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COULD FERROUS BE USED TO ALLEVIATE THE ADVERSE EFFECTS OF SALINITY ON CHRYSANTHEMUM ?

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ABSTRACT

A pot experiment was carried out to investigate the effect of different soil salinity levels and their combinations with ferrous additions on growth, flowering traits and chemical constituents of *Chrysanthemum morifolium* var. Ice Cap plants. Plant height, number of flowers/plant, flower diameter and fresh weight, photosynthetic pigments and ferrous % were decreased, but leaves content of each of chloride, calcium, sodium and proline were increased due to the medium and high (2500 and 4000 ppm) salinity levels. The application of ferrous to salt-stressed plants caused a noticeable relief of the injurious and adverse effects of salinity imposed on growth, flowering aspects and chemical constituents of chrysanthemum plants. It is, therefore, strongly recommended to use ferrous to relief or alleviate the harmful effects of salinity on chrysanthemum plants.

INTRODUCTION

Chrysanthemum is one of the most important marketable floricultural crops. It is belonging to Asteraceae family. It is successfully and widely used as cut flower, potted flowering plant and herbaceous perennial (Anderson, 2007) *Chrysanthemum morifolium*, Ramat var Icecap, characterised with showy yellow flowers, is among many other recently introduced and grown mum varieties in Egypt.

Salinity is the major environmental factor limiting plant growth and productivity. Soil salinity in agriculture soils refers to the presence of high concentration of soluble salts in the soil moisture of the root zone. These concentrations of soluble salts through their high osmotic pressures affect plant growth by restricting the uptake of water by the roots. Salinity can also affect plant growth because the high concentration of salts in the soil solution interferes with balanced absorption of essential nutritional ions by plants (Tester and Davenport, 2003).

Different authors reported the harmful effects of salinity on vegetative growth, flowering aspects and/or chemical constituents of various herbaceous plants such as chrysanthemum (Mohamed, 1990 ; Lee and Van Iersel, 2008 and Elhindi, 2012), there ornamental cultivars (Colom and Vazzana, 2002), *Calendula officinalis* (Chaparzadeh *et al.*, 2004), chamomile (Razmjoo *et al.*, 2008) and geranium (Leithy *et al.*, 2009).

On the other hand, ferrous singly or among different commercial micronutrients was found to be capable of alleviating or reliefing the injurious effects of salinity on growth, flowering and/or chemical composition as revealed by Zayed (1984) on *Saponaria officinalis* ; Koriesh (1984) ; Al-Badawy *et al*. (1989) and Elhindi (2012) on chrysanthemum ; Aly *et al.* (1994) on borage and Badran *et al.* (2012) on *Nigella sativa*.

Therefore, the present study was designated to investigate the ability of such variety to grow and flower under different soil salinity levels. In addition to figure out the capability of ferrous in alleviating the injurious effects of salinity.

MATERIALS AND METHODS

A pot experiment was carried out during two successive seasons 2011/2012 and 2012/2013 in the Nursery and Laboratory of Floriculture Dept., Fac. of Agric., Minia Univ. to explore the effect of soil salinity and the relieving effect of ferrous on salt-stressed *Chrysanthemum morifolium* var. Icecap in terms of plant height, flowering characteristics and chemical composition.

Uniform seedlings, which were taken on last Feb. were repotted in 25 cm clay pots, filled with 3.5 kg of clay loamy soil (Table a) in the middle of April for both seasons. On the last week of June all plants were supplied with NPK fertilization dose at the rate of 6:9:6, per pot where P amounts were add at once, while N and K amounts were divided into 3 batches and added at 3 weeks intervals. Irrigation was executed according to the field capacity, which was determined at the beginning of the experiment by 2 liters/pot added twice weekly or three times weekly on hot days.

Table (a): Physical and chemical analysis of the soil.

