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# THE ROLE OF MAGNETIC IRON IN ENHANCING THE ABILITY OF *Acalypha wilkesiana* MÜLL. ARG. TRANSPLANTS TO TOLERATE SOIL SALINITY

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## ABSTRACT

In order to enhance tolerance of Copper acalypha transplants (*Acalypha wilkesiana* Müll. Arg.) to soil salinity, this investigation was carried out under the full sun at the nursery of Hort. Res. Inst., ARC, Giza Egypt during 2013 and 2014 seasons, as 5-months-old transplants of this ornamental shrub were cultured in 30-cm-diameter plastic pots filled with about 6 kg/pot of sand + loam + cattle manure compost mixture (1: 1: 1, v/v/v), salinized with an equal parts mixture of NaCl and $CaCl_2$ pure salts (1:1, w/w) at the rats of 0, 2000, 4000 and 6000 ppm. Magnetic iron ($Fe_3O_4$) was applied as soil drench at the rates of 0, 3 and 6 g/pot, 4 times with 2 months interval. The effect of interaction between salinity and $Fe_3O_4$ treatments was also studied.

The obtained results have shown that means of vegetative and root growth traits were descendingly decreased, with few exceptions as the rate of salinity was increased to reach the minimal values compared to control in the two seasons by the highest salinity level, while they were progressively increased with increasing $Fe_3O_4$ rate to reach the maximal values over control in the two seasons by the rate of 6 g/pot. Indeed, 3 g/pot $Fe_3O_4$ treatment significantly raised the means of most vegetative and root growth measurements, but the upper hand was for the rate of 6 g/pot in both seasons. The effect of interaction treatments was fluctuated, but the best gains were attained in the two seasons by combining between planting in either unsalinized soil mixture or salinized one at 2000 ppm concentration and drenching with $Fe_3O_4$ at any level. The connecting between cultivating in 4000 ppm-salinized soil mixture and treating with 6 g $Fe_3O_4$/pot significantly improved some growth characters. In general, increasing the rate of $Fe_3O_4$ caused an additional improvement in most growth parameters (plant height, stem diameter, No. of leaves/plant, root length and aerial parts and roots fresh and dry weights) regardless of salinity level. The leaf content of chlorophyll a, b, carotenoids, N, P and K was gradually decreased with increasing salinity level, but was progressively increased as the rate of $Fe_3O_4$ was increased. The content of Na, Cl and free proline was linearly increased with elevating salinity concentration. On the other side, Na content was descendingly diminished, but that of Cl and proline was gradually increased with increasing $Fe_3O_4$ dose. The effect of interaction treatments on chlorophyll a and b, N, P and K content was greatly similar to their effect on growth parameters, but the opposite was the right regarding the content of Na, Cl and proline.

Hence, it can be recommended to apply magnetic iron at the rate of 6 g/pot, 4 times with 2 months interval to the salinized soil mixture in which Copper-leaf transplants is grown to improve their tolerance to salinity stress up to 6000 ppm concentration.
**Keywords:** Jacob`s coat, Copper-leaf plant, *Acalypha wilkesiana*, Soil salinity, Magnetic iron, Vegetative and root growth.

## INTRODUCTION

Jacob`s coat, Copper-leaf or Fire-Dragon plant (*Acalypha wilkesiana* Müll. Arg. (Fam. Euphorbiaceae) is a monocious shrub to 4.5 m height with profuse attractive foliage, elliptic or ovate to 12-20 cm long, serrate with variously colored: bronzy-green mottled with copper, red or purple. Mostly used for bedding, hedging and as lawn specimens. Propagated by cuttings which taken from outdoor bedded plants in the autumn, from plants lifted in the autumn and cut back, and in summer from a stock kept from the previous season. The last is the best method since cuttings may be obtained with a heel, which give excellent plants for use in autumn and winter (Bailey, 1976).

