USAGE OF MAGNETIC IRON TO RAISE TOLERANCE OF SOME ORNAMENTAL TREES AND SHRUBS TO SOIL SALINITY IN CASE OF CHINA ROSE (*HIBISCUS ROSA-SINENSIS* L.)

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Abstract. An investigation was conducted at Orman Botanical Garden, Giza, Egypt to reveal the role of magnetite at 2 or 4 g/pot in reducing the harmful effects of NaCl + $CaCl_2$ salt mixture added to the soil mixture at various concentrations, on growth and quality of Chinese hibiscus transplants. Interaction effect was also studied. The results showed that hibiscus transplants attained 100% survival, even at 8000 ppm salinity level and the absence of magnetic iron. However, means of the different vegetative and root characteristics were progressively decreased as the concentration of salinity was increased scoring minimal values at the highest concentration. The opposite was true regarding magnetite treatments. A marked improvement in growth was also acquired by the different interaction treatments with superiority of combining between any level of salinity and the high rate of magnetite. The percentage of salt resistance index exhibited a descending decrement with salinity level increment, but it was, generally higher than 50% even at the high salinity level. A similar trend was obtained regarding leaf chemical composition, with few exceptions in both seasons. Accordingly, it is advised to apply magnetite at 4 g/pot rates to saline soil for better growth of *Hibiscus rosa-sinensis* L. transplants.
Keywords: *Hibiscus rosa-sinensis L., soil salinity, magnetic iron, chemical composition*

Introduction

China Rose or Chinese hibiscus (*Hibiscus rosa-sinensis* L.) Fam. Malvaceae is one of the most beautiful, evergreen flowering shrubs used widely for landscape in Egypt. It is a large shrub, grow up to 5-7 m height, leaves usually simple ovate to 8-10 cm long, not lobed but toothed or nearly entire. It is native to subtropical and tropical areas as an ornamental plant for its glossy, flourish leaves and very large flowers that are born solitary in many colors on the leaf axils, for hedging and also glasshouses for summer bloom. It is easily propagated by cuttings, grafting and layering (Bailey, 1976).

Concerning its tolerance to salinity, Kratsch et al. (2008) categorized such ornamental shrub as sensitive to salinity, due to its tolerance of salts up to 650 ppm. On the other side, Mcfarland et al. (2014) found that it can tolerate soil salinity up to 2500 ppm, but can tolerate salinity of irrigation water up to 1250 ppm only. So, it considered moderately sensitive to salts. Moreover, Khafagy et al. (2013) reported that it can tolerate the low level of diluted seawater (10%), but higher levels (up to 40%) gradually decreased all growth characters. That was documented by Ahmed (2017) who revealed that soil salinity higher than 2000 ppm clearly depressed it growth and flowering.

Many salinity disorders, such as plant growth reduction, delay flowering, decrease flower quality, tip and marginal leaf burn as a result of Na and Cl accumulation, and finally decreasing of aesthetical value of the plant were explored before by Mahmoud et al. (2008) on *Dovyalis caffra* and *Lantana camara*, Cassaniti et al. (2013) on

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Chrysanthemum morifolium, *Dianthus cartophyllus*, *Gerberra jamesonii*, *Hippeastrum vittatum* and *Anthurium andreanum*, Shahin et al. (2014) on tall fescue (*Festuca arundinacea* var. Festoria), El-Shewaikh et al. (2015) on areca (*Dypsis lutescens*), El-Sayed et al. (2015) on saltbush (*Atriplex halimus*) and Shahin et al. (2017) on *Casuarina equisetifolia* and *Eucalyptus rostrata*. However, these disorders were corrected by some applicable ways elicited by Ahmed et al. (2011) on roselle (*Hibiscus sabdariffa*) Khafagy et al. (2013) and Ahmed (2017) on *H. rosa-sinensis*, Abdel-Fattah (2014) on *Jacaranda acutifolia*, Ahmed et al. (2016) on *Acalypha wilkesiana* and El-Sayed et al. (2019) on *Enterolobium contortisiliquum*.

The purpose of this trial was to evaluate the role of magnetite in alleviating injury of soil salinity on growth and aesthetical performance of Chinese hibiscus during rearing in the nursery.

