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Effect of magnetite and paclobutrazol on growth and chemical composition of *Schefflera arboricola* Endl. cv. Gold Capella plant under salt stress conditions

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Abstract
A pot experiment was conducted under a plastic greenhouse at the nursery of Hort. Res. Inst., ARC, Giza, Egypt during 2019 and 2020 seasons to find out the benefits of both magnetic iron oxide (Fe_3O_4) as a broadcast incorporation at 2 and 4 g/plant rates, and paclobutrazol (PP_{333}) as a foliar spray at 100 and 150 ppm concentrations, in reducing the harmful effect of saline irrigation water (NaCl + $CaCl_2$ salts at equal parts) at concentrations of 0, 1000, 2000, 4000 and 6000 ppm on growth and quality of *Schefflera arboricola* cv. Gold Capella transplants gown in 20-cm-diameter plastic pots. The results of this experiment indicated that the mean values of vegetative and root growth parameters were progressively decreased with increasing saline water level to be minimum by the highest level (6000 ppm) compared to control means in the two seasons, except for root length, which was increased to be longer by various salinity levels than control length. Application of PP_{333} had the least effect on growth traits giving the minimal values comparing with control in most cases of both seasons, whereas application of Fe_3O_4 attained the best effect giving the highest means of plant height, stem diameter, No. leaves/plant, root length and the heaviest fresh and dry weights of leaves, stem and roots over control and PP_{333}treatments in the two seasons, with the superiority of 2 g/plant rate which recorded the utmost high means in most growth traits measured in the two seasons. The interactions exhibited also a marked effect on the different growth characters, but the most effective treatment was combining between irrigation with either fresh water or 1000 ppm saline one and broadcast incorporating the soil mixture with either 2 or 4 g Fe_3O_4/plant, as these four interactions improved growth relative to the other ones with no major differences among themselves. A similar trend was also obtained regarding the chemical composition of the leaves, where concentrations of chlorophyll a, b, carotenoids, total carbohydrates, N and P were gradually declined with increasing salinity level, but markedly improved by applying Fe_3O_4, especially at 2 g/plant dose. The opposite was the right concerning K, Na, Cl and proline concentrations. In general, addition of Fe_3O_4, especially at 2 g/plant rate caused a marked reduction in the harmful salt ions (Na^+ and Cl^-), but greatly improved availability and uptaking the macronutrients (N, P and K) comparing with PP_{333} treatments, giving best growth and performance. Hence, it can be recommended to apply magnetic iron oxide at a rate of 2 g/plant to mitigate saline water hazards (up to 6000 ppm) on growth and quality of *Schefflera arboricola* cv. Gold Capella foliage pot plant.

Keywords: *Schefflera arboricola cv. Gold Capella; salinity; magnetic iron oxide; PP_{333}; growth and chemical composition*

1. Introduction

Due to increasing water crisis in Egypt, it is urgent to find out ornamental plants which can either tolerate saline water stress or those can withstand such stress by amending them with natural or chemical additives. Among the latter ones may be *Schefflera arboricola* Endl. cv. Gold Capella (Fam. Araliaceae). It is native to temperate forests of the Taiwanese mountains. Gold Capella cultivar likes a humid environment, so it can grow well in a moist soil, provided such soil does not become too wet, otherwise the roots may be rot. It is one of the most popular foliage indoor plants, usually grows up to 1-2.5 m high and to 90-120 cm wide, with handshape leaves characterized by yellowish spots on the lowest parts [1]. Moreover, [2] described Gold Capella cultivar as a variegated type of the Shefflera species, often pruned to be used as a hedge. It is moderately sensitive to moderately salt-tolerant with beautiful gold and green foliage. The low or moderate tolerance of *Schefflera arboricola* to saline water was demonstrated by [3], [4] and [5].

However, several approaches are suggested to reduce the risk of salinity on sensitive and moderately sensitive ornamentals, such as using magnetic iron oxide (Fe_3O_4) or magnetized water which naturally produce electromagnetic waves leaching salt ions from the soil, increasing mobility of macro-and microelements to the roots, shocking nematodes and microbes found on the roots and making water of 10000 ppm salinity proper for irrigation [6]. It is a key factor in reducing hazards of N+ and Cl- toxicity and

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in increasing root growth, soil water retention and fertilizer efficiency [7]. Many reports dealing with magnetic iron oxide effect on growth, flowering and chemical composition of different ornamental plants were detected by [8] on *Jacaranda acutifolia*, [9] on *Moringa peregrina*, [10] on *Acalypha wilkesiana*, [11] on *Rosa hybrida* cv. Centrix, [12] on *Enterolobium contortisiliquum*, [13] on *Terminalia arjuna* and [14] and [15] on *Moringa oleifera* and *Hibiscus rosa-sinensis*.

Another way for reducing the harmful effects of abiotic stress on growth and quality of ornamental plants may be spraying their foliage with growth retardants solution, such as paclobutrazol (PP_{333} or cultar). In this regard, [16] on two-year-old seedlings of *Pittosporum eugenioides* found that PP_{333} at 50 ppm concentration reduced growth, promoted leaf epinasty, decreased shoot succulence (by water loss) and increased foliar frost resistance. On *Tagetes erecta*, [17] mentioned that PP_{333} at 12.5 ppm decreased the risk of salinity on growth, leaf weight, oil percentage and yield, but also produced an additional increase in hydrocarbons. On the contrary, [18] observed that PP_{333} at 50-100 ppm concentrations did not enhance the degree of plant resistance to water deficiency (20 and 10% of the optimal regime), but did modify the mineral composition of the dry matter in *Euonymus japonicus* and *Viburnum tinus* ornamentals. Similar observations were also revealed by [19] on *Catharanthus roseus*, [20] on *Chrysanthemum coronarium*, [21] on *Euonymus japonicus* and [22] on ornamental sunflower.