Information about the effect of salinity on growth of *Acalypha* spp. in the literature are very little, except of that mentioned by Bezona *et al*., (2009) about salt and wind tolerance of landscape plants for Hawaii, as they stated that *Acalypha wilkesiana* usually tolerates light salt spray. So, it should not be used in exposed locations. It may be sensitive to wind or to medium salt spray. Further, Johwo and Alokolars (2013) found that subjecting 3-month-old *Acalypha wilkesiana* plants to salinity stress (0.1 M Na) produced lower quantity of alkaloids, flavonoids and tannins, while saponin production was increased.

However, several reports about remedy the harmfull effects of salinity by magnetic iron on the other plants are available, such as those of Abdel-Fattah (2014) who declared that application of magnetite, 3 times at the rate of 4 g/pot improved vegetative and root growth of *Jacaranda acutifolia* seedlings grown in salinized soil up to 4000 ppm. This treatment also increased the leaf content of chlorophyll a, b, N, P and K, but decreased carotenoids, Na, Cl and free proline content under salinity stress. Likewise, El-Sayed (2014) postulated that magnetic water enhanced growth, yield and water content of broad bean plants grown in saline soil. Chlorophyll a and b, carotenoids, total carbohydrates, protein, total amino acids, proline, total indoles and phenols, P, K, Na and Ca contents were also improved in all parts of the plant under this stress by irrigation with magnetic water.

Similar observations were also recorded by El-Hifny *et al*., (2008) on cauliflower, Ali *et al*., (2011) on pepper, Ahmed *et al*., (2011) on *Hibiscus sabdariffa*, Shehata *et al*., (2012) on cucumber, Ali *et al*., (2013) on grapevines and Abdel-All and Mohamed (2014) on broccoli and cauliflower. However, the purpose of this study is to find out the role of magnetic iron in alleviating the deleterious effects of soil salinity on growth and quality of the young and sensitive Copper-leaf transplants to this stress.

## MATERIALS AND METHODS

In order to improve tolerance of Jacob`s coat or Copper-leaf transplants to salinity stress, the present pot experiment was consummated under the full sun at the nursery of Hort. Res. Inst., ARC, Giza, Egypt throughout the two consecutive seasons of 2013 and 2014, where 5-months-old homogenous transplants of *Acalypha wilkesiana* Müll. Arg. at a length of about 25 cm, with a single stem carries about 8 ± 1 leaves were planted on April, 1st for each season in 30-cm-diameter plastic pots (one transplant/pot) filled with about 6 kg/pot of a mixture consists of sand, loam and cattle manure compost at equal parts, by volume. The physical and chemical properties of the sand and loam used in the two seasons are shown in Table (1), while those of the used cattle manure compost are listed in Table (2).

**Table (1): The physical and chemical properties of the sand and loam used in the two studied 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 | 79.81 | 8.36 | 1.76 | 10.07 | 22.5 | 3.43 | 7.82 | 17.48 | 9.95 | 8.33 | 0.76 | 3.11 | 18.69 | 14.72 |
| Loam | 11.78 | 43.55 | 20.33 | 24.34 | 34.16 | 3.1 | 7.98 | 16.33 | 9.1 | 17.95 | 1.86 | 3.96 | 16.46 | 24.82 |

**Table (2): The physical and chemical properties of the cattle manure compost used in the two studied seasons.**

| Weight of $m^3$ (kg) | Humidity (%) | O.M. (%) | O.C. (%) | C/N ratio | pH | E.C. (d.S./m) | Macro-elements (%) | | | | | Micro-elements (ppm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | N | P | K | Ca | Mg | Zn | Fe | Mn | Cu |
| 750 | 19.8 | 20.7 | 12 | 7.19 | 7.91 | 4.1 | 1.44 | 0.28 | 2.42 | 0.16 | 0.62 | 56 | 1621 | 443 | 66 |

The experimental treatments were as follows:

**1. Salinization treatments:**

Immediately before planting, the soil mixture was salinized with a salt mixture of pure NaCl and pure $CaCl_2$ salts (1:1, by weight) at the concentrations of 0, 2000, 4000 and 6000 ppm.