Character	Value	Character	Value
Sand %	29.4	E.C. mmos/cm	1.04
Silt %	30.5	Total N %	0.08
Clay %	40.1	P ppm	15.20
Org. matter %	1.58	Exch. K^+ meg/100 g	2.11
$CaCO_3$ %	2.11	Exch. Ca^{++} meg/100 g	33.82
pH (1:2.5)	7.78	Exch. Na^+ meg/100 g	2.46

The complete randomized block design with three replicates and five plants/replicate was followed in this experiment. Three levels of soil salinity, with or without ferrous addition, were used by mixing equal amounts of sodium chloride and calcium chloride by weight at the rate of 0.10, 0.25 and 0.40 % with the soil on the middle of Aug. for both seasons, in addition to the control (unsalinized) treatment. Ferrous ($FeSO_4$) at the rate of 0.5 g was added to each one of the three salinity treatments 2 weeks after salts addition. So, the seven involved treatments were control, 0.10 % salinity, 0.25 % salinity, 0.40 % salinity, 0.10 % salinity + 0.5 g Fe, 0.25 % salinity + 0.5 g Fe and 0.40 % salinity + 0.5 g Fe.

Data were recorded for plant height (cm), flowering date (number of days from transpotting to first flower opening), flower diameter (cm), single flower fresh weight (g) and number of flowers/plant. Chemical analysis included chlorophyll a, chlorophyll b and carotenoids contents (mg/g F.W.) which were determined, before flowering at the middle of Sept., according to Fadl and Seri-Eldeen (1978). In addition, chl, Ca, Na and Fe % were determined in the dry leaves following the method of Page *et al.* (1982), while proline content was estimated according to Bates *et al.* (1973).

All obtained data were subjected to statistical analysis, at 5 % level, according to the L.S.D. method outlined by Little and Hills (1978).

RESULTS

Plant height (cm):

Plant height was significantly decreased due to soil salinity at 2500 and 4000 ppm with the high concentration being more effective, in both seasons, than the medium one as shown in Table (1). Combining ferrous with salinity treatments caused considerable and significant alleviation of salt stress as the medium soil salinity combined with ferrous (2500 ppm + Fe) did not differ significantly than control treated plants as clearly shown in Table (1).

The reducing effect of salinity, especially at higher levels, on plant height was also found by Mohamed (1990), Lee and Van Iersel (2008) and Elhindi (2012) on chrysanthemum; Razmjoo *et al.* (2008) on chamomile and Leithy *et al.* (2009) on geranium. The role of ferrous in reliefing the harmful influence of salinity on plant height was demonstrated by Al-Badawy *et al.* (1989) and Elhindi (2012) on chrysanthemum, Aly *et al*. (1994) on borage and Badran *et al.* (2012) on *Nigella sativa*.

Flowering traits :

Number of days to flowering was reduced and each of flower number/plant and flower diameter and flower fresh weight were considerably decreased, in both seasons, due to soil salinity at 2500 and 4000 ppm with the high concentration being more pronounce than the medium one. Such high concentration (4000 ppm) gave significantly lesser values, for the three quantity traits, than the low concentration (1000 ppm) and the control treatment as clearly indicated in Table (1). Meanwhile, it was obvious that the application of ferrous to salt-stressed plants minimized the deleterious effect of salinity on different flowering aspects, (Table, 1). In harmony with the four studied flowering traits, as affected by soil salinity, in the present study were the findings of Mohamed (1990), Lee and Van Iersel (2008) and Elhindi (2012) on chrysanthemum ; Colom and Vazzana (2002) on three ornamental cultivars and Razmjoo *et al*. (2008) on chamomile. While, Koriesh (1984) and Elhindi (2012) on chrysanthemum and Aly *et al*. (1994) on borage indicated the role of ferrous in alleviating the harmful influence of salinity.

Table (1): Effect of soil salinity and salinity/ferrous on plant height, flowering date, flower number/plant, flower diameter and flower fresh weight of *Chrysanthemum morifolium* cv. Icecap during 2011/2012 and 2012/2013 seasons.

Soil saline treatments (ppm)	Plant height (cm)		Flowering date (day)		No. of flowers per plant		Flower diameter (cm)		Flower fresh weight (g)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	88.9	84.4	193.3	195.2	18.4	20.3	7.36	7.43	3.37	3.48
1000	87.0	83.5	192.5	194.4	19.5	21.1	7.27	7.37	3.39	3.46
2500	83.6	80.1	190.4	191.5	16.63	19.6	7.08	7.11	3.11	3.20
4000	76.5	74.4	187.2	189.6	13.4	16.4	6.63	6.83	2.86	2.95
1000 + Fe	88.0	84.6	193.5	196.3	19.9	21.2	7.30	7.41	3.41	3.49
2500 + Fe	86.3	81.4	191.3	193.5	18.6	21.4	7.18	7.20	3.23	3.32
4000 + Fe	82.5	78.6	189.5	190.5	15.4	17.0	6.87	7.07	3.00	3.12
L.S.D at 5%	4.2	3.3	N.S.	N.S.	2.5	2.2	0.33	0.41	0.28	0.22
at 1 %	5.9	4.6	N.S.	N.S.	3.5	3.0	N.S.	N.S.	N.S.	0.29

