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REDUCING THE HARMFUL EFFECT OF SALINE IRRIGATION WATER ON GROWTH AND QUALITY OF (*Enterolobium contortisiliquum*) ELEPHANT'S EAR SEEDLINGS

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ABSTRACT

The current study was conducted in order to avoid hazards of saline irrigation water on elephant's ear tree (*Enterolobium contortisiliquum* (Vell.) Morong) seedlings. The experiment was done under the full sun at the nursery of Hort. Res. Inst., ARC, Giza, Egypt during 2017 and 2018 seasons using six-month-old uniform seedlings. The seedlings were planted in 30-cm-diameter plastic pots filled with about 5.5 kg/pot of sand and clay mixture at equal parts (1:1, v/v), drenched monthly with 0, 2 and 4 g/pot (plant) of magnetite (Fe_3O_4) and irrigated with saline water containing NaCl + $CaCl_2$ mixture at concentrations of 0, 1000, 2000, 3000 and 4000 ppm. The results showed that plants irrigated with saline water at concentrations higher than 1000 ppm without magnetite died, while those amended with magnetite at either 2 or 4 g/pot survived regardless of the salinity level. However, the means of plant length, stem diameter, No. leaves/plant, root length and stem, leaves and roots fresh and dry weights of those plants were gradually decreased with increasing salinity level to reach the minimum values by the highest level (4000 ppm). The opposite was correct regarding the effect of Fe_3O_4, as the means of various top and root growth parameters were linearly increased as a result of the progressive increment of magnetite dose with the superiority of 4 g/pot dose that gave the highest records in most cases. The previous characters were also affected by the combined treatments, where the plants received magnetite at either 2 or 4 g/pot and irrigated with fresh water generally recorded the utmost high averages over control, and the interaction treatment of fresh water + 4 g/pot magnetite was the most effective one. A similar trend was also attained concerning the chemical composition of the leaves, as the concentrations of chlorophyll a and b, carotenoids and total carbohydrates were gradually decreased, but those of Na, Cl and proline were progressively increased the level of salt in irrigation water was increased. Magnetic iron, however improved concentrations of these constituents under the different salinity levels. The combination of fresh water + 4 g magnetite /pot scored the maximum concentrations of chlorophyll a and b, carotenoids and total carbohydrates, but that was true for Na, Cl and proline concentrations in plants irrigated with 4000 ppm saline water and supplemented with either 2 or 4 g/pot magnetite. Hence, it can be advised to use 4 g magnetite/ plant as a soil drench every month during the growing season in order to protect *Enterolobium. contortisiliquum* seedlings from salinity hazards.

Key words: *Tamboril, elephant's ear tree, Enterolobium contortisiliquum, saline water, magnetite and magnetic iron.*

1. INTRODUCTION

Enterolobium contortisiliquum(Vell.) Morong is a fast growing shade tree belonging to Fam. Fabaceae. N fixation and up to 20-30 m tree height are recommended for greening the degraded areas and for mixed plantation in parks, squares and gardens (Lorenzi, 1992). It is native Brazil, where it is widely known as tamboril, timbauba and as elephant's ear pod tree. It produces a valuable timber used for the construction of boats, canoes, toys, plywood, furniture frames, doors and crates kernels. It has a broad, leafy canopy providing shade in summer. It may be a key tool for reforestation programs in the marginal soils suffer from salinity because *E. contortisiliquum* cannot tolerate soil salinity exceed 1.2dS.m^{-1}, *i.e.,* 750 ppm (Pereira *et al*., 2012).

A reduction in shoot and root growth, flowering delay and leaf chlorosis are the commonest symptoms resulting from salinity. This was documented by Pereira *et al*. (2012), Leite *et al*., (2017) and daSilva *et al*. (2019) on *Enterolobium contortisiliquum*, Abdel-Moniem *et al*. (2014) on *Tecoma stans*, El-Fouly *et al*. (2015) on *Iris tingitana* cv. Wedgewood, Nawaz *et al*. (2016) on *Eucalyptus camaldulensis*, Oliveira *et al*. (2017) on *Catharanthus roseus*, *Allamanda cathartica*, *Ixora coccinea* and *Duranta erecta*. Shahin *et al*. (2017) on *Casuarina equisetifolia* and *Eucalyptus rostrata* and Bian and Pan (2018) on *Narcissus tazzeta* var Chinensis.