**2. The chemical alleviator of salinity used in the study.**

Magnetite (magnetic iron, $Fe_3O_4$) was applied as soil drench at the rates of 0, 3 and 6 g/pot, 4 times; as the first one was added immediately after planting (on first of April) and the other three with 2 months interval afterwards, i.e., on June, 1st, August, 1st and October, 1st, respectively.

**3. Interaction treatments.**

As each level of salinity was combined with each one of the chemical alleviator to form 12 interaction treatments.

The transplants under the different experimental treatments were fertilized 3 times during the course of this study with 4 g/pot of NPK chemical fertilizer (1:1:1) commencing from May, 1st with 45 days interval and watered every other day. However, the other agricultural practices were done as usually grower did.

A factorial in complete randomized design with 3 replicates, as each one contained 5 transplants was used in the two seasons (Mead *et al*., 1993).

**Data recorded:**

At the end of each season, the following data were recored: plant height (cm), stem diameter at the base (cm), number of leaves/plant, root length (cm), as well as fresh and dry weights of aerial parts and roots (g). In fresh leaf samples, the photosynthetic pigments content (chlorophyll a, b and carotenoids, mg/g f.w.) was determined according to the method of Yadava (1986), while in dry ones, the percentages of nitrogen (Pregl, 1945), phosphorus (Luatanab and Olsen, 1965) and potassium, sodium and chloride (Jackson, 1973) were measured. Besides, the content of free proline (mg/g f.w.) was evaluated using the method described by Batels *et al*., (1973).

Data were then tabulated and statistically analyzed following program of SAS Institute (2009) with Duncan's New Multiple Range Test (Steel and Torrie, 1980) for means comparison.

## RESULTS AND DISCUSSION

**Effect of soil salinity, magnetic iron and their interactions on:**

**1- Vegetative and root growth parameters:**

It is clear from data presented in Tables (3 and 4) that means of all vegetative and root growth traits were progressively decreased as the rate of salinity was increased with significant differences compared to means of control in most cases of the two seasons, except of stem diameter trait (cm), which improved in the first season by 2000 and 4000 ppm salinity levels, while in the second one, improved only by 2000 ppm level. Also, root length (cm) was increased in the first season only by 2000 and 4000 ppm salinity levels, while roots fresh weight (g) was increased in the same season only by 2000 ppm level. This may be due to the negative effect of salinity on water absorption and biochemical processes, such as N, CO2 assimilation and protein biosynthesis or accumulating high concentration of potentially toxic ions such as Na and Cl (Günes *et al*., 1999). Chartzoulakis and Klapaki (2000) attributed the reduction in growth by salinity to the effect of osmotic stress and the inhibition of cell division rather than the cell expansion plus the marked inhibition in photosynthesis. They also added that high salinity levels led to decrease in leaf number due to leaf abscission as a result of ion accumulation in the leaves, particularly old ones. In addition, 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.

On the other hand, the means of various vegetative and root growth characters were gradually increased with increasing magnetic iron dose to reach the maximal values by the rate of 6 g/pot that gave the highest means over control in the two seasons. Indeed, the rate of 3 g/pot $Fe_3O_4$ significantly raised the means of all vegetative and root growth measurements relative the control, but the upper hand was for the rate of 6 g/pot in both seasons. This may be ascribed to the role of magnetic iron in enhancing of N, P, K and Fe uptake which stimulate plant growth rather than the harmful effect of Na and Cl which inhibit plant growth. It induces cell metabolism and mitosis of meristematic cells (Belyavskaya, 2001). It is believed that new protein bands are formed in plants that are treated with magnetite and these proteins are responsible for increased growth (Hozyan and Abdul-Qados, 2010). Moreover, it decreases the hydration of salt ions and colloids, having a positive effect on salt solubility leading finally to leaching of the salts. So, it is successfully used to reclaim soils with high cations and anions content, such as Ca, Na and $HCO_3$ (Mostafazadeh *et al*., 2012).

