Physiological And Biochemical Responses Of Schefflera Arborcola Cv. Gold Capella Plant To Foliar Application Of Magnesium, Zinc And Manganese From Different Sources

M. A., El-Khateeb [(1)], S. E. A., Esmail [(1)] and D.K., Saeed [(1)]

(1) Department of Ornamental Horticulture, Faculty of Agriculture, Cairo University, P.O. Box 12613, Giza, Egypt.
DOI: 10.47750/pnr.2023.14.S02.112

Abstract

This research was carried out to determine suitable source of magnesium, zinc and manganese for quality of Schefflera cv. Gold Capella, plant, using three sources (-Nano, SO4 and-EDTA) as foliar sprays, under greenhouse condition.

According to results, zinc from different sources showed significant increases in growth parameters (plant height, stem diameter, leaf area, numbers of leaves, and fresh and dry weights). The tallest plants with Zn-chelated. The thickest stems were found in Mg-sulphate and Zn-sulphate treated plants. Number of leaves was significantly highest in plants treated with Zn and Nano-Mn. The largest leaf area recoded with Zn-chelated and Mg-salt. The heaviest fresh dry weights of leaves, stems and roots were with Zn and Mn. The highest root number were in Zn-salt and Mn-chelated and Nano-Mg was more effective than the other Mg-sources. All sources of Mg and Nano-Zn, increased the chlorophyll content, over Mn and control. The highest carbohydrate % was in leaves from Mn-salt treated plants, followed by Zn-chelated. Total indoles and phenolic compounds were high in all Zn-sorces followed by Mg-salt. The highest N% and P% were recorded with Nano-treatments, meanwhile, K-% was highest in Mn-chelated and Nano-Zn treatments.

Keywords: Schefflera, Mg, Mn, Zn, Nano, EDTA.

Introduction

Schefflera belongs to Araliaceae family, it is a very popular indoor and outdoor ornamental foliage plant, it has a beautiful and creative leaves, it is evergreen shrub used as a fantastic houseplant. Many cvs are important as indoor pot plants in the market (Luseane, Charlotte and Gold Capella). Schefflera “Gold Capella” is the most attractive cv., with stunning variegated foliage and irregular splashes of gold and yellow with green variegation. It was used outdoor as specimen, can grow in shade and full sun.

It tolerates a range of growing conditions (Conover C.A., 1992, Gilman and Watson, 1994; Chen et al., 2002 and Plunkett et al., 2005). It has the ability to tolerance harsh interior environments which increased its worldwide popularity (Dela Cruz et al., 2014).

Plant nutrition is important factor affecting growth of indoor plants. Growth quality require 17 nutrients for proper development, among which Mg, Mn and Zn, which are commonly deficient in plants that grown in pots. To assure growth quality and favorable plant growth, these nutrients must be available not only in sufficient amounts, but also in appropriate source and ratios (Maathuis,2009).

Several studies revealed the beneficial effects and roles of Mg and micro nutrients Zn and Mn for plants, as they involved in functioning of number of enzymes. So, foliar spray of Mg, Zn and Mn is more effective way to avail such nutrients and overcome deficiencies to increase and improve the growth quality. Plants need them for best quality.

The deficiency or insufficient quantities, produced pale leaves and decrease of chlorophyll content with a reduction of quality. Foliar spray method increases performance absorption and reduce consumption. Mg-element plays vital role in regulating the enzymatic activity, photosynthesis, chlorophyll synthesis, it is used in large quantity by plants for plant growth, development and quality of plants (Cakmak and Kirkby,2008 & Marschner,2011). Mg serves as the key atom of chlorophyll, where it acts in pigment-protein complexes to gather photons in photosystem (PSI&II). Mn is an essential element as enzyme cofactor (Andresen et al., 2018), it is involved in physiological and biochemical processes (photosynthetic proteins and enzymes), growth and plant development (Chen et al. 2015; Zhao et al. 2017), Mg and Mn deficiencies severely decreased plant growth and quality. Zinc (Zn) is required by all plants to stimulate plant growth and improve their size, weight and quality (Maurya et al, 2018), it has a key role in biosynthesis of the natural auxin-IAA (Mengel and Kirkby, 1987), it is essential constituent of cell component and various cell membranes for the maintenance of cell structure, induce cell division and enhance vegetative growth, it enhances chloroplast development and cell division it regulates ion balance within plants (Sarwar et al. 2014). Zn plays an important role in the stability of the membrane structure, elongation of the cell and tolerance of environmental stresses, moreover it is mainly involved in the metabolism of nitrogen and carbohydrates as well as protein synthesis, maintaining and integrating cell membrane structure. (Marreiro et al. 2017).