Effect of paclobutrazol on growth and chemical composition of Schefflera and other ornamental species was documented by [23] on *Aglaonema* cv. Ernesto`s Favourite and *Schefflera arboricola*, [24] on *Schefflera variegata*; *Aglaonema pseudopracteata* and *Syngonium podophyllum*, [25] on *Helianthus annuus*, *Zinnia elegans*, *Tagetes erecta* and *Petunia* × *hybrida*, [26] on *Iris tingitana* cv. Wedgewood, [27] on *Hibiscus roas-sinensis*, [28] on *Helianthus annuus*, [29] on *H. rosa-sinensis* cv. Yellow and [30] on ornamental pepper (*Capsicum* cvs. Biquinho Vermelha and Bode Amarela). This work, however, was set out in order to investigate the role of either magnetic iron oxide or paclobutrazol on mitigating the harmful effect of saline water on growth appearance and quality of Schefflera plant.

2. MATERIALS AND METHODS

Two pot experiments were performed under plastic house at the nursery of Hort. Res. Inst., ARC, Giza, Egypt throughout 2019 and 2020 seasons to reveal the benefits of both magnetite and paclobutrazol (each alone) in reducing the deleterious effects of saline irrigation water on vegetative and root growth as well as chemical composition of *Schefflera arboricola* Endl. cv. Gold Capella plant. The temperature, relative humidity and light intensity inside the plastic house during the course of the study ranged between: 23.8-38.5 °C, 45.5-80.9% and 490-580 lux, respectively.

Schefflera transplants were selected to be as uniform as possible (about 15 cm length, with one main stem carrying about 6 leaves) and transplanted on April 15th for each season in 20-cm-diameter plastic pots filled with about 3 kg of sand + clay soil mixture at equal volumetric ratio (1:1, v/v). The physical and chemical properties of the sand and clay used in the two seasons were determined and averaged in Table (a).

Directly after planting, the transplants were irrigated once every 2 days with 250 ml of fresh water/pot till May, 1st, as they received the following treatments:

a. Saline water treatments: pure salts of both NaCl and $CaCl_2$ were mixed well together at equal weights (1:1, w/w), then saline water was prepared from such salt mixture at concentrations of 0, 1000, 2000, 4000 and 6000 ppm.

b. Paclobutrazol (a synthetic growth retardant commercially introduced under the name of Bonzi, cultar, PBZ and PP_{333}, manufactured by ICI Co.) as an aqueous solution was sprayed at concentrations of 0, 100 and 150 ppm, 3 times with 3 weeks interval till the solution was run-off.

Table (a): The physical and chemical properties of the sand and clay used in 2019 and 2020 seasons.

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	89.00	2.05	0.43	8.52	23.01	3.5	7.9	7.50	1.63	33.60	0.50	3.20	22.0	18.03
Clay	7.54	22.28	30.55	39.63	55.00	2.21	8.0	7.82	2.12	15.40	0.75	6.60	8.20	11.29

c. Magnetite (magnetic iron oxide; Fe_3O_4, 22.5%) obtained from Alahram Mining Co., Almaadi, Cairo, Egypt was broadcast incorporated to the soil mixture, 3 times with one-month interval, at the rates of 0, 2 and 4 g/pot (plant).

The effect of interactions between saline water treatments and both PP_{333} concentrations and Fe_3O_4 rates were also studied.

A factorial experiment in a complete randomized design replicated thrice, as each replicate contained 3 transplants was used in the two seasons [31]. The plants under various treatments were fertilized 3 times during the course of this study with 2 g/plant of NPK

+ microelements chemical fertilizer, and all the other agricultural practices needed for such plantation were done in time. At the end of each season, (15th, October), data were recorded as follows: plant height (cm), stem diameter at the base (cm), number of the leaves/plant, the longest root length (cm), as well as fresh and dry weights of leaves, stem and roots (g). In fresh leaf samples taken from the middle parts of the plants, photosynthetic pigments (chlorophyll a, b and carotenoids, mg/g. f.w.) and free proline (mg/100 g f.w.) concentrations were determined according to the methods of [32] and [33], respectively. While in dry leaf ones, the percentages of total carbohydrates [34], nitrogen, phosphorus and potassium [35] as well as sodium and chloride as mg/100 g d.w. [36], were measured.

Data were then tabulated and subjected to analysis of variance using the Assistant Software Program described by [37], which followed by Duncan's New Multiple Range Test [38] for means comparison