Chemical constituents:

Photosynthetic pigments and ferrous contents:

The three photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids), as well as, ferrous contents were gradually decreased parallel to the increase in soil salinity level, in both seasons, in comparison with the unsalinized control plants as shown in Table (2). Significant differences were detected, in the two seasons, between the high salinity treatment (4000 ppm) and the unsalinized control treatment for the three photosynthetic pigments and ferrous contents, (Table, 2). The addition of ferrous to each one of the three salinity treatments caused a pronounced relief of the harmful effect of salinity on each of chlorophyll a, chlorophyll b, carotenoids and ferrous contents, in both seasons, as clearly illustrated in Table (2).

In accordance with these results concerning salinity were those pointed out by Mohamed (1990), Lee and Van Iersel (2008) and Elhindi (2012) on chrysanthemum. Furthermore, Elhindi (2012) on chrysanthemum proved the role of ferrous addition in minimizing the injurious effect on salt-stressed plants.

Table (2): Effect of soil salinity and salinity/ferrous on chlorophyll a, chlorophyll b, carotenoids and ferrous contents of *Chrysanthemum morifolium* cv. Icecap during 2011/2012 and 2012/2013 seasons.

Soil saline treatments (ppm)	Chl. a content (mg/g F.W.)		Chl. b content (mg/g F.W.)		Carotenoids content (mg/g F.W.)		Ferrous	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	2.766	2.642	2.164	1.975	2.432	2.252	57.4	61.2
1000	2.742	2.640	2.124	1.961	2.414	2.247	56.2	53.6
2500	2.703	2.615	2.044	1.915	2.366	2.163	52.2	54.1
4000	2.624	2.543	1.924	1.805	2.285	2.018	48.1	50.8
1000 + Fe	2.761	2.665	2.154	2.005	2.426	2.249	66.5	72.1
2500 + Fe	2.733	2.634	2.093	1.934	2.390	2.195	62.6	68.2
4000 + Fe	2.661	2.583	1.985	1.855	2.331	2.068	59.2	63.4
L.S.D at 5 %	0.067	0.047	0.054	0.048	0.036	0.042	4.6	4.3
at 1 %	0.094	0.066	0.076	0.067	0.050	0.059	6.4	6.0

Chloride, calcium, sodium and proline contents:

Table (3) shows clearly that the leaves contents of chloride, calcium, sodium and proline were significantly increased, in both seasons, due to all three soil salinity levels. Such increase was gradually upward parallel to the gradual increase in salinity level. So, the highest values for such four chemical constituents were obtained from the high salinity level (4000 ppm). The alleviating effect of ferrous, when added to salt-stressed plants, was obvious as it clearly reduced the increase in the four studied chemical constituents, in the two seasons, especially at the low salinity level (1000 ppm) as shown in Table (3).

The increase in the contents of chloride, calcium, sodium and proline due to salinity was emphasized by Mohamed (1990), Lee and Van Iersel (2008) and Elhindi (2012) on chrysanthemum; Chaparzadeh *et al*. (2004) on *Calendula officinalis* and Leithy *et al.* (2009) on geranium. Meanwhile, the role of ferrous in alleviating the harmful effects of salinity on such four chemical components was found by Koriesh (1984), Al-Badawy *et al.* (1989) and Elhindi (2012) on chrysanthemum.

Table (3): Effect of soil salinity and salinity/ferrous on chloride, calcium, sodium and proline contents of Chrysanthemum morifolium cv. Icecap during 2011/2012 and 2012/2013 seasons.