On the other hand, many efforts had been exerted to overcome salinity hazards, among which using the magnetic iron, as an easy and affordable method. These efforts were reported by Baraga *et al*. (2009) on *Enterolobium schomburgkii*, Abdel-Fattah (2014) on *Jacaranda acutifolia*, Ahmed *et al*., (2016) on *Acalypha wilkesina*, Moustafa *et al*., (2017) on *Moringa aleifera*, Shahin *et al*., (2018) on *Terminalia arjuna*, Amer (2016) on wheat and maize, Khalil and Abou Leila (2016) on tomato and Abdel-Hamied and Ghieth (2017) on peach.

The present study, is an attempt to evaluate the role of magnetite in minimizing the deleterious effects of irrigation water salinity on growth and chemical composition of tamboril (elephant's ear tree) seedlings.

2. MATERIALS AND METHODS

A pot experiment was carried out under open field condition at the nursery of Hort. Res. Inst., ARC, Giza, Egypt during 2017and 2018 seasons to evaluate the response of tamboril seedlings of (*Enterolobium contortisiliquum*) to irrigation with saline water with or without magnetite .

Six-month-old uniform seedlings of *Enterolobium contortisiliquum* (Vell.) Morong (30 cm height with 10 leaves) were individually transplanted on April, 1st in each season in 30-cm-diameter plastic pots (one seedling/pot) filled with about 5.5 kg/pot of sand and clay mixture (1:1, v/v). The physical and chemical analyses of the sand and clay used in the two seasons are shown in Table (a).

Immediately after transplanting, the seedlings were irrigated with fresh water once every three days till mid April, then they received the following treatments:

1. Magnetite (magnetic iron ore): the soil mixture in each pot was monthly drenched with 0, 2 and 4 g Fe_3O_4, 22.5 % (obtained from Alahram Mining Co., Giza, Egypt). Till the end of experiment.

2. Saline water treatments: A pure NaCl salt was mixed well with a pure $CaCl_2$ at the rate of (1:1, w/w), to prepare saline water at concentrations of 0, 1000, 2000, 3000 and 4000 ppm. The seedlings were irrigated with the previous saline water every three days till the end of the experiment (on October, 15th).

3. The magnetite treatments were combined factorially with those of saline water ones to create 15 interaction treatments.

The seedlings under various treatments were monthly fertilized with (commercial name flowering spring) 20 N : 20 P : 20 K + micronutrients compound chemical fertilizer at 1 g/pot and the other agricultural practices were undertaken whenever needed, as usually grower did. A factorial experiment based on a complete randomized design, replicated thrice with 5 seedlings per replicate was accomplished in both seasons (Mead *et al*., 1993).

At the end of each season (October, 15th), data were recorded as follows: plant length (cm), No. leaves/plant, stem diameter at the base (mm), root length (cm), as well as stem, leaves and roots fresh and dry weights (g). In fresh leaf samples, photosynthetic pigments (chlorophyll a, b and carotenoids, mg/g f.w.) were measured according to the method of Moran (1982), while in dry leaf samples, total carbohydrates percentage as well as sodium and chloride (mg/g d.w.) were determined using the methods of Herbert *et al*. (1971) and Jackson (1973), respectively. Moreover, free proline content was colorimetrically evaluated in fresh leaf samples using the method described by Bates *et al*., (1973).

Data were then tabulated and statistically

Table (a): The physical and chemical analyses of the used sand and clay.

Soil type	Particle size distribution (%)				S.P.	E.C. (dS/m)	pH	Cations (meq/l)				Anions (Meq/l)		
	Coarse Sand	Fine sand	Silt	Clay				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Sand	80.75	10.30	1.26	7.69	23.10	3.82	7.83	8.96	8.33	17.66	0.75	3.48	18.67	13.55
Clay	7.64	22.50	30.15	39.71	50.10	2.27	8.12	8.12	2.20	15.50	0.75	6.78	8.02	11.15

analyzed using the program of SAS Institute (2009), followed by Duncan's New Multiple Range Test (Steel and Torrie, 1980) for means comparison of the treatment.

3. RESULTS AND DISCUSSION

3.1. Effect of salinity levels, magnetite rates and their interactions on

3.1.1. Vegetative and root growth parameters

It is obvious from the data averaged in Table (1) that plants irrigated with saline water at concentrations more than 1000 ppm without the application of magnetic iron died in both seasons, while those supplemented with magnetic iron at either 2 or 4 g/pot survived irrespective of salinity level of irrigation water. However, the means of plant height (cm), No. leaves/ plant, stem diameter (mm), root length (cm) as well as stem, leaves and roots fresh and dry weights (g) of these plants progressively decreased with increasing salinity level of the irrigation water to reach the least values at the highest level (4000 ppm).