3. RESULTS AND DISCUSSION

3.1. Vegetative and root growth parameters:

Data outlined in Tables (1, 2, 3, 4 and 5) show that mean values of vegetative and root growth characters were gradually decreased with increasing saline water concentration to reach minimum values by the highest salinity level (6000 ppm) compared to control means in the two seasons, with the exception of root length (cm) which was increased to the longest one by salinity treatments over the length of control in both seasons, especially by 1000, 2000 and 4000 ppm levels. Likewise, 1000 ppm salinity treatment gave records of different growth parameters very close to those of control ones with non-significant differences among themselves in the two seasons. Reduction of growth by salinity treatments may be attributed to either low water uptake due to either low potential of saline water or certain ion toxicity (Na^+ and Cl^-) or both [39]. [40] stated that salinity inhibits cell division rather than cell expansion with a great reduction in photosynthesis. High salinity leads to a leaf abscission, a decrease in all volume at a constant cell number, increases reactive oxygen species (ROS) accumulation and the activity of antioxidant enzymes are also affected [41]. In this regard, [3] noticed that all vegetative and root growth traits of *Schefflera arboricola* seedlings grown on sandy soil were significantly decreased by saline water irrigation up to 4000 ppm. [4] reported that means of various growth attributes of *Schefflera arboricola* cv. Gold Capella were reduced by saline water at 4000 and 6000 ppm levels, but 2000 ppm level improved means of most growth traits, which were in some cases higher than control means. Similarly, [5] found that increasing irrigation water salinity up to 10 and 20 dS/m significantly diminished No. leaves from 141.67 to 81.66 and 35.00 leaves, shoot fresh weight from 52 g to 22.33 and 12 g and shoot dry weight from 21 g to 10 and 5 g, respectively.

On the other side, the application of PP_{333} at either 100 or 150 ppm concentrations exhibited the least effect on growth parameters giving the minimal values comparing with control in most cases of both seasons. This may be reasonable because PP_{333} usually inhibits the formation of gibberellins and cytokinins leading to cell division and extension reduction [24]. This result was documented before by [23] who postulated that

Table (1): Effect of magnetite, paclobutrazol, saline water concentrations and their interactions on plant height and stem diameter of *Schefflera arboricola* cv. Gold Capella plant during 2019 and 2020 seasons.

Additives / Salinity level	Plant height (cm)						Stem diameter (cm)					
	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean
	First season: 2019											
0.00 ppm	34.00c	24.33de	23.76e	38.00ab	36.71bc	31.36A	1.07cd	1.07cd	1.27a	1.10bc	1.03cd	1.11A
1000 ppm	33.76c	23.50e	22.68ef	41.33a	40.50a	32.36A	1.07cd	0.97de	1.16b	1.03cd	1.10bc	1.07A
2000 ppm	28.33d	18.33gh	19.33f-h	34.68bc	35.33bc	27.20B	0.93e	0.97de	1.05cd	1.07cd	1.05cd	1.02B
4000 ppm	24.50de	17.90gh	17.50gh	31.92cd	31.46cd	24.66C	0.88ef	0.90ef	0.83f	1.00d	0.93e	0.91C
6000 ppm	23.67e	17.63gh	16.10h	23.68e	23.93e	21.00D	0.87ef	0.88ef	0.80fg	0.93e	0.90ef	0.88C
Mean	28.85B	20.34C	19.88C	33.92A	33.59A		0.97B	0.96B	1.02A	1.03A	1.00A	
	Second season: 2020											
0.00 ppm	35.36c	25.38e	24.50e	39.00ab	37.33bc	32.32A	1.32a	1.13b-d	1.10c-e	1.33a	1.15bc	1.21A
1000 ppm	34.00c	25.50e	23.79ef	42.10a	41.31a	33.34A	1.28a	1.02d-f	1.08c-e	1.25ab	1.16bc	1.16AB
2000 ppm	30.00d	20.00f-h	20.33fg	36.00bc	36.33bc	28.53B	1.12b-e	1.02d-f	1.07de	1.17bc	1.10c-e	1.10B
4000 ppm	25.76e	19.31f-i	19.50f-i	32.26cd	31.50d	25.67C	1.00e-g	0.96fg	0.90ef	1.10c-e	0.97fg	.99C
6000 ppm	25.13e	17.35g-i	17.36g-i	25.67e	23.00f	21.70D	0.95fg	0.88gh	0.88gh	1.03d-f	0.88gh	0.93C
Mean	30.05B	21.51C	21.10C	35.01A	33.90A		1.14A	1.00B	1.01B	1.18A	1.05B	

Means within a column or row having the same letters are not significantly different according to Duncan`s New Multiple Range t-Test at 5 % level.

Table (2): Effect of magnetite, paclobutrazol, saline water concentrations and their interactions on No. of leaves/plant and root length of *Schefflera arboricola* cv. Gold Capella plant during 2019 and 2020 seasons.

Additives / Salinity level	No. of leaves/plant						Root length (cm)					
	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean
	First season: 2019											
0.00 ppm	17.00b-d	15.33de	15.67c-e	20.00a	20.00a	17.60A	37.00d	39.00d	27.33e	45.67bc	37.00d	37.20B
1000 ppm	17.33bc	15.10de	15.33de	19.10ab	18.68ab	17.11A	47.00b	36.33d	38.50d	48.33b	48.63b	43.76A
2000 ppm	15.50de	14.00e-g	12.00gh	17.67bc	17.80bc	15.40B	43.67c	41.67cd	37.10d	58.00a	47.33b	45.56A
4000 ppm	14.33ef	12.83f-h	10.36h	15.50de	15.00de	13.61C	43.50c	42.50cd	45.33bc	43.71bc	45.50bc	44.11A
6000 ppm	12.67f-h	12.67f-i	8.67i	14.00e-g	11.36h	11.88D	41.96cd	35.76de	35.91de	36.68d	37.33d	37.53B
Mean	15.37B	13.99C	12.41D	17.26A	16.57A		42.63B	39.05C	36.84D	46.48A	43.16B	
	Second season: 2020											
0.00 ppm	17.85bc	16.20cd	16.50cd	21.00a	21.00a	18.51A	38.00d	37.33d	31.68e	38.33d	38.00d	36.67C
1000 ppm	17.50bc	16.10cd	15.67de	20.00ab	20.00ab	17.86A	48.33b	40.33d	39.50d	47.33bc	48.10b	44.65A
2000 ppm	16.17cd	13.50e-g	13.00fg	18.76b	18.67b	16.02B	46.76bc	41.50d	40.00d	49.00a	50.00a	45.45A
4000 ppm	13.99e-f	13.81ef	13.00fg	15.33de	13.33fg	13.89C	41.50d	42.70cd	38.65d	39.75d	46.00c	41.72AB
6000 ppm	13.00fg	12.33g	9.67h	14.10ef	12.00g	12.22D	42.65cd	36.98d	35.93de	36.73d	38.50d	38.16B
Mean	15.70B	14.39C	13.57C	17.84A	17.00A		43.45A	39.77C	37.15D	42.23B	44.12A	