Materials and methods

In order to find out the function of magnetic iron to mitigate damage of salinized soils on growth and flowering of China rose transplants an experiment was consummated under the full sun, temperature between (27-38^{o}c) the average percentage of humidity is 56% throughout the course of study at nursery of Orman Botanical Garden, Giza, Egypt during 2018 and 2019 consecutive seasons to determine the importance of this natural ore in enhancing growth of this plant under such stress.

Therefore, 4-months-old, uniform transplants of China rose of 17-18 cm height, carrying about 8-9 leaves were planted on April, 1st for each season in 15-cm-diameter polyethylene black bags (one transplant/bag) filled with about 3.5 kg of sand and clay mixture at equal volume parts (1:1, v/v). The physical and chemical properties of the soil mixture used in both seasons were measured and listed in *Table 1*.

Table 1. *The physical and chemical analysis of the soil mixture used in 2018 and 2019 seasons*

Soil mixture	**Particle size distribution (%)**				**S.P.**	**E.C. (dS/m)**	**pH**	**Cations (meq/l)**			
Sand + Clay (1:1, v/v)	Coarse sand	Fine sand	Silt	Clay				Ca^{++}	Mg^{++}	Na^{+}	K^{+}
	38.6	31.3	20.6	9.5	25	6.5	7.86	17.8	14.2	33.1	0.9
Soil texture	**Anions (meq/l)**				**Macro-and micro-elements (ppm)**						
	HCO_3^-	Cl^-	SO_4^{--}	CO_3	N	P	K	Fe	Zn	Mn	Cu
Sandy clay	2.10	58.40	5.50	0.00	173.10	15.78	361.76	15.80	4.36	8.03	8.81

Immediately before planting, the soil mixture was salinized with a mixture of NaCl and $CaCl_2$ pure salts at equal weight parts (1:1, g/g) at the concentrations of 0, 2000, 4000, 6000 and 8000 ppm, while after planting the soil mixture was well mixed with magnetic iron ore (Fe_3O_4, 22.5%) obtained from Alahram Mining Co., Maadi, Cairo at the rates of 0, 2 and 4 g/plant, added as one batch at the commencing of the season. Salinity and magnetite treatments were connected factorially to create fifteen interactions.

During the course of the study, the plants under the different experimental treatments were fertilized 3 times with 2 g/plant of a compound chemical fertilizer (NPK + microelements i.e., Kristalon 19: 19: 19) and watered day by day. Besides, the various agricultural practices required for such plantation were carried out whenever needed. A factorial experiment based

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on a complete randomized design was accomplished in the two seasons, replicated thrice with five transplants for each replicate (Mead et al., 1993). The magnetite treatments represented the main factor and salinity levels represented the sub-factor.

At the end of each season (on October, 1st), the following data were recorded: survival (%), plant height (cm), stem diameter (cm), number of branches/plant, number of leaves/plant, leaf area (cm^2) using a planimeter, root length (cm), aerial parts and roots fresh and dry weights (g) after removing the soil under running water then lefts to dry and salt resistance index as a percentage (SRI %) which was estimated from the equation of Wu and Huff (1983) as follows:

$$\text{SRI (\%)} = \frac{\text{Mean root length of the longest root in salt treated plant}}{\text{mean root length of the longest root in control one}} \times 100$$

Furthermore, the benefit coefficient of magnetite (Fe_3O_4) under various salinity levels as a percentage (B. Coe %) was calculated from the following equation:

$$\text{B. Coe (\%)} = \frac{\text{Increase rate in dry matter of treated plant}}{\text{dry matter of control one}} \times 100$$

In the second season only, concentrations of photosynthetic pigments (chlorophyll a, b and carotenoids, mg/g f.w.) were assessed in fresh leaf samples using the method of Sumanta et al. (2014), whereas in dry ones, the percentages of nitrogen, phosphorus as well as potassium, sodium and chloride were measured according to the methods of Blake (1965), Luatanab and Olsen (1965) and Jackson (1973), consecutively. Proline concentration (g/100 g d.w.) was evaluated in dry leaf sample using the method of Batels et al. (1973).

Data were statistically analyzed using the computer program of SAS Institute (2009) and Duncan's New Multiple Range to compare among means of treatments (Steel and Torrie, 1980).