Soil saline treatments (ppm)	Chloride		Calcium		Sodium		Proline	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	1.87	2.01	0.332	0.345	0.362	0.352	6.47	6.11
1000	2.05	2.32	0.346	0.361	0.383	0.368	7.79	7.53
2500	2.49	2.52	0.367	0.396	0.414	0.398	8.12	7.88
4000	2.88	2.97	0.398	0.437	0.449	0.413	8.76	8.25
1000 + Fe	1.98	2.09	0.334	0.349	0.366	0.366	6.69	6.44
2500 + Fe	2.27	2.38	0.340	0.357	0.375	0.372	7.06	6.76
4000 + Fe	2.40	2.62	0.363	0.398	0.411	0.390	7.63	7.26
L.S.D at 5 %	0.07	0.08	0.009	0.011	0.017	0.012	0.31	0.37
at 1 %	0.10	0.11	0.013	0.015	0.024	0.017	0.43	0.52

DISCUSSION

The role of soil salinity, especially at the medium and high concentration, in reducing plant height, flower quantity and quality, photosynthetic pigments and ferrous, but increased chloride, calcium, sodium and proline, as indicated in the present experiment, could be attributed to a reduction in cell division, cell enlargement and meristemic activity, osmotic inhibition of water absorption and specific ions concentration in the saline media interfering with normal stomatal closure, causing excessive water loss and leaf injury symptoms like those of drought, (Bernstein, 1972). Early flowering, which means a short growth duration, generally involves a reduction in plant size and leaf area and leads to a complete life cycle before severe drought stress, a known escape strategy (Hirose *et al.*, 2005). Our results indicated a gradual reduction in number of flowers/plant flower diameter and flower fresh weight due to the increase in soil salinity level, and this reduction could be due to osmotic stress.

Regarding the reducing effect of salinity on the contents of the three photosynthetic pigments, it was suggested by Patil and Patil (1982) and Batanouny (1988) that such reduction under salt stress was due to stomata closure, inhibition chlorophyll synthesis, a decrease in carboxylase and due to the high chlorophyllase activity. Regarding the influence of soil salinity on increasing proline %, which observed in the present study, Ackerson (1984) postulated that cellular osmotic adjustment occurs in response to stress via an active or passive accumulation of solutes. The author assumed that salt stress enhanced the production of proline, which causes osmotic adjustment.

Concerning ferrous application, the results showed that Fe could alleviate the adverse effects of soil salinity, at the medium and high concentrations, on plant height, flowering aspects and chemical composition of chrysanthemum plants. The plants grown in medium and high soil salinity levels and treated with Fe had considerably taller plants, more flower number, wider flower diameter and heavier flower fresh weight than those received no Fe application. In addition, ferrous-treated plants, in comparison with non-treated ones, exhibited a trend of increasing chlorophyll a, b and carotenoids contents and Fe concentration and decreased each of chl, Ca, Na and proline. Such effect might be attributed to the favourable influence of Fe on metabolism and biological activity and its stimulating effect on photosynthetic pigments and enzyme activity, which in turn, improve vegetative growth and flowering traits. Ferrous is known to be involved in many photosynthetic, respiratory and N-assimilation reactions, as Fe is a cofactor in redox reactions, (Mengel and Kirkby, 1982).

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الملخص العربي

هل يمكن استعمال الحديد لتخفيف الآثار الضارة للملوحة على نباتات الأراولا ؟

رجاء علي طه

قسم البساتين – كلية الزراعة – جامعة المنيا

في تجربة أصص تم دراسة تأثير مستويات مختلفة من ملوحة التربة وكذلك تأثير إضافة عنصر الحديد لتلك المعاملات من ملوحة التربة على النمو والصفات الزهرية والمكونات الكيماوية لنباتات الأراولا صنف أيس كاب.

حدث نقص في كل من طول النبات وعدد الأزهار للنبات وقطر الزهرة ووزنها الطازج ومحتوى الأوراق من كل من الصبغات الضوئية والحديد في حين حدثت زيادة في محتوى الأوراق من كل من الكلوريد والكالسيوم والصوديوم والبرولين وذلك نتيجة معاملات التربة من الملوحة بالتركيز المتوسط والمرتفع (2500 ، 4000 جزء في المليون). ووجد أن إضافة الحديد لنباتات الأراولا قد خفف من التأثيرات الضارة للملوحة التي تعرضت لها هذه النباتات والتي شملت النمو الخضري والصفات الزهرية والمكونات الكيماوية لنباتات الأراولا.

وبناء على ذلك فإنه يمكن التوصية باستعمال عنصر الحديد لتخفيف التأثير الضارة للملوحة على نباتات الأراولا.