As for the effect of interactions on vegetative and root growth triats, it was fluctuated, but the best records were attained in the two seasons by combining between planting in either unsalinized soil mixture or salinized one at the rate of 2000 ppm and drenching with magnetite at any level (3 or 6 g/pot). Also, combining between cultivating in 4000 ppm salinized-soil and treating with $Fe_3O_4$ at 6 g/pot significantly improved some growth characters. In general, increasing applying rate of magnetic iron ($Fe_3O_4$) caused an additional improvement in most growth traits in both seasons regardless of salinity level. This may be attributed to the role of magnetic iron in alleviating the deleterious effects of salinity through creating an electromagnetic field helps the passage of useful nutrients to the plants and shock the nematodes and microbs on the roots, solving the problem of soil tdhaguet and consequently improving the water balance and the antenna in the soil, increasing root growth and soil water retention, raising the adequacy of washing of salts in the soil (3 times the capacity of regular water) and finally separating chlorihe and toxic gasses magnetically from the growing medium.

The previous results were supported by those revealed by Abdel-Fattah (2014) on Jacaranda, El-Sayed (2014) on broad bean and Abdel-All and Mohamed (2014) whom reported that magnetic iron at 250 kg/fed. greatly reduced the harmful effect of soil salinity on growth of both broccoli and cauliflower, but significantly improved their vegetative growth, yield and yield components.

**Table (3): Effect of soil salinity, magnetic iron and their interactions on some growth parameters of *Acalypha wilkesiana* Müll. Arg. plants during 2013 and 2014 seasons.**

| Magnetic treatments / Soil salinity (ppm) | Plant height (cm) | | | | Stem diameter (cm) | | | | No. of leaves/plant | | | | Root length (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Control | $Fe_3O_4$ (3 g/pot) | $Fe_3O_4$ (6 g/pot) | Mean | Control | $Fe_3O_4$ (3 g/pot) | $Fe_3O_4$ (6 g/pot) | Mean | Control | $Fe_3O_4$ (3 g/pot) | $Fe_3O_4$ (6 g/pot) | Mean | Control | $Fe_3O_4$ (3 g/pot) | $Fe_3O_4$ (6 g/pot) | Mean |
| First season: 2013 | | | | | | | | | | | | | | | | |
| Control | 97.56d | 117.20b | 124.13a | 112.96A | 1.31de | 1.22fg | 1.70bc | 1.41BC | 32.72c | 38.96b | 46.26a | 39.31A | 39.01e | 43.53d | 48.26c | 43.60B |
| 2000 | 82.47h | 95.52e | 115.07c | 97.69B | 1.17g | 1.82a | 1.39d | 1.46AB | 28.15e | 33.14c | 38.98b | 33.42B | 39.75e | 50.05bc | 60.01a | 49.94A |
| 4000 | 74.33i | 86.08g | 90.11f | 83.51C | 1.27ef | 1.36d | 1.78ab | 1.47A | 22.39g | 27.07e | 29.65d | 26.37C | 32.11f | 50.01bc | 50.78b | 44.30B |
| 6000 | 59.82l | 68.50k | 71.76j | 66.69D | 1.31d-f | 1.23e-g | 1.62c | 1.38C | 17.59h | 22.16g | 23.96f | 21.24D | 29.87g | 32.51f | 39.44e | 33.94C |
| Mean | 78.54C | 91.83B | 100.27A | | 1.27C | 1.41B | 1.62A | | 25.21C | 30.33B | 34.71A | | 35.19C | 44.03B | 49.62A | |
| Second season: 2014 | | | | | | | | | | | | | | | | |
| Control | 71.41h | 95.39c | 114.54a | 93.78A | 1.30f | 1.41e | 1.53d | 1.41C | 29.01d | 33.87b | 38.52a | 33.80A | 58.11c | 60.71b | 67.11a | 61.98A |
| 2000 | 70.92h | 89.41d | 109.33b | 89.89B | 1.36ef | 1.62c | 1.90a | 1.63A | 25.11f | 31.49c | 35.08b | 30.56B | 52.01e | 55.34d | 58.41c | 55.25B |
| 4000 | 58.67i | 79.81f | 88.24e | 75.57C | 1.17g | 1.31f | 1.70bc | 1.39C | 22.31g | 24.62f | 27.34c | 24.76C | 41.07g | 51.80e | 51.64e | 48.17C |
| 6000 | 50.77j | 77.01g | 78.76f | 68.85D | 1.30f | 1.51d | 1.63bc | 1.48B | 13.57j | 17.34i | 18.91h | 16.61D | 38.66h | 47.33f | 50.83e | 45.61D |
| Mean | 62.94C | 85.94B | 97.72A | | 1.28C | 1.46B | 1.69A | | 22.50C | 26.83B | 29.96A | | 47.46C | 53.80B | 57.00A | |