Results

Effect of soil salinity, magnetite and their interaction on vegetative and root growth parameters

It is obvious from data presented in *Table 2* that no mortality was occurred among transplants subjected to salinity concentration up to 8000 ppm, giving 100% survival % in the two seasons, although (*Tables 3-6*) means of plant height (cm) stem diameter (cm), No. branches and leaves / plant, leaf area (cm^2), root length (cm) and aerial parts and roots fresh and dry weights (g) were progressively declined with increasing salinity level to become the least at 8000 ppm concentration in both seasons. On the contrary, a gradual elevating in values of the previously stated traits was occurred as the rate of Fe_3O_4 was raised. Therefore, the utmost high means were attained by 4 g/pot rate in the two seasons. Interacting between salinity treatments and magnetite rates recorded also a marked improvement in averages of all vegetative and root growth characters mentioned above irrespective of salinity concentration. However, combining between salinity levels and 4 g magnetic iron/pot dose fulfilled higher records than salinity levels + 2 g/pot magnetite combination in most cases of both seasons.

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Table 2. *Effect of salinity levels, magnetite rates and their interactions on survival and height of Hibiscus rosa-sinensis L. plant during 2018 and 2019 seasons*

Fe_3O_4 rate (g/plant) / **Salinity level (ppm)**	**Survival (%)**				**Plant height (cm)**			
	0.00	**2 g**	**4 g**	**Mean**	**0.00**	**2 g**	**4 g**	**Mean**
	First season 2018							
0.00	100.00a	100.00a	100.00a	100.00A	37.00g	45.00c	55.43a	45.81A
2000	100.00a	100.00a	100.00a	100.00A	38.53f	42.30d	47.07b	42.63B
4000	100.00a	100.00a	100.00a	100.00A	35.83h	39.30ef	42.80d	39.31C
6000	100.00a	100.00a	100.00a	100.00A	34.13i	37.07g	40.17e	37.12D
8000	100.00a	100.00a	100.00a	100.00A	31.00j	33.27i	36.48gh	33.58E
Mean	100.00 A	100.00 A	100.00 A	–	35.30C	39.39B	44.39A	–
	Second season 2019							
0.00	100.00a	100.00a	100.00a	100.00A	36.33d	40.00b	47.07a	41.13A
2000	100.00a	100.00a	100.00a	100.00A	32.10g	38.00c	40.90b	37.00B
4000	100.00a	100.00a	100.00a	100.00A	29.87h	35.33d	37.53c	34.24C
6000	100.00a	100.00a	100.00a	100.00A	27.77i	32.63f	33.90e	31.43D
8000	100.00a	100.00a	100.00a	100.00A	25.67j	28.87hi	31.13g	28.56E
Mean	100.00 A	100.00 A	100.00 A	–	30.35C	34.97B	38.11A	–

Mean followed by the same letter in a column or row do not differ significantly according to Duncan's new multiple range test

Table 3. *Effect of salinity levels, magnetite rates and their interactions on stem diameter and No. branches/plant of Hibiscus rosa-sinensis L. plant during 2018 and 2019 seasons*

Fe_3O_4 rate (g/plant) / **Salinity level (ppm)**	**Stem diameter (cm)**				**No. branches/plant**			
	0.00	**2 g**	**4 g**	**Mean**	**0.00**	**2 g**	**4 g**	**Mean**
	First season 2018							
0.00	0.500fg	0.667ab	0.700a	0.622A	2.67cd	3.00c	4.00a	3.22A
2000	0.467g	0.567de	0.633bc	0.556B	2.67cd	3.00c	3.50b	3.06B
4000	0.600cd	0.600cd	0.600cd	0.600A	2.67cd	3.00c	3.00c	2.89B
6000	0.533ef	0.567de	0.600cd	0.567B	2.33de	2.67cd	2.67cd	2.56C
8000	0.533ef	0.533ef	0.567de	0.544B	1.67f	1.67f	2.00ef	1.78D
Mean	0.427C	0.587B	0.620A	–	2.40C	2.67B	3.03A	–
	Second season 2019							
0.00	0.410fg	0.557b	0.613a	0.527A	1.67g	2.33e	2.67cd	2.22C
2000	0.387g	0.463de	0.513c	0.454BC	2.00f	3.00b	3.33a	2.78A
4000	0.470de	0.477cd	0.467de	0.471B	1.67g	2.83bc	3.00b	2.50B
6000	0.437d-f	0.433ef	0.440d-f	0.437CD	1.63g	2.67cd	2.83bc	2.38BC
8000	0.440d-f	0.407fg	0.417fg	0.421D	1.27h	1.83fg	2.44de	1.84D
Mean	0.429C	0.467B	0.490A	–	1.65C	2.53B	2.85A	–