The previous results may be attributed to a decrease in cell size at a constant cell number caused by salinity. In this regard, Baraga *et al*. (2009) mentioned that salinity inhibited cell division and enlargement, consequently suppression of plant growth. Furthermore, salinity may have a negative effect on water absorption and biochemical processes, such as N and CO_2 assimilation and protein biosynthesis or may accumulate high concentration of some highly hydrophilic ions (*e.g.* Na or borate) and toxic ones such as Cl in plant tissues (Handreck and Black, 2002). Jou *et al*. (2006) suggested that ATPase participates in endoplasmic reticulum-Golgi mediated protein sorting machinery for both house keeping function and compartmentalization of excess Na^+ under high salinity. A parallel records were also explored by Pereira *et al*. (2012) who stated that salinity at concentrations more than 750 ppm negatively affected vegetative growth of *E. contortisiliquum*, especially height, stem diameter and No. leaves to a great extent. Leite *et al*. (2017) declared that as the salt content of a soil increases, it reduces the ability of *E. contortisiliquum* plant to absorb water and nutrients leading to inhibition of biomass production. Recently, Da Silva *et al*. (2019) concluded that proportions of poultry litter more than 35 % added to the commercial substrate for the production of *E. contortisiliquum* seedlings compromise the production due to its relative high salinity.

On the other hand, means of the different top and root growth traits were gradually increased to the maximum as a result of increasing magnetic iron dose to the highest dose (4 g/pot) in most cases of the two seasons. Although Fe_3O_4 at the rate of 2 g/pot significantly raised the means of top and root growth parameters over the control ones, the upper hand was for the rate of 4 g/pot, as it gave significantly the highest values in both seasons. In this regard, Baraga *et al*. (2009) indicated the role of Fe_3O_4

Table (1): Effect of salinity levels, magnetite rates and their interactions on plant height and No. leaves of *Enterolobium contortisiliquum* (Vell.) Morong plant during 2017 and 2018 seasons.

Salinity levels	Plant length (cm)				Number of leaves/plant			
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
First season: 2017								
Control	182.43c	197.33b	209.90a	196.56A	42.33b	43.00b	50.33a	45.22A
1000ppm	99.67g	166.33d	177.67c	147.89B	20.43ef	27.00d	34.00c	27.14B
2000ppm	0.00j	146.33e	146.47e	97.60C	0.00h	24.43de	28.67d	17.70C
3000ppm	0.00j	106.17g	117.67f	74.61D	0.00h	19.77ef	22.10ef	13.96D
4000ppm	0.00j	66.33i	89.30h	51.88E	0.00h	13.00g	18.67f	10.56E
Mean	56.42C	136.50B	148.20A		12.55C	25.44B	30.75A	
Second season: 2018								
Control	189.83bc	196.33b	211.97a	199.38A	44.00b	45.67b	49.67a	46.44A
1000ppm	87.47g	170.00d	180.93c	146.13B	23.33e	27.00de	33.00c	27.78B
2000ppm	0.00i	139.53e	146.70e	95.41C	0.00g	23.57e	30.10cd	17.89C
3000ppm	0.00i	112.90f	117.33f	76.74D	0.00g	16.67f	24.23e	13.63D
4000ppm	0.00i	73.70h	79.83gh	51.18E	0.00g	15.33f	22.90e	12.74D
Mean	55.46C	138.49B	147.35A		13.47C	25.65B	31.98A	

- Means followed by the same letters in row or column are not significantly different according to Duncan's. New Multiple Range t-Test at 5 % level.

Table (2): Effect of salinity levels, magnetite rates and their interactions on stem diameter and root length of *Enterolobium contortisiliquum* (Vell.) Morong plant during 2017 and 2018 seasons.