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

**Table (4): Effect of soil salinity, magnetic iron and their interactions on fresh and dry weights of *Acalypha wilkesiana* Müll. Arg. aerial parts and roots during 2013 and 2014 seasons.**

| Magnetic treatments / Soil salinity (ppm) | Aerial parts f.w. (g) | | | | Aerial parts d.w. (g) | | | | Roots fresh weight (g) | | | | Roots dry weight (g) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Control | $Fe_3O_4$ (3 g/pot) | $Fe_3O_4$ (6 g/pot) | Mean | Control | $Fe_3O_4$ (3 g/pot) | $Fe_3O_4$ (6 g/pot) | Mean | Control | $Fe_3O_4$ (3 g/pot) | $Fe_3O_4$ (6 g/pot) | Mean | Control | $Fe_3O_4$ (3 g/pot) | $Fe_3O_4$ (6 g/pot) | Mean |
| First season: 2013 | | | | | | | | | | | | | | | | |
| Control | 92.73d | 106.34b | 118.34a | 105.80A | 23.63c | 28.41b | 31.95a | 28.00A | 28.06g | 32.72d | 36.46ab | 32.41A | 7.42c-e | 7.98c-e | 9.15ab | 818A |
| 2000 | 73.56i | 85.97e | 98.36c | 85.96B | 18.43fg | 22.32cd | 21.04c-e | 20.60B | 28.13g | 29.45f | 33.91c | 30.50B | 6.97ef | 9.24b-d | 10.14a | 8.45A |
| 4000 | 75.11hi | 81.52f | 87.01e | 81.21C | 14.88h | 19.58e-g | 20.72d-f | 19.54B | 23.37h | 35.27b | 37.33a | 30.12B | 5.87f | 8.44bc | 9.56a | 7.96A |
| 6000 | 58.11j | 76.03h | 79.63g | 71.25D | 18.32g | 16.97gh | 18.33fg | 16.73C | 21.52i | 27.28g | 31.01e | 26.60C | 4.18g | 7.16de | 8.22b-d | 6.52B |
| Mean | 74.88C | 87.48B | 95.84A | | 18.82B | 21.82A | 23.01A | | 25.02C | 31.18B | 34.68A | | 6.11C | 7.96B | 9.27A | |
| Second season: 2014 | | | | | | | | | | | | | | | | |
| Control | 70.14f | 78.33c | 91.11a | 79.86A | 17.43c | 19.68b | 24.49a | 20.53A | 33.23f | 39.18b | 40.27a | 37.56A | 6.65d | 8.51ab | 8.76ab | 7.97A |
| 2000 | 59.27h | 60.70g | 91.43a | 70.47C | 14.95d | 15.74d | 24.89a | 18.53B | 30.04g | 36.05de | 36.87cd | 34.32B | 6.91d | 7.34cd | 9.20a | 7.82A |
| 4000 | 58.72hi | 73.35de | 83.61b | 71.89B | 15.67d | 18.01c | 20.29b | 17.99B | 27.99h | 37.51c | 34.67e | 33.79B | 5.49e | 6.78d | 7.91bc | 6.73B |
| 6000 | 57.62i | 72.51e | 73.93d | 68.02D | 13.41e | 17.50c | 17.12c | 16.01C | 32.52f | 32.31f | 36.55cd | 33.39B | 5.92f | 5.47e | 7.08cd | 5.49C |
| Mean | 61.44C | 71.22B | 85.02A | | 15.37C | 17.73B | 21.30A | | 30.95E | 36.26B | 37.09A | | 5.74C | 7.03B | 8.24A | |