Mean followed by the same letter in a column or row do not differ significantly according to Duncan's new multiple range test

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Table 4. *Effect of salinity levels, magnetite rates and their interactions on leaf and root length and root callar diameter of Hibiscus rosa-sinensis L. plant during 2018 and 2019 seasons*

Fe_3O_4 rate (g/plant) / Salinity level (ppm)	No. leaves/plant				Leaf area (cm^2)				Root length (cm)			
	0.00	2 g	4 g	Mean	0.00	2 g	4 g	Mean	0.00	2 g	4 g	Mean
	First season 2018											
0.00	33.67e	42.33b	48.67a	41.56A	28.40cd	30.77b	33.57a	30.91A	33.33e	36.40c	40.67a	36.80A
2000	32.67e	39.37c	42.03b	38.02B	27.40de	29.53c	33.23a	30.06B	32.03e	35.00d	38.50b	35.18B
4000	29.07f	34.43e	37.10d	33.53C	25.37f	27.20de	30.97b	27.84C	27.77g	30.63f	32.87e	30.42C
6000	24.77g	29.03f	34.27f	29.36D	22.50h	23.97g	26.90e	24.46D	24.37i	26.40h	28.60g	26.46D
8000	20.67h	23.03g	30.17f	24.62E	20.00i	21.70h	24.17fg	21.96E	19.70k	21.60j	23.43i	21.58E
Mean	28.17C	33.64B	38.45A	–	24.73C	26.63B	29.77A	–	27.44C	30.01B	32.81A	–
	Second season 2019											
0.00	32.40cd	36.60b	40.87a	36.62A	33.00d	39.43b	41.60a	38.01A	19.33h	22.73de	31.00a	24.36A
2000	29.10e	33.80c	35.47b	32.79B	29.47f	32.80d	37.27c	33.18B	17.40ij	21.20fg	27.07b	21.89B
4000	26.43f	31.33d	32.50cd	30.09C	24.43ij	28.90f	33.20d	28.84C	16.80j	20.10gh	25.50c	20.80C
6000	24.47g	27.93e	29.17e	27.19D	23.93j	27.00gh	30.93e	27.29D	16.10jk	19.27h	23.77d	19.71D
8000	21.83h	24.83g	26.47f	24.38E	21.33k	25.77hi	28.10fg	25.07E	15.03k	17.70i	21.80ef	18.18E
Mean	26.85C	30.90B	32.89A	–	26.43C	30.78B	34.22A	–	17.60C	20.20B	25.83A	–

Mean followed by the same letter in a column or row do not differ significantly according to Duncan's new multiple range test

Table 5. *Effect of salinity levels, magnetite rates and their interactions on aerial parts fresh and dry weights of Hibiscus rosa-sinensis L. plant during 2018 and 2019 seasons*

Fe_3O_4 rate (g/plant) / Salinity level (ppm)	Aerial parts fresh weights (g)				Aerial parts dry weights (g)			
	0.00	2 g	4 g	Mean	0.00	2 g	4 g	Mean
	First season 2018							
0.00	42.27d	47.10b	52.20a	47.19A	12.40d	13.80b	17.43a	15.54A
2000	37.67e	41.53d	44.33c	41.18B	10.76d	12.18c	14.37b	12.44B
4000	35.10g	34.60f	38.70e	36.13C	9.70e	10.10de	12.90c	10.90C
6000	26.90h	28.43h	32.07g	29.13D	7.50g	8.37f	10.43de	8.77D
8000	20.57j	21.03j	24.00i	21.87E	5.43h	6.07h	8.00fg	6.50E
Mean	32.50C	34.54B	38.26A	–	9.16C	10.10B	12.63A	–
	Second season 2019							
0.00	23.97d	25.93c	32.17a	27.36A	8.80ef	9.87cd	12.67a	10.44A
2000	21.53e	24.07d	27.87b	24.49B	8.13fg	9.27de	11.63b	9.68B
4000	19.40f	21.80e	25.17cd	22.12C	7.14h	8.23fg	10.53c	8.63C
6000	16.40g	19.17f	22.10e	19.22D	5.80jk	7.00hi	9.30e	7.37D
8000	13.83h	16.73g	19.87f	16.81E	4.90k	6.10ij	7.63gh	6.21E
Mean	19.03C	21.54B	25.43A	–	6.95C	8.09B	10.35A	–