Salinity levels	Stem diameter (mm)				Root length (cm)			
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
First season: 2017								
Control	14.00ab	13.67bc	13.33c	13.67A	53.67b	51.83bc	57.67a	54.39A
1000ppm	12.00d	14.00ab	14.33a	13.44A	33.60f	48.53c	51.83bc	44.66B
2000ppm	0.00h	12.33d	12.00d	8.11B	0.00g	34.67f	44.27d	26.31C
3000ppm	0.00h	11.00ef	11.33e	7.44C	0.00g	32.53f	39.67c	24.07D
4000ppm	0.00h	10.33g	10.67fg	7.00D	0.00g	34.63f	33.60d	22.74D
Mean	5.20B	12.27A	12.33A		17.45C	40.44B	45.41A	
Second season: 2018								
Control	14.00ab	13.67a-c	14.33a	14.00A	58.80a	50.17b	58.07a	55.68A
1000ppm	13.67a-c	13.33b-d	14.00ab	13.67A	32.83d	51.70b	51.57b	45.37B
2000ppm	0.00g	13.00cd	12.67d	8.56B	0.00e	39.30c	39.67c	26.32C
3000ppm	0.00g	11.33e	11.33e	7.56C	0.00e	32.53d	36.90c	23.14D
4000ppm	0.00g	10.33f	10.00f	6.78D	0.00e	29.83d	31.03d	20.29E
Mean	5.53B	12.33A	12.47A		18.33C	40.71B	43.45A	

- Means followed by the same letters in row or column are not significantly different according to Duncan's New Multiple Range t-Test at 5 % level.

Table (3): Effect of salinity levels, magnetite rates and their interactions on stem fresh weight of *Enterolobium contortisiliquum* (Vell.) Morong plant during 2017 and 2018 seasons.

Salinity levels	Stem fresh weight (g)							
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
	First season: 2017				**Second season: 2018**			
Control	57.57b	66.50a	68.90a	64.32A	61.63b	66.42a	65.43ab	64.49A
1000ppm	20.20hi	42.64d	52.07c	38.30B	19.20g	46.00d	54.27c	39.82B
2000ppm	0.00j	36.97e	43.43d	26.80C	0.00i	34.43e	45.13d	26.52C
3000ppm	0.00j	25.73fg	29.87f	18.53D	0.00i	24.07f	33.23e	19.10C
4000ppm	0.00j	15.70i	21.17gh	12.29E	0.00i	15.04h	19.92g	11.65E
Mean	15.55C	37.51B	43.09A		16.17C	37.19B	43.60A	

- Means followed by the same letters in row or column are not significantly different according to Duncan's. New Multiple Range t-Test at 5 % level.

Table (4): Effect of salinity levels, magnetite rates and their interactions on stem dry weight of *Enterolobium contortisiliquum* (Vell.) Morong plant during 2017 and 2018 seasons.

Salinity levels	Stem dry weight (g)							
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
	First season: 2017				**Second season: 2018**			
Control	20.10b	23.12a	24.93a	22.72A	18.55c	22.29ab	24.03a	21.62A
1000ppm	8.49f	15.54c	19.29b	14.44B	7.53g	14.82d	21.42b	14.59B
2000ppm	0.00g	13.35cd	15.32c	9.56C	0.00h	14.08de	16.96c	10.35C
3000ppm	0.00g	11.79de	12.40d	8.06D	0.00h	11.10f	12.52ef	7.87D
4000ppm	0.00g	8.17f	9.48ef	5.89E	0.00h	8.67g	7.68g	5.45E
Mean	5.72C	14.40B	16.28A		5.22C	14.19B	16.52A	

- Means followed by the same letters in row or column are not significantly different according to Duncan's. New Multiple Range t-Test at 5 % level.

Table (5): Effect of salinity levels, magnetite rates and their interactions on leaves fresh of *Enterolobium contortisiliquum* **(Vell.) Morong plant during 2017 and 2018 seasons.**

Salinity levels	Leaves fresh weight (g)							
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
	First season: 2017				Second season: 2018			
Control	16.90b	18.87a	20.40a	18.72A	16.54b	20.40a	22.20a	19.71A
1000ppm	10.30f	14.13cd	15.90bc	13.45B	10.53e	13.40c	16.90b	13.61B
2000ppm	0.00i	14.47cd	15.03bc	9.83C	0.00g	12.87cd	14.57c	9.14C
3000ppm	0.00i	11.30ef	12.77de	8.02D	0.00g	11.07de	13.33c	8.13C
4000ppm	0.00i	5.94h	8.21g	4.72E	0.00g	6.27f	9.90e	5.39D
Mean	5.44C	12.94B	14.46A		5.41C	12.80B	15.38A	

- Means followed by the same letters in row or column are not significantly different according to Duncan's. New Multiple Range t-Test at 5 % level.