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

**2- Chemical composition of the leaves:**

Data illustrated in Table (5) show that content of chlorophyll a, b and carotenoids (mg/g f.w.), as well as the percentages of nitrogen, phosphorus and potassium were descendingly decreased in the leaves with increasing salinity concentration in the soil mixture to reach the minimum values at the highest salinity level (6000 ppm) with significant differences as compared to the control means, but they were significantly increased as a result of increasing the level of magnetic iron to reach the maximum values at the rate of 6 g $Fe_3O_4$/pot. This may indicate the role of magnetite in repairing the reduction caused in these important constituents by salinity. In this connection, El-Hifny (2008) found that increasing magnetite level up to 200 kg/fed led to an increase in the content of N, P, K and Fe in the leaves and curds of cauliflower.

The opposite was the right regarding the content of sodium and chloride (%) and free proline (mg/g f.w.), which were gradually increased with elevating salinity level. This may be due to that the higher salt concentration in the nutrient medium usually leads to an increase in the uptake of some highly hydrophilic ions, e.g. Na or borate (Doak *et al*., 2005). It was also suggested that accumulation of some amino acids and amides in the leaves of salinity-stressed plants may be due to *de novo* synthesis and not to the result of degradation (Gilbert *et al*., 1998). However, the effect of magnetic iron on these components was different, as it was descendingly diminished Na %, but gradually raised Cl and proline content increasing its level. This may be in favor of growth of the plants, where reducing Na % protect the plants from plasmolysis, while increasing the free proline improves the water balance in the tissues of plants.

The effect of interaction treatments on leaf content of pigments, N, P and K was similar to their effects on vegetative and root growth parameters, as these constituents reached the utmost high content by cultivating in the unsalinized soil mixture interacted with the application of $Fe_3O_4$ at 6 g/pot and followed by either planting in unsalinized soil mixture + 3 g/pot $Fe_3O_4$ or planting in salinized one at 2000 ppm + 6 g/pot $Fe_3O_4$ combined treatments, which gave records greatly near to those of the superior combination. The case was different concerning the content of Na, Cl and free proline, which reached the maximal values in the leaves of plants cultured in 6000 ppm-salinized-soil mixture and abandoned of $Fe_3O_4$ application. This may be demonstrate the importance of applying magnetic iron in reducing the harmful effect of salinity through decreasing the absorption of Na and Cl from the soil solution under high salinity conditions.

In this regard, El-Hifny *et al*., (2008) stated that the favourable influence of magnetic iron application on rising the content of N, P, K and Fe with reducing that of Na and Cl may be attributed to creating a high energy magnetic field in the root media of the growing plants and this in turn, may stimulate the absorption of these elements versus decrease that of Na and Cl. Besides magnetic iron solubolises NaCl salt and leaches it out of the soil. Thus, the plants do not uptake higher amounts of either Na or Cl.

These results are in good harmony with those explored by Ali *et al*., (2011) on pepper, Ahmed *et al*., (2011) on *Hibiscus sabdariffa*, Shehata *et al*., (2012) on cucumber, Ali *et al*., (2013) on grapevines and Abdel-Fattah (2014) on *Jacaranda acutifolia*

**Table (5): Effect of soil salinity, magnetic iron and their interactions on chemical composition of *Acalypha wilkesiana* Müll. Arg. leaves during 2013 season.**