Mean followed by the same letter in a column or row do not differ significantly according to Duncan's new multiple range test

Salt resistance index (SRI %) and benefit coefficient of magnetite (B. coe. %)

As shown in *Table 7*, a progressive decrease in the percentages of salt resistance index was acquired due to the gradual increment in salinity concentration to reach the least values by 8000 ppm level in the two seasons. However, these values were higher

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than 50% at such high concentration (8000 ppm); 58.78% in the first season and 75.14% in the second one pointing to the good tolerance of Chinese hibiscus to soil salinity up to 8000 ppm. On the other side, adding Fe_3O_4 was found to be out of order, especially at 4 g/pot rate, which gave means for such index closely near to those of control ones. The rates of 2 g/pot, however, slightly improved the percent of this index in the 1st season, whilst in the second one, caused a significant increase in it. Moreover, combining between magnetite (especially at 4 g/pot dose) and various salinity levels was worthless compared to control treatment in the two seasons. Thus, application of Fe_3O_4 may be unvalued to improve resistance of Chinese hibiscus to soil salinity. This result may be unexpected and deserve more investigation to confirm it.

The opposite was the right concerning the benefit coefficient of magnetite percentages (*Table 7*) that cleared a great benefit for applying of Fe_3O_4 in production of dry matter, especially at the high salinity concentration (8000 ppm) in the first season and at 4000, 6000 and 8000 ppm concentrations in the second one. In addition, drenching the soil mixture with magnetic iron at the rate of 4 g/pot attained the highest benefit for dry matter formation in both seasons, followed by 2 g/pot rate relative to control treatment. Results of the combined treatments in the first season were fluctuated except for 8000 ppm level + magnetite at any rate combination which showed higher benefit than other combinations. In the second season, all combinations cleared more advantage than control ones giving heaviest dry matter at all.

Table 6. *Effect of salinity levels, magnetite rates and their interactions on roots fresh and dry weights of Hibiscus rosa-sinensis L. plant during 2018 and 2019 seasons*

Fe_3O_4 rate (g/plant) / Salinity level (ppm)	Roots fresh weights (g)				Roots dry weights (g)			
	0.00	**2 g**	**4 g**	**Mean**	**0.00**	**2 g**	**4 g**	**Mean**
	First season 2018							
0.00	13.97d	16.80b	17.57a	16.11A	6.20ef	7.07c	8.40a	7.22A
2000	13.00e	15.77c	16.53b	15.10B	5.73g	6.57de	7.87b	6.72B
4000	11.27g	13.87d	13.97d	13.03C	5.00h	5.80fg	6.70cd	5.83C
6000	9.80h	11.70fg	12.10f	11.20D	4.37i	4.90h	5.87fg	5.04D
8000	8.07i	9.77h	10.10h	9.31E	3.57j	4.13j	4.83h	4.18E
Mean	11.22C	13.58B	14.05A	–	4.97C	5.69B	6.73A	–
	Second season 2019							
0.00	5.40e	6.47cd	9.53a	7.13A	3.43d-f	3.70b-d	4.53a	3.89A
2000	4.90ef	6.07d	8.37b	3.45B	3.07gh	3.60c-e	3.90b	3.52B
4000	4.70ef	5.80de	7.88bc	6.13C	2.83hi	3.33e-g	3.73bc	3.30C
6000	4.50f	5.60de	7.03c	5.71D	2.70ij	3.10gh	3.30fg	3.03D
8000	4.20g	5.01e	6.40cd	5.20E	2.43j	2.87hi	3.00h	2.77E
Mean	4.74C	5.79B	7.84A	–	2.89C	3.32B	3.69A	–