Table (6): Effect of salinity levels, magnetite rates and their interactions on leaves dry weights of *Enterolobium contortisiliquum* **(Vell.) Morong plant during 2017 and 2018 seasons.**

Salinity levels	Leaves dry weight (g)							
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
	First season: 2017				Second season: 2018			
Control	3.11d	3.46c	4.60a	3.72A	2.70ef	3.56c	4.32a	3.53A
1000ppm	1.91f	3.01d	4.01b	2.97B	1.89h	3.00d	4.05b	2.98B
2000ppm	0.00g	3.00d	4.05b	2.35C	0.00i	2.88de	3.98b	2.29C
3000ppm	0.00g	2.36e	3.58c	1.98D	0.00i	2.53f	3.59c	2.04D
4000ppm	0.00g	1.97f	2.03f	1.33E	0.00i	2.07gh	2.24g	1.44E
Mean	1.00C	2.76B	3.65A		0.92C	2.81B	3.63A	

- Means followed by the same letters in row or column are not significantly different according to Duncan's. New Multiple Range t-Test at 5 % level.

Table (7): Effect of salinity levels, magnetite rates and their interactions on roots fresh and dry weights of *Enterolobium contortisiliquum* **(Vell.) Morong plant during 2017 and 2018 seasons.**

Salinity levels	Roots fresh weight (g)				Roots dry weight (g)			
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
	First season: 2017							
Control	67.43b	62.87b	78.21a	69.50A	27.07b	24.99bc	33.47a	28.51A
1000ppm	25.57hi	46.27d	55.83c	42.56B	11.93fg	20.84d	25.33b	19.37B
2000ppm	0.00j	39.65ef	41.50de	27.05C	0.00h	21.07d	25.40b	15.49C
3000ppm	0.00j	28.57hi	35.17fg	21.24D	0.00h	17.17e	21.93cd	13.03C
4000ppm	0.00j	24.40i	30.43gh	18.28D	0.00h	9.03g	13.29f	7.44E
Mean	18.60C	40.35B	48.23A		7.80C	18.62B	23.88A	
	Second season: 2018							
Control	62.87b	59.67bc	73.47a	65.33A	25.63bc	25.10bc	31.80a	27.51A
1000ppm	29.47f	55.40c	54.83c	46.57B	11.13fg	23.27cd	23.77cd	19.39B
2000ppm	0.00h	41.50d	45.73d	29.08C	0.00h	21.87d	26.33b	16.07C
3000ppm	0.00h	31.67ef	35.03e	22.23D	0.00h	18.53e	22.10d	13.54D
4000ppm	0.00h	23.13g	32.10ef	18.41E	0.00h	9.83g	13.20f	7.68E
Mean	18.47C	42.27B	48.23A		7.35C	19.72B	23.44A	

- Means followed by the same letters in row or column are not significantly different according to Duncan's. New Multiple Range t-Test at 5 % level.

(magnetite) in enhancing uptaking of N, P, K and Fe which stimulate plant growth against the harmful effect of salinity. It is suggested that new protein bands are formed in plants that are treated with Fe_3O_4 and these proteins activate vegetative growth of the plant (Hozyan and Abdul-Qados, 2010). In addition, Fe_3O_4 decreases the hydration of salt ions and colloids, having a positive effect on salt solubility leading finally to leaching of the salts (Mostafazadeh *et al*., 2012). In the iron atom, there is a number of valence electrons that generates a magnetic field influence on the biochemical processes in plants, and it renders the roots of plants to exhibit the symptoms of magnetism (Yuliando *et al*., 2016).

These findings are in accordance with those reported by Abdel-Fattah (2014) on *Jacaranda acutifolia*, Ahmed *et al*. (2016) on *Acalypha wilkesiana*, Moustafa *et al*. (2017) on *Moringa oleifera* and Shahin *et al*. (2018) on *Terminalia arjuna*. In this respect, Baraga *et al*. (2009) found that a polyamine (Putrescine) at 5 mM concentration increased germination % and germination velocity index of *Enterolobium schomburgkii* seeds subjected to salt stress with NaCl and $CaCl_2$.

The interactions between salinity and magnetite treatments also exerted a marked effect on top and root growth characters, where the plants received magnetite at either 2 or 4 g/pot and irrigated with fresh water recorded, in general, the utmost high values in the two seasons, with the superiority of the combined treatments of fresh water + 4 g/pot magnetite as it gave the highest records in most measurements. Generally, the gradual increment in salinity of irrigation water was accompanied by a progressive supress in growth rate, which improved by the gradual increase in magnetite dose. This may show the role of magnetite in alleviating salinity hazards through creating an electromagnetic field that helps in releasing the nutrients to the plants and shock the nematodes and microbes on the roots, improving the water balance in the soil, increasing root growth and soil water retention, raising the adequacy of salts washing (3 times the capacity of regular water) and finally removing chlorine and toxic gasses magnetically from the growing medium (Yulianto *et al*., 2016).