Application of chelated-macro and micro nutrients has proven to be a highly effective way to increase growth and quality of plants, it increases utilization efficiency. Micronutrients such as Mn, Zn and Fe are easily oxidized or precipitated in soil and utilization become not efficient. Most fertilizers used in ornamentals and floral crop production with micronutrient (Fe, Mn, and Zn) are used in chelating (EDTA, DTPA and EDDHA). Chelated-Mg,-Mn,- Zn and -Fe are the most common among formulations. Micro-element chelates are used to prevent or correct deficiencies and have been reported to be more effective than other non-chelated ones, since they are involved in the direct supply to plant (Broschat, 2003).

Nano fertilizers are rapidly and completely absorbed by plants and fix nutrients shortages and plant needs. The use of Nano-elements leads to an increased efficiency of the elements, it reduces the its toxicity and frequency of application (Naderi et al, 2011). Albano and Merhaut (2012) on Tagetes erecta cv. First Lady, supplied with Fe-EDDHA, Nano-Fe and FeSO4-salt found that all treatments were in the same level in the most of characteristics, but Nano-form was superior.

On Spathiphyllum plant, Mohamadipoor, et al (2013) applied Fe as foliar sprays from different sources (-Nano-,-SO4,and-EDTA), found that Nano-Fe had the significant superiority effect over other forms particularly EDDH. On basil plant, the replacement of iron-sulphate fertilizer with Nano or Chelate forms showed that Nano could increase the quantitative and qualitative of plant growth traits (Peyvendi,et al 2011). Roosta, et al (2015) on lettuce showed that plant growth and plant pigments were significantly increased by chelate application and nano.

This study aimed to evaluate the physiological and biochemical responses of Schefflera cv. Gold Capella plant to foliar application of magnesium, zinc and manganese from different sources for good quality growth under greenhouse condition.

Materials and Methods

Plant materials

Terminal rooted cuttings of Schefflera cv. Gold Capella (14-16 cm height, 4-5 leaves) were prepared from mother plants growing in the greenhouse. They were inserted in plastic pots (20 cm) filled with a mixture of sand + peat+ clay (1:1:1, v/v).

Growth Condition

A greenhouse experiment was conducted at Depart. of Ornamental Horticulture, Fac. of Agric., Cairo Univ., during 2021, to study the response of cv. Gold Capella to monthly foliar sprays of some sources of Mg, Mn and Zn, throughout the period from 5 th April to 5 th Dec.

Treatments

Plants were received a monthly foliar spray of the following treatments: Mg. sulphate 250 ppm, Mg- Chelated 250 ppm, Mg Nano at 50ppm, Mn salt at 250 ppm, Mn chalet at 250ppm, Mn nano at 50 ppm, Zn salt at 250 ppm, Zn chalet at 250ppm, and Zn nano at 50 ppm, besides the control. standard fertilization treatment N P K (2g /pot/month). All plants were fertilized with NPK at 1:1:1 at g/ at monthly intervals. The plants were grown in these media for 2 months.

Data recorded: The following data were recorded: Plant height, stem diameter, No. of leaves/plant, leaf area (using portable laser leaf area meter, CL-202), fresh and dry weights of leaves stem and roots as well as root number and length.

Chemical analysis

The contents of chlorophyll-a, b, carotenoids in fresh leaves (mg/g F.W.) were carried out to (Saric, et al., 1976) method. Total carbohydrate in leaves(% DW) was determined using phenol sulfuric colorimetric method (Herbert, et al. 1971). , total nitrogen content using method of Pregl (1945), P-content according to (Troug and Meyer, 1939), and K-content by using operation chart of Shimadzu Atomic Absorption /Flame Spectrophotometer A646 (Chapman and Pratt, 1961).Total phenolic contents in methanolic extract (mg/g F.W) were estimated using the Folin-Ciocalteau reagent as described by Singleton, V. L. and J. A. Rossi (1965).The indoles content (mg/g F.W) was determined by Larson, et al.(1962) method, in methanolic extract of fresh leaves, using Ehrlich's reagent (p-4-Di-methyl-amino benzaldehyde, Aldrich Co.).

Statistical Analysis & Layout

The experiment was a complete randomized design, with 3 replicates (each replicate contained 3 plants) design including ten treatments in three replicates, each replicate contains 5 seedlings. Data obtained were statistically analyzed and analysis of variance (ANOVA) and the means of treatments were compared using LSD test at 5% level (Snedecor & Cochran, 1989.