Mean followed by the same letter in a column or row do not differ significantly according to Duncan's new multiple range test

Chemical composition of the leaves

As shown in *Table 8*, concentrations of chlorophyll a, b and carotenoids (mg/g. f. w.) and the percentages of N, P and K exhibited a gradual decrease as a result of the progressive increment in salinity level, whereas Na and Cl percentages and proline

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(mg/100 g d. w.) were linearly increased. On the other hand, drenching the soil mixture with magnetite successively raised chlorophyll a, b, N, P and K concentrations as the rate of magnetite was increased, but concentrations of carotenoids, Na, Cl and proline were cumulatively declined. Generally, the combining between salinity level up to 4000 ppm and magnetic iron at the rate of 4 g/plant recorded the utmost high concentrations of chlorophyll a, b, N, P and K, but that was true for carotenoids when plants grown in no salinized soil mixture and abandoned of Fe_3O_4, and for Na, Cl and proline constituents when plants cultured in soil mixture which received 8000 ppm salinity level in the absence of Fe_3O_4.

The results pronouncedly clear that magnetite application markedly reduced Na^+ and Cl^- toxic ions leading to mitigating their deleterious effects on growth and performance of Chinese hibiscus plants. As Na and Cl concentration was decreased by raising Fe_3O_4 rate the concentration of proline was diminished due to alleviating salt stress.

Table 7. *Effect of salinity levels, magnetite rates and their interactions on resistance index and benefit coefficient of Hibiscus rosa-sinensis L. plant during 2018 and 2019 seasons*

Fe_3O_4 rate (g/plant) / Salinity level (ppm)	Resistance index (%)				Benefit coefficient of Fe_3O_4			
	0.00	**2 g**	**4 g**	**Mean**	**0.00**	**2 g**	**4 g**	**Mean**
	First season 2018							
0.00	100.00a	100.00a	100.00a	100.00A	0.00g	11.41e	40.50b	17.80B
2000	96.33b	96.28b	94.69b	95.76B	0.00g	13.48d	33.93c	15.51C
4000	83.44c	84.25c	84.18c	83.96C	0.00g	7.83f	33.59c	13.81D
6000	73.24d	72.78de	70.40e	72.14D	0.00g	11.88de	39.84b	17.24B
8000	59.16f	59.43f	57.75f	58.78E	0.00g	12.02de	47.38a	19.80A
Mean	82.43AB	82.55A	81.40B	–	0.00C	11.32B	39.05A	–
	Second season 2019							
0.00	100.00a	100.00a	100.00a	100.00A	0.00g	12.15h	43.90d	18.68C
2000	66.60h	93.22b	87.70cd	82.51C	0.00g	13.93gh	42.84d	18.92C
4000	86.88cd	88.38c	82.54e	85.93B	0.00g	15.38g	47.68c	21.02B
6000	83.24e	84.74de	77.13f	81.71C	0.00g	19.71f	59.78a	26.50A
8000	78.16f	76.55f	70.71g	75.14D	0.00g	24.51e	55.94b	26.82A
Mean	83.97B	88.58A	83.62B	–	0.00C	17.14B	50.03A	–

Mean followed by the same letter in a column or row do not differ significantly according to Duncan's New Multiple Range test

Discussion

Effect of soil salinity, magnetite and their interaction on vegetative and root growth parameters

From the previous results it was notice that the adverse effects of saline soil on growth may be attributed to either low water uptake due to low potential of soil water (Munns, 2002) or certain ion toxicity (Na^+ and Cl^-) or both (Carter et al., 2005). This fact was emphasized by Elhag and Abdalla (2014) who stated that salinity depresses plant growth via affecting water absorption and biochemical processes such as N, CO_2 assimilation and protein biosynthesis or accumulated high concentration of potentially toxic ions (Na^+ and Cl^-). Jose et al. (2016) ascribed the reduction in growth by salinity

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to the effect of osmotic stress and the inhibition of cell division rather than cell expansion coupled with the great reduction in photosynthesis. High salinity also leads to leaf abscission due to ion accumulation in the leaves, particularly the oldest ones. Reduction of growth by salinity may be attributed to a decrease in all volume at a constant cell number. Mechanism of salt may result in inhibition of cell division, consequently reduces the rate of plant development (Khan et al., 2009). Jou et al. (2006), however suggested that ATPase participates in the endoplasmic reticulum-Golgi mediated, protein sorting machinery for both housekeeping function and compartmentalization of excess Na^+ under high salinity.