The above mentioned results are supported by those reported by Amer (2016) on wheat and maize, Khalil and Abou-Leila (2016) on tomato. Abdel-Hamid and Ghieth (2017) on peach pointed out that magnetized water was better than non- magnetized one in improving shoot length, No. leaves/shoot, leaf area, fruit characteristics and yield, besides, EC, pH, Ca, Mg, K and Na in the soil decreased when irrigated with magnetized water, whereas Fe, Zn, Cu and Mn were increased.

3.1.2. Chemical composition of the leaves

The data listed in Tables (8 & 9) show that the concentrations of chlorophyll a and b and carotenoids (mg/g f.w.) and the percentage of total carbohydrates linearly decreased in the leaves as the concentration of salts cumulatively increased in the irrigation water with few exceptions in the two seasons. The opposite was concerning concentrations of Na and Cl (mg/g d.w.) and proline (mg/g f.w.), which were increased with variable ratios in response to irrigation with saline water (Tables 10 and 11). This may be reasonable because salinity usually depresses the water potential of the soil solution and hence reduces minerals and water uptake by plant roots that is coupled with reducing of photosynthesis and enzymatic system activities. Moreover, higher salinity usually increases the uptake of some highly hydrophilic ions such as Na (Handreck and Black, 2002). It was also suggested that accumulation of some amino acids and amides in the leaves and roots of salinity stressed plants may be referred to *de novo* synthesis and not the result of protein degradation (Gilbert *et al*., 1998).

Magnetic iron however, induced a marked increase in the concentrations of all above mentioned constituents when applied at either 2 or 4 g/pot without dominance of either doses indicating its role in repairing the harmful effects of salinity due to increasing the free proline, that improves the water balance in plant tissues. Besides, magnetite may create a high energy magnetic field in the root medium of the growing plants leading to increase the solubility of N, P, K and Fe nutrients, and this in turn stimulates the absorption of such elements and improves growth (Yulianto *et al*., 2016).

The aforestated constituents were also affected by the interaction treatments, as the concentration of chlorophyll a, b, carotenoids and total carbohydrates reached the maximum in the leaves of plants irrigated with fresh (unsalinized) water and received 4 g/pot Fe_3O_4 dose, followed by those irrigated with 1000 ppm saline water and drenched with 4 g Fe_3O_4 /pot in most instances of both seasons. However, that was true for Na, Cl and free proline concentrations in plants irrigated with the

Table (8): Effect of salinity levels, magnetite rates and their interactions on chlorophyll a and b concentration in the leaves of *Enterolobium contortisiliquum* (Vell.) Morong plant during 2017 and 2018 seasons.

Salinity levels	Chlorophyll (a) (mg/g f.w.)				Chlorophyll (b) (mg/g f.w.)			
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
First season:2017								
Control	1.187	1.187	1.283	1.219	0.358	0.512	0.557	0.476
1000ppm	1.157	1.197	1.290	1.215	0.322	0.358	0.498	0.393
2000ppm	0.000	0.937	1.133	0.690	0.000	0.251	0.394	0.215
3000ppm	0.000	0.760	0.975	0.578	0.000	0.197	0.342	0.180
4000ppm	0.000	0.616	0.870	0.495	0.000	0.143	0.229	0.124
Mean	0.469	0.939	1.110		0.136	0.292	0.404	
Second season:2018								
Control	1.073	1.137	1.353	1.188	0.460	0.507	0.532	0.500
1000ppm	1.043	1.253	1.327	1.208	0.372	0.480	0.517	0.456
2000ppm	0.000	0.940	1.203	0.714	0.000	0.322	0.447	0.256
3000ppm	0.000	0.709	0.963	1.490	0.000	0.212	0.331	0.181
4000ppm	0.000	0.637	0.860	0.499	0.000	0.127	0.258	0.128
Mean	0.423	0.935	1.141		0.166	0.330	0.417	

Table (9): Effect of salinity levels, magnetite rates and their interactions on carotenoids and total carbohydrates concentration in the leaves of *Enterolobium contortisiliquum* (Vell.) Morong plant during 2017 and 2018 seasons.

