de	0.71fg	0.65hi	0.71cd
6000	1.21ef	1.29de	1.33cd	1.28c	0.53de	0.57de	0.64bc	0.58b	0.79de	0.75ef	0.70gh	0.75bc
8000	0.97fg	1.00fg	1.21ef	1.06d	0.41de	0.43de	0.48de	0.44c	0.84bc	0.80cd	0.78de	0.81b
10000	0.73g	0.78g	0.98fg	0.83e	0.37e	0.38e	0.39e	0.38c	0.97a	0.90ab	0.82cd	0.90a
Mean	1.19b	1.23b	1.41a		0.54b	0.56ab	0.62a		0.78a	0.73ab	0.68b	
	N(%)				P(%)				K(%)			
Control	2.80cd	2.93bc	3.10a	2.94a	0.57bc	0.62bc	0.73a	0.64a	1.92a	1.99a	2.03a	1.98a
2000	2.71de	2.80cd	3.01ab	2.84a	0.52de	0.56cd	0.68ab	0.59a	1.64cd	1.68bc	1.73b	1.68b
4000	2.13ef	2.21ef	2.32de	2.22b	0.39fg	0.46ef	0.52de	0.46b	1.19de	1.23de	1.27d	1.23c
6000	1.90ef	1.93ef	2.11ef	1.98bc	0.31fg	0.35fg	0.50de	0.39bc	1.07e	1.11e	1.20e	1.10cd
8000	1.55f	1.62f	1.89fe	1.69c	0.27g	0.31fg	0.38fg	0.32c	0.92f	0.96f	1.01ef	0.96bc
10000	1.43f	1.59f	1.80f	1.61c	0.25g	0.29fg	0.37fg	0.30c	0.84f	0.93f	0.94f	0.91d
Mean	2.09a	2.18a	2.37a		0.39b	0.43b	0.53a		1.26a	1.32a	1.35a	
	Na(%)				Cl(%)				Free praline (mg/g F.W.)			
Control	0.418g	0.398g	0.375g	0.397d	1.25g	1.24g	1.50g	1.21d	5.81de	4.74fg	4.32g	4.96e
2000	0.582f	0.415g	0.374g	0.457d	1.69f	1.14g	0.94g	1.26d	5.92de	5.23fg	4.84fg	5.33de
4000	0.763cd	0.693de	0.613ef	0.690c	2.08de	1.92ef	1.85ef	1.95c	6.13de	5.81de	5.35ef	5.76cd
6000	0.873bc	0.804cd	0.769cd	0.815b	2.70bc	2.53c	2.41cd	2.55b	7.23bc	5.56ef	5.99de	6.26c
8000	0.933ab	0.836cd	0.802cd	0.857ab	2.97b	2.69bc	2.43cd	2.70b	7.91ab	7.19bc	6.67cd	7.26b
10000	1.017a	0.931ab	0.876bc	0.941a	3.41a	3.40a	3.01b	3.27a	8.57a	7.82ab	7.31bc	7.90a
Mean	0.764a	0.680b	0.635b		2.35a	2.15b	1.97c		6.93a	6.06b	5.75b	

- M= Micorrhizae free, M1 = micorrhizae at 50ml/bag and M2 = micorrhizae at 100ml/bag.
- Means within column or row having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

The aforementioned results showed a similar trend to those were obtained by **Grzybawska (2004)** on *Lotus sp., Ramunculus repens* and *Matricaria chamomilla*, **Sharma *et al.* (2005)** on Morus alba and **Giri *et al.* (2007)** on *Acacia nilotica*.

From the previously stated results, it could be recommended to inoculate one-year-old transplants of *Ficus retusa L*. grown in 30-cm-diameter container under salinity stress with 100ml of mycorrhizae fungi (VAM, *Glomus sp*.), three times with three weeks interval to improve their growth and performance.

REFERENCES

Abbaspour, H.; F. Fallahyan and H. Fahimi (2005). Effects of endomycorrhizal fungi and salt stress on nutrient acquisition and growth of *Pistacia vera* L. Pakistan J. Bio Sci., 8(7):1006-1010.

Bates, L.S.; R.P. Waldern and I.D. Tear (1973). Rapid determination of free proline under water stress studies. Plant and Soil, 39:205-207.