Table 8. *Effect of salinity levels, magnetite rates and their interactions on some constituent's concentrations in the leaves of Hibiscus rosa-sinensis L. plants during 2019 seasons*

Fe3O4 rate (g/plant) / Salinity level (ppm)	**Chlorophyll a (mg/g f.w.)**				**Chlorophyll b (mg/g f.w.)**				**Carotenoids (mg/g f.w.)**			
	0.00	**2 g**	**4 g**	**Mean**	**0.00**	**2 g**	**4 g**	**Mean**	**0.00**	**2 g**	**4 g**	**Mean**
	First season 2018											
0.00	2.320d	2.673b	3.040a	2.678A	0.887cd	1.006b	1.163a	1.019A	0.819a	0.533c	0.537c	0.630A
2000	1.765h	2.135f	2.669b	2.190B	0.794ef	0.845de	1.056b	0.898B	0.658b	0.494d	0.461e	0.538B
4000	1.512j	2.258e	2.605c	2.125C	0.687g	0.799ef	0.932c	0.806C	0.447e	0.410fg	0.418f	0.425C
6000	1.450c	1.610i	1.821i	1.627D	0.689g	0.743fg	0.940c	0.791C	0.450e	0.381gh	0.394fg	0.408D
8000	0.675n	0.811m	1.062l	0.849E	0.553h	0.680g	0.710g	0.648D	0.387gh	0.359h	0.380gh	0.375E
Mean	1.545C	1.898B	2.239A	–	0.722C	0.815B	0.960A	–	0.552A	0.436B	0.438B	–
	N (%)				P (%)				K (%)			
	0.00	2 g	4 g	Mean	0.00	2 g	4 g	Mean	0.00	2 g	4 g	Mean
0.00	3.475d	3.861b	4.147a	3.828A	0.829a	0.843a	0.854a	0.842A	1.696e	1.983b	2.012a	1.897A
2000	3.088g	3.187e	3.501c	3.259B	0.753b	0.758b	0.775b	0.762B	1.552f	1.753d	1.892c	1.732B
4000	2.779i	2.891h	3.153f	2.941C	0.599d	0.671c	0.698c	0.656C	1.208j	1.394h	1.534g	1.380C
6000	2.303l	2.376k	2.575j	2.418D	0.493e	0.550d	0.563d	0.535D	1.087k	1.223j	1.350i	1.220E
8000	1.843o	1.873n	1.991m	1.902E	0.392f	0.456e	0.457e	0.435E	1.879c	0.980l	1.080k	1.313D
Mean	2.698C	2.838B	3.073A	–	0.613B	0.656A	0.669A	–	1.484B	1.467C	1.574A	–
	Na (%)				Cl (%)				Proline (mg/100 g f.w.)			
	0.00	2 g	4 g	Mean	0.00	2 g	4 g	Mean	0.00	2 g	4 g	Mean
0.00	0.812h	0.796h	0.730i	0.779E	1.460h	1.460h	1.490h	1.470E	53.23k	49.12l	45.48m	49.27E
2000	0.933g	0.914g	0.813h	0.887D	1.780f	1.670g	1.500h	1.650D	68.16h	64.83i	64.77i	65.92D
4000	1.120f	1.118f	1.108f	1.115C	2.050d	1.830f	1.620g	1.830C	74.32g	65.35i	62.49j	67.39C
6000	1.543b	1.416d	1.133ef	1.364B	2.360b	2.050d	1.830f	2.080B	89.19d	79.73e	76.36f	81.76B
8000	1.850a	1.481c	1.154e	1.495A	2.590a	2.230c	1.950e	2.260A	129.50a	113.61b	99.91c	114.34A
Mean	1.252A	1.145B	0.988C	–	2.050A	1.850B	1.680C	–	82.88A	74.53B	69.80C	–

Means followed by the same letter is a column or row do not differ significantly according to Duncan's new multiple range test