Salinitylevels	Carotenoids (mg/ g d.w)				Total carbohydrates (%)/D.W			
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
First season:2017								
Control	0.551	0.601	0.601	0.584	31.37	35.85	33.57	33.59
1000ppm	0.347	0.428	0.428	0.401	22.40	30.08	32.53	28.34
2000ppm	0.000	0.227	0.227	0.151	0.00	26.74	28.64	18.46
3000ppm	0.000	0.195	0.195	0.130	0.00	24.70	26.74	17.15
4000ppm	0.000	0.171	0.171	0.114	0.00	19.93	21.35	13.76
Mean	0.180	0.324	0.324		10.75	27.46	28.57	
Second season:2018								
Control	0.544	0.614	0.571	0.576	33.68	33.80	33.68	33.72
1000ppm	0.330	0.446	0.504	0.427	24.47	29.73	32.73	28.98
2000ppm	0.000	0.250	0.362	0.204	0.00	27.37	29.01	18.79
3000ppm	0.000	0.212	0.321	0.178	0.00	24.27	28.25	17.50
4000ppm	0.000	0.177	0.270	0.149	0.00	20.67	22.60	14.42
Mean	0.175	0.340	0.406		11.63	27.17	29.25	

highest level of saline water (4000 ppm) and drenched with either 2 or 4 g Fe_3O_4/pot. These gains are in line with those postulated by Baraga *et al*. (2009) on *Enterolobium schomburgkii*, Abdel-Fattah (2014) on *Jacaranda acutifolia* and Ahmed *et al.* (2016) who elicited that applying magnetite at 6 g/pot (4 times) at 2 month interval to salinized soil mixture improved tolerance of *Acalypha wilkesiana* transplants to salinity up to 6000 ppm concentration. Likewise, Khalil and Abou- Leila (2016) indicated that magnetic iron at either 2 or 4 g/plant significantly increased yield, vitamin C, acidity and carotenoids content of tomato fruit husk irrigated with saline water up to 6000 ppm.

Accordingly, because *Enterolobium contortisiliquum* seedlings are sensitive to salinity, it can be recommended to drench the soil with magnetite at 4 g/plant, monthly during the growing season to avoid hazards caused by salinity stress.

Table (10): Effect of salinity levels, magnetite rates and their interactions on sodium and chloride concentration in the leaves of *Enterolobium contortisiliquum* (Vell.) Morong plant during 2017 and 2018 seasons.

Salinity levels	Na (mg /g d.w)				Cl (mg /g d.w)			
	(Magnetite) Fe_3O_4 rate (g/plant)							
	Control	2 gm	4 gm	Mean	Control	2 gm	4 gm	Mean
First season:2017								
Control	1.210	1.037	1.017	1.088	1.170	1.180	1.105	1.152
1000ppm	1.757	1.627	1.697	1.694	1.850	1.723	1.830	1.801
2000ppm	0.000	2.097	2.083	1.393	0.000	2.253	2.147	1.467
3000ppm	0.000	2.157	2.147	1.435	0.000	2.280	2.077	1.452
4000ppm	0.000	2.490	2.350	1.613	0.000	2.617	2.490	1.702
Mean	0.593	1.882	1.859		0.604	2.011	1.930	
Second season:2018								
Control	1.220	1.077	1.027	1.108	1.130	1.217	1.120	1.156
1000ppm	2.017	1.660	1.527	1.735	2.097	1.827	1.687	1.870
2000ppm	0.000	2.230	1.957	1.396	0.000	2.227	1.933	1.387
3000ppm	0.000	2.263	2.200	1.488	0.000	2.363	2.100	1.488
4000ppm	0.000	2.587	2.327	1.638	0.000	2.687	2.487	1.725
Mean	0.647	1.963	1.808		0.645	2.064	1.865	

Table (11): Effect of salinity levels, magnetite rates and their interactions on proline concentration in the leaves of *Enterolobium contortisiliquum* (Vell.) Morong plant during 2017 and 2018 seasons.

Salinity levels	Proline (mg/ g f.w)			
	(Magnetite) Fe_3O_4 rate (g/plant)			
	Control	2 gm	4 gm	Mean
First season:2017				
Control	1.633	1.590	1.687	1.637
1000ppm	2.070	2.083	2.080	2.078
2000ppm	0.000	2.273	2.247	1.507
3000ppm	0.000	2.573	2.660	1.744
4000ppm	0.000	2.717	2.770	1.829
Mean	0.741	2.247	2.289	
Second season:2018				
Control	1.747	1.713	1.657	1.706
1000ppm	2.097	2.023	2.323	2.148
2000ppm	0.000	2.210	2.300	1.503
3000ppm	0.000	2.663	2.820	1.828
4000ppm	0.000	2.657	2.840	1.832
Mean	0.769	2.253	2.388	