Chen, J. (2006). The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. International workshop on Sustained Management of the Soil-Rhizosphere System for Efficient Crop Production and Fertilizer Use. 16-20/Oct., Land Develop. Dept., Bangkok, Thailand: 1-11.

Devecchi, M. and D. Remotti (2004). Effect of salts on ornamental ground covers for green urban areas. Acta Hort., 643:153-156.

Duncan, D.B. (1955). Multiple range and multiple F-tests. J. Biometrics, 11:1-42.

El-Hadidi, M.N. and L. Boulous (1979). Street Trees in Egypt. 2nd Ed., Dar Memphis for Printing, Cairo, Egypt, 142 pp.

Giri, B.; R. Kapoor and K.G. Mukerji (2007). Improved tolerance of *Acacia nilotica* to salt stress by arbuscular mycorrhizae, *Glomus fasciculatum* may be partly related to elevated K/Na ratios in root and shoot tissues. Microbial Ecology, 54(4): 753-760.

Grzybowska, B. (2004). Arbuscular mycorrhiza of herbs colonizing a salt affected area near Krako (Poland). Acta Societatis Bolanicorum, Poloniae, 73(3):247-253.

Handreck, K. and N. Black (2002). Growing Media for Ornamental Plants and Turf. 3rd Ed., Univ. New South Wales Press Ltd., Sydney, Australia, 542 pp.

Hattatt, L. (2001). Encyclopedia of Garden Plants and Flowers. Parragon Queen Street Hause, 4 Queen st., Bath BAI IHE, U.K., 256 pp.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall of India Private Ltd. M-97, New Delhi, India, 498 pp.

Kumar, T. and M. Ghose (2006). Mycorrhizal status (VAM) on some mangroves growing in saline and non-saline soils. J. Mycopathological Res., 44(2): 311-320.

Langenfeld-Heyser, R.; J. Gao; T. Ducic; P. Tachd; C.F. Lu; E. Fritz; A. Gafur and A. Polle (2007). *Paxillus involutus* mycorrhiza attenuate NaCl- stress responses in the salt-sensitive hybrid poplar (*Populus cancescens*). Mycorrhizae, 17(2): 121-131.

Luatanab, F.S. and S.R. Olsen (1965). Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. Soil Sci. Soc. Amer. Proc., 29:677-678.

Mead, R.; R.N. Curnow and A.M. Harted (1993). Statistical methods in Agriculture and Experimental Biology, 2nd Ed., Chapman & Hall Ltd., London, 335 pp.

Menge, J.A.; C.K. Larue; E. Labanauskas and L.V. Jackson (1980). The effect of mycorrhizal fungi on growth and nutrition of avocado seedlings grown with six fertilizer treatments. J. Amer. Soc. Hort. Sci., 105(3):400-404.

Moran, R. (1982). Formula for determination of chlorophyllous pigment extracted with N-N-dimethyl formamid, Plant Physiol., 69:1376-1381.

Pregl, F. (1945). Quantitative Organic Micro-Analysis, 4th Ed., J.A. Churchill Ltd., London, pp. 203-209.

Rao, V.M.; A. Keshawat; G. Bhushan; S.K. Sharma and H.C. Jain (2005). Role of arbuscular mycorrhiza on tolerance to salinity of the tree legume *Dalbergia sissoo* Roxb. inoculated by *rhizobium.* J. Phytological Res., 18(2): 223-226.

Sannazzaro, A. I.; M. Echeverria; E.O. Alberto; O.A. Ruiz and A.B. Menendez (2007). Modulation of polyamine balance in *Lotus glaber* by salinity and arbuscular mycorrhiza. Plant Physiol. and Biochem., 45(1):39-46.

Sarhan, A.Z.; M.A. Salem and L. Soliman (2006). Effect of irrigation water salinity levels and soil mycorrhizal fungi

inoculation on growth of African mahogony (*Khaya senegalensis*) transplants. Ann. Agric. Sci., Moshtohor, 44(2):625-635.

SAS Institute (1994). SAS/STAT User's Guide statistics, vers. 6.04, 4th Ed., SAS Institute. Inc., Cary, N.C., USA.

Sharma, S.; S. Kashyab and P. Vasodevan (2005). *In vitro* rhizogenesis of *Morus* alba by mycorrhizal extracts under saline stress. European J. Hort Sci., 70(2): 79-84.