Likewise, Cassaniti et al. (2013) claimed that brackish water can be commercially used for production of *Chrysanthemum morifolium*, *Dianthus caryophyllus*, *Gerbera jamesonii*, *Hippeastrum vittatum* and *Anthurium andreanum*, but saline water higher than 2500 ppm concentration reduced their growth, delayed flowering and decreased flower quality. Similarly, were those results of Shahin et al. (2008) on *Ficus macrocarpa* var. Hawaii and *Euonymus Japonica* cv. Mediopicta, Shahin et al. (2013) on *Ficus benjamina* cv. *Samantha and Schefflera arboricola* cv. Gold Capella, El-Fouly et al. (2015) on *Iris tingitana* cv. Wedgewood, Jose et al. (2016) on *Eucalyptus urophylla* and the hybrid of *E. urophylla* x *E. grandis*.

On the other hand, the positive effect of magnetic iron on growth of plants suffered from salt stress may be due to its role in promoting the uptake of N, P, K and Fe which

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stimulate plant growth against the toxicity of Na^+ and Cl^- ions that inhibit it. It induces cell metabolism and mitosis of meristematic cells (Barage et al., 2009). It is believed that new protein bands are formed in plants that are treated with Fe_3O_4 and these proteins are responsible for the increased growth (Hozyan and Abdul-Qodos, 2010). Furthermore, it declines the hydration of salt ions and colloids, increasing salt solubility, and finally leading to leaching such salts from the soil. So, it is successfully used to reclaim soils with high cations and anions, such as Ca, Na, Cl and HCO_3 (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 renders the roots to exhibit symptoms of magnetism that kills nematodes and injurious bacteria (Yuliando et al., 2016). Supporting results for those of this study were also obtained by Abdel Fattah (2014) on *Jacaranda ocutifolia*, Ahmed et al. (2016) on *Acalypha wilkesiana*, Shahin et al. (2018) on *Terminalia arjuna* and El-Sayed et al. (2019) on elephant`s ear tree.

Salt resistance index (SRI%) and benefit coefficient of magnetite (B. coe.%)

Such gains may be reasonable, as they indicate the role of magnetic in alleviating salt hazards and promoting dry matter production. These results are reasonable because magnetite usually solubilizes and leaches salts from the soil, and this gives roots a chance to penetrate and distribute well through the growing medium, consequently uptake enough water and nutrients necessary for good and healthy growth. On the same line were those results attained by Al-Qubaie et al. (2003) on *Ficus benghalensis*, *Bougainvillea glabra*, *Jasminum azoricum*, *Conocarpus erectus*, *Tamarix articulata* and *Ziziphus spina-christi*, Shahin et al. (2008) on *Ficus macrocarpa* var. Hawaii and *Euonymus Japonica* cv. Mediopicta, Abdel-Fattah et al. (2012a) on *Ficus retusa*, Abdel Fattah et al. (2012b) on *Ficus benjamina* and El-Sayed et al. (2019) *Enterolobium contortisiliquum*.

Chemical composition of the leaves

This may be reasonable because salts usually reduces the water potential of soil solution, consequently decrease minerals and water uptake by roots, accompanied by a depression of photosynthesis and enzymes activity (Munns, 2002). It was also remarkable that accumulation of some amino acids and amides in the leaves and roots of salinity-stressed plants may be attributed to *de novo* synthesis by protein sorting machinery and not the result of protein degradation (Jou et al., 2006).

These results, are similar trend to those of Elhag and Abdalla (2014) and Moustafa et al. (2017) on *Moringa oleifera*, Ahmed et al. (2016) on *Acalypha wilkesiana*, Shahin et al. (2018) on *Terminalia arjuna* and El-Sayed et al. (2019) who observed that chlorophyll a, b, carotenoids and total carbohydrates concentrations were increased in the leaves of *Enterolobium contortisiliquum* under salt stress by application of Fe_3O_4 at either 2 or 4 g/pot.

Conclusion

Hence, it can be recommended to drench the soil mixture, in which hibiscus of China plants are grown with 4 g/pot of magnetic iron (Fe_3O_4) to improve their growth and aesthetic value under salt stress during rearing in the nursery.

It is recommended to use transplants of different ages growing under higher dose of salinity.

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