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خفض التأثير الضار لمياه الري المالحة على نمو وجودة شتلات شجرة أذن الفيل
(*Enterolobium contortisiliquum*) (Vell. Morong)

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ملخص

لتجنب أضرار ملوحة مياه الري على شتلات شجرة أذن الفيل (*Enterolobium contortisiliquum* (Vell.) Morong) أجريت هذه الدراسة في الحقل المكشوف المعرض للشمس الساطعة بمشتل معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر خلال موسمي 2017، 2018. تم استخدام شتلات متماثلة، عمرها ستة أشهر، حيث تم شتلها في أصص بلاستيك قطرها 30 سم ومملوءة بحوالي 5.5 كجم من مخلوط الرمل والطين بنسب متساوية (1:1 حجما)، وقد أضيف إليها تكبيشاً الماجنتيت (الحديد الممغنط) شهرياً بمعدلات: صفر، 2، 4 جم/أصيص (نبات). وقد رويت النباتات بعد أسبوعين من الزراعة بالماء المالح بتركيزات: صفر، 1000، 2000، 3000 و 4000 جزء في المليون من مخلوط متساوي وزنا من أملاح كلوريد الصوديوم وكلوريد الكالسيوم. أيضاً تم دراسة تأثير المعاملات المشتركة بين جرعات الماجنيتيت والري بالماء المالح. أوضحت النتائج المتحصل عليها أن ري النباتات بالماء المالح بتركيزات أعلى من 1000 جزء في المليون بدون المعاملة بالماجنيتيت ادي الي موت الشتلات، بينما ادت المعاملات المضاف اليها الماجنيتيت (بمعدل 2، 4 جم/نبات) بصرف النظر عن تركيز ملوحة مياه الري الي عدم موت النباتات. إلا أن متوسطات صفات النمو الخضري والجذري (طول النبات، قطر الساق، عدد الأوراق/نبات، طول الجذر، الوزن الطازج والجاف للساق، الأوراق والجذور) لهذه النباتات قد انخفضت تدريجياً بزيادة تركيز الملوحة لتصل إلى أدنى القيم مع التركيز الأعلى من الأملاح (4000 جزء في المليون). ولقد كان العكس صحيحاً فيما يتعلق بتأثير الماجنتيت، حيث زادت متوسطات قياسات النمو الخضرى والجذرى سالفة الذكر تدريجياً كلما زادت جرعة الماجنيتيت المضافة، مع تفوق الجرعة 4 جم/أصيص والتي سجلت أعلى قيم النمو الخضري في معظم الحالات بكلا الموسمين، ولقد تأثرت صفات النمو السابقة بالمعاملات المشتركة، حيث سجلت النباتات التي عوملت بالماجنتيت (2، 4 جم/أصيص) ورويت بالماء العذب أعلى المتوسطات مقارنة بالكنترول، مع تفوق التفاعل المشترك بين الري بالماء العذب والمعاملة بالماجنتيت بمعدل 4 جم/أصيص والذي أعطى قيماً أعلى في معظم القياسات. ولقد تم الحصول على اتجاه مشابه فيما يتعلق بالتركيب الكيماوي للأوراق، حيث انخفضت تركيزات الكلوروفيل (أ، ب)، الكاروتينويدات والكربوهيدرات الكلية تدريجياً، بينما زادت تركيزات عنصر الصوديوم، الكلوريد والبرولين بشكل تصاعدي وبنسب متفاوتة كلما زاد تركيز الملوحة في مياه الري. بينما ادي اضافه الماجنيتيت الي تحسين تركيزات هذه المكونات بغض النظر عن تركيز ملوحة المياه المستخدمة في الري،ووجد ان ري النباتات بالماء العذب مع اضافه الماحنيتيت بمعدل 4 جم/نبات اعطت أعلى القيم لتركيزات الكلوروفيلل (أ، ب)، الكاروتينويدات والكربوهيدرات الكلية، بينما أعلى تركيزات للصوديوم والكلوريد والبرولين في الاوراق وجدت مع معاملة الري بالماء المالح بتركيز 4000 جزء في المليون واضافه الحديد الممغنط بمعدل 2 أو 4 جم/نبات. بناء على ما سبق، فإنه لحماية شتلات شجرة أذن الفيل (*Enterolobium contortisiliquum* (Vell.) Morong) من أضرار الري بالماء المالح يمكن النصح بإضافة الحديد الممغنط (الماجنيتيت) للتربة تكبيشاً بمعدل 4 جم/نبات، مرة كل شهر خلال موسم النمو.

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