Means within a column or row having the same letters are not significantly different according to Duncan`s New Multiple Range t-Test at 5 % level.

Table (3): Effect of magnetite, paclobutrazol, saline water concentrations and their interactions on fresh and dry weights of Schefflera arboricola cv. Gold Capella leaves during 2019 and 2020 seasons.

Additives / Salinity level	Leaves fresh weight (g)						Leaves dry weight (g)					
	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean
	First season: 2019											
0.00 ppm	79.00c	62.78d	50.30fg	81.65b	85.28a	70.80A	13.50ef	10.58gh	10.60gh	16.92ab	18.21a	13.96A
1000 ppm	68.67c	50.76fg	40.51hi	78.10b	87.13a	65.04B	13.36ef	10.23gh	10.45gh	15.23cd	16.30bc	13.12A
2000 ppm	63.81d	45.48gh	40.33hi	71.98c	76.50bc	59.62C	12.05fg	9.85h	7.85ij	13.78de	15.96bc	11.90B
4000 ppm	58.50de	44.33h	39.92hi	69.72c	63.10d	55.12D	10.65gh	8.99hi	7.57ij	11.00gh	10.33gh	9.71C
6000 ppm	50.10fg	41.90h	35.46i	60.77d	56.33e	48.91E	9.98h	6.67j	6.53j	10.81gh	7.99ij	8.40D
Mean	63.02B	49.05C	41.31D	72.45A	73.67A		11.91B	9.27C	8.60D	13.55A	13.76A	
	Second season: 2020											
0.00 ppm	74.73c	63.52d	50.75fg	82.17ab	85.63a	71.36A	13.69ef	11.17g-i	11.03g-i	17.75ab	18.84a	14.50A
1000 ppm	69.58c	48.50g	43.10h	79.00b	80.70b	64.18B	12.70fg	10.68hi	8.70jk	16.91bc	16.73bc	13.15B
2000 ppm	63.55d	46.23gh	41.33hi	72.41c	73.00c	59.31C	11.53gh	9.78ij	8.53jk	15.68cd	16.86bc	12.48C
4000 ppm	60.10de	44.70h	40.35hi	70.35c	65.38d	56.18D	10.49hi	9.31ij	7.96jk	14.33de	11.50g-i	10.72D
6000 ppm	44.68h	41.27hi	35.96i	61.29de	55.70e-g	47.78E	9.56ij	6.78k	6.60k	11.46g-i	8.19jk	8.52E
Mean	62.53B	48.85C	42.30D	73.05A	72.08A		11.60B	9.55C	8.57C	15.23A	14.43A	

Means within a column or row having the same letters are not significantly different according to Duncan`s New Multiple Range t-Test at 5 % level.

Table (4): Effect of magnetite, paclobutrazol, saline water concentrations and their interactions on fresh and dry weights of Schefflera arboricola cv. Gold Capella stem during 2019 and 2020 seasons.

Additives / Salinity level	Stem fresh weight (g)						Stem dry weight (g)					
	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean
First season: 2019												
0.00 ppm	17.15d	10.40f-h	12.10f	27.60a	27.10a	18.87A	3.41d	2.37f-h	2.25g-i	4.99ab	4.40bc	3.48A
1000 ppm	15.76de	8.93h-j	9.36h-j	23.50b	23.60b	16.23B	3.06de	1.78i-k	1.97ij	5.43a	4.30c	3.31A
2000 ppm	15.03e	8.82h-j	8.45i-k	19.77c	22.29b	14.87C	2.89d-f	1.57jk	1.70i-k	4.45bc	4.26c	2.98B
4000 ppm	11.35fg	7.70jk	7.00k	18.95c	10.33g-i	11.07D	2.36f-h	1.51jk	1.38jk	2.56e-g	2.11hi	1.99C
6000 ppm	10.10f-g	7.52jk	6.65k	14.61e	9.50h-j	9.68E	2.27g-i	1.43jk	1.21k	2.33g-i	1.85h-j	1.82C
Mean	13.88B	8.68C	8.71C	20.89A	18.57A		2.80B	1.73C	1.70C	3.95A	3.39A	
Second season: 2020												
0.00 ppm	17.43d	10.85f-h	9.92h-j	28.24a	27.67a	18.82A	3.89c	2.81f-h	2.68gh	5.30b	5.00b	3.94A
1000 ppm	16.20de	10.20f-h	10.30f-h	20.33c	24.10b	16.23B	3.71cd	2.10ij	2.03ij	6.01a	5.19b	3.81A
2000 ppm	15.45e	9.39h-k	8.99i-l	19.50c	23.00b	15.27B	3.40c-e	1.93ij	1.92ij	5.18b	4.33bc	3.35A
4000 ppm	11.73fg	8.23j-l	8.00kl	15.36e	10.65g-i	10.80C	3.13de	1.82j	1.85j	3.61cd	2.40hi	2.56B
6000 ppm	10.16f-h	8.00kl	7.43l	13.41ef	9.78h-k	9.76D	2.98e-g	1.82j	1.70j	3.33c-e	2.16ij	2.40B
Mean	14.20B	9.34C	8.93C	19.37A	19.04A		3.42B	2.10C	2.04C	4.69A	3.82A	

Means within a column or row having the same letters are not significantly different according to Duncan`s New Multiple Range t-Test at 5 % level.