Wu, L. and D.R. Huff (1983). Characteristics of creeping bentgrass clones (*Agrostis stolanifera* L.) from a salinity-tolerant population after surviving drought stress.Hort Science, 18(6): 883-885.

تحسين تحمل نبات الفيكس نيتدا لإجهاد مياه الري المالحة باستخدام الميكورهيزا

جيهان حسن عبد الفتاح[1] و سيد محمد شاهين[1]وعزة محمد عبد المنعم[2]

[1] قسم بحوث الحدائق النباتية، معهد بحوث البساتين، مركز البحوث الزراعية – الجيزة- مصر.
[2] قسم بحوث الزينة، معهد بحوث البساتين، مركز البحوث الزراعية – الجيزة – مصر.

تعتبر شجرة الفيكس نتدا واحدة من أكثرالأشجار أستخداما لتوفير الظل والتجميل فى مصر، حيث تعطى نموا كثيفا متداخلا خلال أشهر الربيع والصيف، لكنها تسقط معظم أوراقها خلال الشتاء ، خاصة تحت ظروف اجهاد الملوحة. لذلك فانه من المهم التوصل الى معاملة دائمة لتغذيتها والحفاظ على حيويتها ونضارتها دون جهد أو تكاليف اضافيه لذلك أجريت مجموعة من تجارب الأصص بمشتل معهد بحوث البساتين، الجيزة، مصر خلال موسمي 2010، 2011 لتحديد دور تلقيح التربة بأحد فطريات الميكورهيزا (VAM, *Glomus sp.*) بمعدلات: صفر، 50، 100مل /نبات ، ثلاث مرات بفاصل زمني ثلاثة أسابيع بين كل مرتين لمساعدة شتلات الفيكس نيتدا عمر سنة (*Ficus retusa* L.) علي تحمل ملوحة مياه الري عند إضافتها بمعدلات: صفر، 2000، 4000، 6000، 8000، 10000جزء في المليون، عند زراعتها في أكياس بلاستيك سوداء قطرها (30سم) وملأت بحوالي 7كجم من مخلوط متساوي من الرمل والطين بنسبة (1:1) حجماً.

أوضحت النتائج عدم حدوث موت لأي من شتلات الفيكس نيتدا التي تعرضت للمستويات المختلفة من الملوحة، بصرف النظر عن التلقيح بالميكورهيزا من عدمه. وبصفة عامة

انخفضت جميع قياسات النمو الخضري والجذري تدريجياً كلما زاد تركيز ملوحة مياه الري، لكنها تحسنت جميعاً بشكل واضح عند حقن التربة بالمستويات المختلفة من فطر الميكورهيزا، مع تفوق معاملة الحقن بمعدل 100مل/نبات. ولقد زادت النسبة المئوية لمعامل مقاومة الملوحة (SRI%) نتيجة للمعاملة بالمستويات المنخفضة من الملوحة، لكنها انخفضت عند المعاملة بالمستويات المرتفعة، بينما أحدث التلقيح بالميكورهيزا تحسناً واضحاً في هذا المعامل رغم التعرض للمستويات المختلفة من الملوحة. أحدثت أيضا معاملات الملوحة المختلفة إنخفاضاً تدريجياً في محتوي الأوراق من كلوروفيللي أ ، ب ، النيتروجين، الفوسفور والبوتاسيوم، لكنها أحدثت زيادة معنوية في محتواها من الكاروتينويدات، الصوديوم، الكلوريد والبرولين. علي الجانب الآخر، أدي الحقن بالميكورهيزا إلي تعديل محتوي الأوراق من المكونات سالفة الذكر بما يخدم مصلحة النبات، حيث زاد محتواها من كلوروفيللي أ ، ب، النيتروجين، الفوسفور والبوتاسيوم والذي كان مصحوباً بانخفاض واضح في الصوديوم، الكلوريد والبرولين.

وعليه .. لكي نحصل علي أفضل معدل للنمو من شتلات الفيكس نيتدا عمر سنة النامية في أواني قطرها (30سم) ورويت بمياه مالحة حتي تركيز 10000 جزء في المليون، فإنه يفضل تلقيح التربة النامية فيها تلك الشتلات بفطر الميكورهيزا (VAM, *Glomus sp.*) بمعدل 100مل/نبات، ثلاث مرات وبفاصل زمني ثلاثة أسابيع بين المرة والتي تليها خلال فترة النمو النشط.