| Magnetic treatments | Control | $Fe_3O_4$ (3 g/ pot) | $Fe_3O_4$ (6 g/ pot) | Mean | Control | $Fe_3O_4$ (3 g/ pot) | $Fe_3O_4$ (6 g/ pot) | Mean | Control | $Fe_3O_4$ (3 g/ pot) | $Fe_3O_4$ (6 g/ pot) | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Soil salinity (ppm)** | **Chlorophyll a (mg/g f.w.)** | | | | **Chlorophyll b (mg/g f.w.)** | | | | **Carotenoids (mg/g f.w.)** | | | |
| Control | 0.45de | 0.51bc | 0.55a | 0.50a | 0.32de | 0.36b | 0.38a | 0.35a | 0.32cd | 0.27ab | 0.29a | 0.26a |
| 2000 | 0.40fg | 0.46de | 0.52ab | 0.46b | 0.31ef | 0.33cd | 0.34bc | 0.32b | 0.21de | 0.25bc | 0.27ab | 0.24b |
| 4000 | 0.37g | 0.43ef | 0.50bc | 0.43bc | 0.30fg | 0.32de | 0.33cd | 0.32b | 0.20ef | 0.23cd | 0.25bc | 0.23c |
| 6000 | 0.33h | 0.40fg | 0.48cd | 0.40c | 0.26h | 0.29fg | 0.31ef | 0.29c | 0.18f | 0.21de | 0.22de | 0.20d |
| Mean | 0.39c | 0.45b | 0.51a | | 0.30c | 0.32b | 0.34a | | 0.21c | 0.24b | 0.26a | |
| | N (%) | | | | P (%) | | | | K (%) | | | |
| Control | 1.08f | 1.76b | 1.96a | 1.60a | 0.39de | 0.47bc | 0.58a | 0.48a | 1.41h | 1.76b | 1.84a | 1.67a |
| 2000 | 1.07f | 1.52cd | 1.91a | 1.50b | 0.36e | 0.49bc | 0.52ab | 0.46a | 1.34i | 1.70cd | 1.73bc | 1.59b |
| 4000 | 0.93g | 1.48d | 1.61c | 1.34c | 0.28f | 0.39e | 0.45cd | 0.37b | 1.15j | 1.63e | 1.67de | 1.48c |
| 6000 | 0.77h | 1.15f | 1.21e | 1.04d | 0.24f | 0.37e | 0.40de | 0.34b | 0.97k | 1.48g | 1.57f | 1.34d |
| Mean | 0.96c | 1.48b | 1.67a | | 0.32e | 0.43b | 0.49a | | 1.22c | 1.62b | 1.70a | |
| | N a (%) | | | | Cl (%) | | | | Free proline (mg/g f.w.) | | | |
| Control | 2.59de | 2.54e | 1.55f | 2.23c | 1.25g | 1.24g | 1.50f | 1.33c | 1.39ef | 1.37ef | 1.35f | 1.37d |
| 2000 | 2.75bc | 2.71c | 2.67cd | 2.71b | 1.69e | 1.14g | 0.94h | 1.26c | 1.61d | 1.52de | 1.48d-f | 1.54c |
| 4000 | 2.81ab | 2.74bc | 2.72c | 2.76a | 2.08c | 1.92d | 1.82de | 1.94b | 2.38b | 2.29b | 2.04c | 2.24b |
| 6000 | 2.85a | 2.74bc | 2.68c | 2.75a | 2.70a | 2.53b | 2.41b | 2.55a | 2.54a | 2.43ab | 2.41ab | 2.46a |
| Mean | 2.75a | 2.68b | 2.41c | | 1.67b | 1.71b | 1.93a | | 1.82c | 1.90b | 1.98a | |

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

From the above mentioned results, it can be advised to drench magnetic iron at the rate of 6 g/pot to improve the tolerance of Copper-leaf plant to soil salinity up to 6000 ppm concentration.

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## دور الحديد الممغنط فى رفع قدرة شتلات نبات الأكاليفا النحاسية (*Acalypha wilkesiana* Müll. Arg.) لتحمل ملوحة التربة

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لكى نزيد من قدرة شتلات نبات الورقة النحاسية (*Acalypha wilkesiana* Müll. Arg.) لتحمل ملوحة التربة، أجري هذا البحث تحت الشمس الساطعة بمشتل معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر خلال موسمي ٢٠١٣، ٢٠١٤ حيث زرعت شتلات عمر خمسة أشهر من هذه الشجيرة (والتى تزرع كنبات زينة لجمل أوراقها) فى أصص بلاستيك قطرها ٣٠ سم، ملئت بحوالي ٦ كجم من مخلوط الرمل + الطمي + كومبوست مخلفات المواشي جيد التحلل (بنسبة ١ : ١: ١ بالحجم)/أصيص بعد تمليحه بمخلوط متساوي من أملاح كلوريد الصوديوم وكلوريد الكالسيوم (١:١ بالوزن) بتركيزات: صفر، ٢٠٠٠، ٤٠٠٠، ٦٠٠٠ جزء فى المليون. ولقد أضيف الحديد الممغنط تكبيشاً للتربة بمعدلات صفر، ٣، ٦ جم/أصيص، ٤ مرات وبفاصل شهرين بين كل مرتين. أيضاً، تم دراسة تأثير التفاعل بين معاملات الملوحة والحديد الممغنط على النمو والمحتوى الكيماوي للنبات موضع الدراسة.