Table (5): Effect of magnetite, paclobutrazol, saline water concentrations and their interactions on fresh and dry weights of Schefflera arboricola cv. Gold Capella roots during 2019 and 2020 seasons.

Additives / Salinity level	Roots fresh weight (g)						Roots dry weight (g)					
	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean
First season: 2019												
0.00 ppm	44.76a	30.84fg	25.50hi	41.55b	42.33ab	37.00A	19.20a	12.81de	10.31fg	18.95a	19.20a	16.10A
1000 ppm	41.15b	27.90gh	24.33hi	40.30bc	42.31ab	35.20B	16.90b	10.96f	9.50gh	16.50b	16.87b	14.15B
2000 ppm	33.60e	25.00hi	21.10i	36.32e	39.10c	31.02C	16.63b	9.33gh	6.76ij	13.96cd	16.75b	12.69C
4000 ppm	26.75gh	22.73i	17.43j	29.00g	34.10ef	26.02D	15.10c	8.15hi	6.70ij	11.53ef	11.33ef	10.56D
6000 ppm	23.10i	13.30k	15.86k	25.11hi	23.31i	20.14E	10.86f	4.80k	5.85jk	11.10f	10.78f	8.68E
Mean	33.87C	23.96D	20.87E	34.46B	36.23A		15.74A	9.21C	7.83D	14.41B	14.99AB	
Second season: 2020												
0.00 ppm	45.23b	31.67fg	27.00hi	45.96b	52.83a	40.54A	19.81a	13.34de	11.84g	19.76a	19.91a	16.93A
1000 ppm	41.90bc	31.50fg	26.07hi	42.00bc	43.00bc	36.90B	17.50b	13.50de	10.90gh	17.28b	17.38b	15.31B
2000 ppm	34.30ef	28.37gh	24.85hi	37.03de	39.64cd	32.83C	17.00b	9.76i	10.85gh	14.53cd	17.31b	13.89C
4000 ppm	31.50fg	23.42i	18.11j	29.18gh	31.56ef	26.76D	15.56c	8.56ij	7.33jk	12.19e-g	12.40ef	11.21D
6000 ppm	25.53hi	13.76j	16.65j	27.60h	25.10hi	21.73E	10.86gh	8.53ij	7.10jk	7.92j	8.00j	8.48E
Mean	35.69C	25.75D	22.54E	36.36B	38.42A		16.15A	10.74C	9.60D	14.34B	15.00B	

Means within a column or row having the same letters are not significantly different according to Duncan`s New Multiple Range t-Test at 5 % level.

application of PP_{333} at 0.25 mg/pot drastically reduced plant height of *Schefflera arboricola* "Trinetta" to 1.91 cm with retarding all the growth characters, and [24] who revealed that PP_{333} at 0.125 mg broadcast incorporating/pot gave the highest reduction in plant height, leaf length and petiole length and width.

The opposite was the right regarding the effect of magnetic iron oxide (Fe_3O_4), which attained in general, the utmost high mean values in plant height (cm), stem diameter (cm), No. leaves/plant, root length (cm) and the heaviest fresh and dry weights of leaves, stem and roots (g) relative to control and PP_{333}treatments in the two seasons were recorded by 2 g/plant dose that recorded higher means than 4 g/plant dose in most growth traits measured in both seasons. This may be ascribed to that Fe_3O_4 reducing hazards of Na^+ and Cl^- ion toxicity by leaching them from both saline soil and saline water via the electromagnetic field, that also makes nutrients more available to plant roots and shocks the nematodes and microbes found on the roots [6]. Furthermore, Fe_3O_4 increases root growth, the soil water retention and fertilizer efficiency, declines the hydration of salt ions and colloids, increases salt solubility, and consequently filtering the soil from these ions, such as Ca^{++}, Na^{+}, Cl^{-} and HCO_3^{-}, so it can successfully used for reclaiming soils with high cations and anions [17].

In this respect, [8] declared that broadcast incorporating saline soil (4000 ppm salinity) with 4 g/plant of Fe_3O_4 greatly improved vegetative and root growth of *Jacaranda acutifolia* seedlings. On *Rosa hybrida* cv. Centrix irrigated with diluted sea water (10 and 15%), [11] pointed out that magnetic iron oxide at 6 g/plant could partially alleviate the harmful effect of salinity on growth. Likewise, [14] recommended to apply Fe_3O_4 at a rate of 4 g/plant to the soil salinized with NaCl + $CaCl_2$ (w/w) salts up to 6000 and 8000 ppm to improve growth and quality of *Moringa oleifera* and *Hibiscus rosa-sinensis* plants.

The interaction treatments exerted also a marked effect on the different growth measurements, which were variable among various interactions with the prevalence of interacting between irrigation with fresh water (zero salinity) or saline one at 1000 ppm and applying Fe_3O_4 at either 2 or 4 g/plant rates, as these four interactions improved growth over all the other interactions with no major differences observed between themselves in the two seasons. However, combining between non-saline or saline water at 1000 ppm and Fe_3O_4 at 2 g/plant gave mostly the highest records in most instances of both seasons.

These findings are in accordance with those revealed by [10] on *Acalypha wilkesiana*, [12] on *Enterolobium contortisiliquum*, [13] on *Terminalia arjuna* and [42] who noted that adding Fe_3O_4NPs at either 5 or 10 mg/l mitigated NaCl stress (up to 8000 ppm) on survival %, No. shootlets, shootlet length, No. leaves, rooting % and number and length of roots of micro-propagated *Antigonon leptopus* plant.

The results of this trial showed the failure of PP_{333} in alleviating hazards of salinity on growth of *Schefflera arboricola* cv. Gold Capella plant, and this coincide with the results of [18] who found that PP_{333} at 50-100 ppm concentrations had no effect on the degree of ability of *Euonymus japonicus* and *Viburnum tinus* plants to water deficit, but conflict with those of [19] who suggested that PP_{333} has significant role in contributing salt stress tolerance of *Catharanthus roseus* by improving the components of antioxidant defense system. [20] mentioned that salinity up to 5 dS/m reduced the photosynthetic capacity in *Chrysanthemum coronarium* plant by reducing the maximum quantum yield of PSII (Fv/Fm), but PP_{333} at 25 ppm improved salinity resistance by preventing the decrease in Fv/Fm. Besides, [21] cited that PP_{333} is one of the most important triazole compounds, which increase plant tolerance to abiotic stress, as it help *Euonymus japonicus* plant to tolerate 150 mM NaCl stress when applied at 1000 ppm concentration. Similarly, [22] indicated that PP_{333} application, mainly via soil favored “Sol Noturno” sunflower plants irrigated with brackish waters (ECw: 0.4; 1.9; 3.4; 4.9 and 6.4 dS/m).

3.2. Chemical composition of the leaves:

From data averaged in Table (6), it is obvious that concentrations of chlorophyll a, b and carotenoids (mg/g f.w.) and total carbohydrates percentages were gradually decreased in response to the progressive increment in saline water concentration. Thus, 6000 ppm salinity level attained the least records in these constituents. This may be due to the negative effect of saline water on stroma lamella formation and grana and chlorophyll appearance during the normal growth of the leaves. In this concern, [20] reported that Cl^{-} damage firstly appears like a slight bronzing and leaf-tip yellowing afterward by tip death and general necrosis, whereas Na^{+} toxicity starts as a marginal yellowing followed by progressive necrosis. Besides, [41] claimed that salinity usually retards chlorophyll formation, photosynthesis and various metabolic processes. On *Schefflera arboricola* cv. Gold Capella, [4] found that concentrations of chlorophyll a, b, carotenoids and total carbohydrates were linearly decreased in the leaves with raising water salinity up to 6000 ppm which gave the minimum records.

Moreover, the addition of PP_{333} at either 100 or 150 ppm was not valuable, while magnetic iron oxide improved the previous constituents, especially when applied at a rate of 2 g/plant that recorded the highest concentrations of pigments and total carbohydrates at all. This may indicate the role of Fe_3O_4 in chlorophyll biosynthesis. In this connection, [43] demonstrated that application of 20 mg/l coated magnetite nanoparticles with humic acid (Fe_3O_4/HA NPs) in nutrient solution significantly increased chlorophyll a, b, total (a + b) and carotenoids content in the leaf of *Chrysanthemum morifolium* ’Salvador’ plant to 14.8, 12.2, 13.9 and 14.0% compared to Fe-EDTA, respectively, where Fe nano particles penetrated the root cells and transferred to the aerial parts of chrysanthemum increasing the formation of photosynthetic pigments and obviating iron chlorosis.

The connection between irrigation with fresh (unsalinized water) and the addition of Fe_3O_4at either rate hastened pigments concentration to the highest values, while that was occurred for the total carbohydrates by combining either fresh or 1000 ppm-salinized water and Fe_3O_4 at the low rate (2g/plant). Such results could be supported by those obtained by [8] on jacaranda, [10] on *Acalypha wilkesiana*, [11] on cv. Centrix rose, [13] on *Terminalia arjuna* and [14] and [15] on *Moringa oleifera* and *Hibiscus rosa-sinensis.*

A similar trend to that of pigments and total carbohydrates concentrations was also observed regarding the percentages of both nitrogen and phosphorus (Table, 7), as their concentrations were descendingly decreased with increasing salinity levels and improved only by applying Fe_3O_4, especially at the rate of 2 g/plant. Thus, the highest mean values of them were acquired by combining fresh irrigation water and a magnetite dose of 2 g/plant. The opposite was the right in respect of potassium, sodium, chloride and proline concentrations (Table, 7), which were progressively increased as saline water concentrations were increased, and reached to maximum by irrigating with 6000 ppm saline water in the absence of both PP_{333} and Fe_3O_4, except for K % which was the highest by addition of PP_{333} at either 100 or 150 ppm rate. Hence, the greatest means of Na, Cl and proline were obtained by combining irrigation with the highest salinity level (6000 ppm) and the absence of either additives used, whereas the greatest mean of K was attained by combining 6000 ppm saline water treatment with PP_{333}at any rate. In general, the addition of magnetic iron oxide, especially at 2 g/plant dose

Table (6): Effect of magnetite, paclobutrazol, saline water concentrations and their interactions on pigments and total carbohydrates in Schefflera arboricola cv. Gold Capella leaves during 2020 season.