أوضحت النتائج المتحصل عليها أن متوسطات جميع قياسات النمو الخضرى والجذري قد انخفضت بشكل تنازلي، مع بعض الاستثناءات البسيطة، كلما زاد تركيز الملوحة لتصل إلى أدني القيم مقارنة بالكنترول فى كلا الموسمين بمعاملة أعلى مستوى من الملوحة، بينما زادت قيم هذه المتوسطات تدريجياً كلما زاد معدل إضافة الحديد الممغنط (الماجنتيت) لتصل إلى أقصاها عند إضافة هذا المركب بمعدل ٦ جم/أصيص. صحيح، أن المعاملة بالحديد الممغنط بمعدل ٣ جم/أصيص أحدثت زيادة معنوية فى متوسطات قياسات النمو الخضري والجذري مقارنة بالكنترول، لكن اليد العليا فى كلا الموسمين كانت لمعدل الإضافة ٦ جم/أصيص. ولقد كان تأثير معاملات التفاعل على النمو الخضري والجذري متقلباً، لكن أفضل النتائج أحرزت فى كلا الموسمين بالجمع بين الزراعة إما فى مخلوط التربة الغير مملح أو المملح بمعدل ٢٠٠٠ جزء فى المليون + إضافة الحديد الممغنط بأي مستوى (٣ أو ٦ جم/أصيص). أيضاً فإن الجمع بين الزرعة فى مخلوط تربة مملح بمعدل ٤٠٠٠ جزء فى المليون والمعاملة بالماجنتيت بمعدل ٦ جم/أصيص أحدثت تحسناً معنوياً فى بعض قياسات النمو. وبصفة عامة، فإن زيادة معدل إضافة الحديد الممغنط أحدثت تحسناً إضافياً فى معظم قياسات النمو الخضري والجذري بصرف النظر عن مستوى الملوحة. ولقد إنخفض محتوى الأوراق من كلوروفيللي أ، ب، الكاروتينويدات، النيتروجين، الفوسفور، البوتاسيوم تدريجياً بزيادة مستوى الملوحة، لكنه زاد تصاعدياً كلما زاد معدل إضافة الحديد الممغنط. أما محتوى الصوديوم، الكلوريد والبرولين الحر فى الأوراق فقد زاد على طول الخط بزيادة تركيز الملوحة. على الجانب الآخر، إنخفض محتوى الصوديوم تنازلياً، بينما زاد تصاعدياً محتوى الكلوريد والبرولين بزيادة معدل إضافة الحديد الممغنط. أوضحت النتائج أيضاً أن تأثير معاملات التفاعل على محتوى كلوروفيللى أ، ب، الكاروتيويدات، النيتروجين، الفوسفور، البوتاسيوم كان مشابهاً إلى حد كبير لتأثيرها على قياسات النمو الخضري والجذري، لكن العكس كان صحيحاً فيما يتعلق بمحتوى الأوراق من الصوديوم، الكلوريد والبرولين.

وعليه، يمكن التوصية بالإضافة الحديد الممغنط (الماجنتيت) بمعدل ٦ جم/أصيص، ٤ مرات وبفاصل شهرين بين كل مرتين لمخلوط التربة المملح والذي ستزرع فيه شتلات نبات الورقة النحاسية (الأكاليفا) لتحسين قدرتها على تحمل إجهاد الملوحة حتى ٦٠٠٠ جزء فى المليون.