Additives / Salinity level	Chlorophyll a (mg/g f.w.)						Chlorophyll b (mg/g f.w.)					
	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean
0.00 ppm	0.893	0.890	0.880	0.913	0.909	0.897	0.558	0.563	0.506	0.601	0.604	0.566
1000 ppm	0.876	0.881	0.867	0.880	0.878	0.876	0.562	0.500	0.501	0.569	0.581	0.543
2000 ppm	0.858	0.863	0.796	0.873	0.850	0.848	0.501	0.479	0.446	0.516	0.510	0.490
4000 ppm	0.781	0.752	0.601	0.832	0.792	0.752	0.436	0.395	0.355	0.504	0.450	0.428
6000 ppm	0.733	0.708	0.528	0.770	0.739	0.696	0.310	0.346	0.336	0.386	0.369	0.349
Mean	0.828	0.819	0.734	0.854	0.834		0.473	0.457	0.429	0.515	0.503	
	Carotenoids (mg/g f.w.)						Total carbohydrates (%)					
0.00 ppm	0.299	0.286	0.269	0.301	0.303	0.292	20.14	13.83	14.30	24.33	21.38	18.80
1000 ppm	0.281	0.279	0.258	0.289	0.300	0.281	19.20	13.21	13.56	23.67	19.20	17.77
2000 ppm	0.240	0.264	0.241	0.283	0.279	0.261	18.46	12.38	11.73	20.50	19.71	16.56
4000 ppm	0.231	0.236	0.220	0.255	0.246	0.238	17.30	12.00	10.35	18.47	17.25	15.07
6000 ppm	0.203	0.210	0.200	0.246	0.233	0.218	14.31	11.79	9.85	15.80	15.43	13.44
Mean	0.251	0.255	0.238	0.275	0.272		17.88	12.64	11.96	20.55	18.59	

Table (7): Effect of magnetite, paclobutrazol, saline water concentrations and their interactions on some constituents in Schefflera arboricola cv. Gold Capella leaves during 2020 season.

Additives / Salinity level	Nitrogen (%)						Phosphorus (%)					
	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean	0.00	PP_{333} (100 ppm)	PP_{333} (150 ppm)	Fe_3O_4 (2 g)	Fe_3O_4 (4 g)	Mean
0.00 ppm	2.34	2.30	2.23	2.45	2.36	2.34	0.890	0.760	0.690	0.900	0.900	0.828
1000 ppm	2.16	2.08	2.18	2.21	2.18	2.16	0.870	0.760	0.680	0.880	0.780	0.794
2000 ppm	1.91	1.93	1.93	1.98	2.07	1.96	0.840	0.630	0.600	0.850	0.810	0.746
4000 ppm	1.50	1.86	1.62	1.83	1.76	1.71	0.560	0.450	0.360	0.670	0.590	0.526
6000 ppm	1.43	1.32	1.30	1.76	1.34	1.43	0.380	0.350	0.270	0.510	0.430	0.388
Mean	1.87	1.90	1.85	2.05	1.94		0.708	0.590	0.520	0.762	0.702	
	Potassium (%)						Sodium (%)					
0.00 ppm	0.788	0.809	0.836	0.958	0.916	0.861	0.504	0.325	0.307	0.149	0.126	0.282
1000 ppm	0.891	1.086	1.108	0.956	0.971	1.002	0.628	0.541	0.363	0.156	0.154	0.368
2000 ppm	1.218	1.450	1.421	1.024	1.038	1.230	0.673	0.592	0.315	0.179	0.173	0.386
4000 ppm	1.235	1.500	1.465	1.033	1.049	1.256	0.697	0.610	0.272	0.176	0.184	0.388
6000 ppm	1.550	1.666	1.978	1.167	1.246	1.521	0.733	0.636	0.293	0.188	0.189	0.408
Mean	1.136	1.302	1.362	1.028	1.044		0.647	0.541	0.310	0.170	0.165	
	Chloride (mg/100 g f.w.)						Proline (mg/100 g f.w.)					
0.00 ppm	3.80	2.91	3.51	2.32	2.32	2.97	28.81	23.23	25.33	23.85	23.61	24.96
1000 ppm	4.39	2.93	3.97	2.34	2.41	3.21	34.16	27.15	30.84	25.13	25.70	28.60
2000 ppm	5.85	4.34	4.64	3.51	3.40	4.35	36.26	35.00	34.76	26.58	27.93	32.11
4000 ppm	7.61	5.62	5.85	3.85	3.80	5.34	35.90	35.63	35.50	28.21	29.50	32.95
6000 ppm	7.74	6.44	6.44	3.88	4.11	5.72	41.37	38.41	39.71	30.62	30.33	36.09
Mean	5.88	4.45	4.88	3.18	3.21		35.30	31.88	33.23	26.88	27.42	

markedly reduced the harmful salt ions (Na^+ and Cl^-) concentration, but improved that of macronutrients (N, P and K) more than paclobutrazol regardless of salinity level, giving better mineral equilibrium for better growth and performance.

On the same line, [18] noticed that PP_{333} at 50-100 ppm concentrations did not improve resistance of *Euonymus japonious* and *Viburnum tinus* plants to water deficit. On the other side, [7] stated that magnetic iron oxide usually enhances nutrient mobility in the soil and consequently uptaking by roots. In this concern, [13] told that treating *Terminalia arjuna* transplants irrigated with saline water (NaCl at 4000 ppm) with magnetite greatly improved N, P, K and Ca content in their leaves. Similarly, [14] indicated that N, P and K concentrations in the leaves of *Moringa oleifera* seedlings were linearly increased with increasing Fe_3O_4 rate from 2 g to 4 g/plant, even under soil salinity of 6000 and 8000 ppm.

From the previous gains, it can be proposed to add magnetic iron oxide as a safe natural material at the rate of 2 g/plant to improve the growth performance of *Schefflera arboricola* cv. Gold Capella, as a decorative foliage pot plant, subjected to saline water stress up to 6000 ppm.

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تأثير أكسيد الحديد الممغنط والباكلوبيوترازول على النمو والتركيب الكيماوي لنبات الشيفليرا (صنف جولد كابيللا) تحت ظروف الإجهاد الملحي

سيد محمد شاهين ، ماجدة عبد الحميد أحمد
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أجريت تجربة أصص بإحدى الصوبات البلاستيكية بمشتل معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر خلال موسمي 2019 و 2020 لمعرفة فوائد كل من الحديد الممغنط عند إضافته تكبيشاً للتربة بمعدل: 2، 4 جم/نبات والباكلوبترازول (الكلتار) عند إضافته رشاً على الأوراق بمعدل: 100، 150 جزء في المليون في خفض التأثير الضار لملوحة مياه الري (مخلوط كلوريد الصوديوم + كلوريد الكالسيوم بنسب وزنيه متساوية) بتركيزات: 0 ، 1000، 2000، 4000، 6000 جزء في المليون على نمو وجودة شتلات نبات الشيفليرا (صنف جولد كابيللا) النامي في أصص بلاستيك قطرها 20 سم مملوءة بحوالي 3 كجم من مخلوط الرمل + الطين بنسب حجمية متساوية. أيضاً، تم دراسة تأثير التفاعلات بين المستويات المختلفة لملوحة مياه الري والمعدلات المختلفة لكلٍ من الكلتار والحديد الممغنط. أوضحت نتائج هذه التجربة ان متوسطات قياسات النمو الخضري والجذري قد أنخفضت تدريجياً بزيادة مستوى ملوحة مياه الري لتصبح أقل ما يمكن بالمستوى الأعلى للملوحة (6000 جزء في المليون) مقارنة بمتوسطات الكنترول في كلا الموسمين، باستثناء صفة طول الجذر والتي زادت لتكون أطول بمختلف مستويات الملوحة عن طول الجذور لنباتات الكنترول بكلا موسمي الدراسة. ولقد كان لإضافة الكلتار أقل التأثيرات على قياسات النمو المختلفة معطياً أقل القيم مقارنة بمتوسطات الكنترول بمعظم الحالات بكلا الموسمين، بينما حققت إضافة الحديد الممغنط نتائج أفضل معطية أعلى المتوسطات لارتفاع النبات، قطر الساق، عدد الأوراق/نبات، طول الجذر، كما أعطت أثقل الأوزان الطازجة والجافة للأوراق، السيقان، الجذور عن المتوسطات التي حققتها نباتات الكنترول والنباتات المعاملة بالكلتار في كلا الموسمين، مع تفوق معاملة الحديد الممغنط بمعدل 2 جم/نبات والتي أحرزت أعلى القيم في معظم قياسات النمو عن المعدل 4 جم/نبات بكلا الموسمين. أحدثت أيضاً معاملات التفاعل تأثيراً ملحوظاً على مختلف صفات النمو الخضري والجذري، إلا أن السيادة والتفوق كان لمعاملات الجمع بين الري إما بالماء العذب أو الماء المالح تركيز 1000 جزء في المليون وإضافة الحديد الممغنط إما بمعدل 2 أو 4 جم/نبات، حيث حسنت هذه التفاعلات الأربعة النمو بشكل أفضل من التفاعلات الأخرى دون وجود أي فروق معنوية فيما بين هذه التفاعلات الأربعة. ولقد تم الحصول على إتجاه مشابه فيما يتعلق بالتركيب الكيماوي للأوراق، حيث إنخفضت تركيزات كلوروفيللي أ، ب، الكاروتينويدات، الكربوهيدرات الكلية، النيتروجين والفوسفور تدريجياً كلما زاد تركيز ملوحة مياه الري، بينما تحسنت بشكل ملحوظ بإضافة الحديد الممغنط، خاصة بمعدل 2جم/نبات. ولقد كان العكس صحيحاً فيما يتعلق بتركيزات البوتاسيوم، الصوديوم، الكلوريد والبرولين. وبصفة عامة؛ أحدثت إضافة الحديد الممغنط خاصة بمعدل 2 جم/نبات إنخفاضاً ملحوظاً في أيونات الملح الضارة (الصوديوموالكلوريد)، بينما حسنت بوضوح تيسر وأمتصاص العناصر الغذائية الكبرى (النيتروجين، الفوسفور والبوتاسيوم) مقارنة بمعاملات الكلتار معطية بذلك أفضل نمو ومظهر للنباتات. وعليه؛ يمكن التوصية بإضافة الحديد الممغنط تكبيشاً للتربة بمعدل 2 جم/نبات لتخفيف أضرار الماء المالح (حتى تركيز 6000 جزء في المليون) على نمو وجودة نبات الشيفليرا (صنف جولد كابيللا) الورقي.