Results

Vegetative growth parameters

Data in Table (1) reveal that the foliar application of Mg and micronutrients Zn and Mn significantly affected growth parameters of Schefflera plant cv. Gold Capella (plant height, stem diameter, leaf area, numbers of leaves and fresh and dry weights of leaves). Treating Schefflera plant with different sources of Zn significantly affected the plant height. The tallest plants (58.24 cm) were recorded with Zn-chelated at 250ppm. Meanwhile, the shortest one (44.39 cm) was recorded with the untreated plants. Treating plants with Mg (all sources), was less effective in enhancing height growth than Zn and Mn. All sources of Mn significantly increased the plant height, and nano-Mn was more effective, in this respect, than the other two sources (52.80 cm).

The highest values of stem thickness (13.56 and 13.19 mm) were attained in plants treated with sulphate salts of Mg and Zn (each at 250 ppm), respectively. Whereas, the thinnest ones (10.06 mm) was recorded control plant followed by plants treated with Mg-or Mn- in chelated form. The formation of leaves was significantly responded to the application of all sources of Zn, as well as Nano –Mn. The least number of leaves was noticed in the control plants (9.67) and plant sprayed with Mg- Chelated (9.88). Nano-sprays of Zn, Mg and Mn were more effective, in this regard, among the different forms used in this study.

The average leaf area of Schefflera was the greatest with the foliar application of Zn-chelated and Mg-salt (sulphate). The smallest leaves were attained in control plants (28.43cm2) as well as Mn-chelated treatment (29.96 cm2).

The heaviest fresh and dry weight of leaves (117.78 ,109.27, 37.69 and 34.55 g) were obtained in plants treated with chelated- and nano-Zn, respectively. The least weights (68.15and 19.40 g, respectively) were recorded in control plants.

TABLE 1. Influence of foliar spray with Mg and micronutrients Mn and Zn on vegetative characteristics of Schefflera cv. Gold Cablella plants.

Treatments	Plant height (cm)	Stem Diameter (mm)	Leaves No / plant	Leaf area (cm^2)	FW of leaves (g)	DW of leaves (g)
Control	44.39	10.06	9.67	28.43	68.15	19.40
Mg sulphate	44.60	13.19	10.33	38.27	79.08	23.86
Mg-Chelated	45.60	10.38	9.88	31.94	73.55	23.38
Mg Nano	46.88	10.82	11.90	31.95	68.33	20.16
Mn sulphate	49.19	11.28	10.67	34.92	78.75	25.51
Mn-Chelated	50.45	10.31	10.20	29.96	70.73	21.40
Mn nano	52.80	11.56	13.00	31.90	75.25	23.46
Zn sulphate	53.64	13.56	13.99	37.97	102.16	30.65
Zn-Chelated	58.24	12.42	13.67	47.11	117.78	37.69
Zn nano	55.60	12.69	14.25	33.27	109.27	34.55
LSD 5 %	3.44	1.12	1.28	2.56	5.45	2.72

Element source: Sulphate at 250 ppm, Chelated et 250 ppm, and Nano at 50 ppm.

As shown in Table (2) concerning the effect of Mg and microelements (Zn and Mn) from different sources on stem and roots vegetative growth parameters of Schefflera plant cv. Gold Capella. the obtained results revealed that the foliar application of Zn of different sources followed by nano-Mn significantly increased the fresh and dry weights of stems.

Additionally, it was found that spraying plants with Zn in the form of nano –Zn, gave the heaviest stems fresh and dry weights (67.36 and 22.90 g), respectively. This trend was nano-Mn treatment which was more effective in increasing stem weights than the other two sources. The lowest values (48.21 and 13.27 g, respectively) were recorded in the untreated plants(control).

The root system growth of Schefflera plants (Table 2), showed a great response to the foliar application of Zn from the different sources and Mn in the form of nano-particles, which significantly increased the number of roots per seedling. The highest number of roots 16.67and the longest one 39.33cm were recorded in plants treated with Zn salt and Mn- chelated, respectively. Mg in the form of nano-Mg was more effective in increasing the root number than the other two Mg- sources with a marked reduction in length. Moreover, Mn in the form of nano-Mg was more effective in increasing the root number as well as length than the other two Mn- sources.

The highest values fresh and dry weights of roots were found in plants treated with the different sources of Zn and Zn-sulphate at 250 ppm followed by Zn-chelated were the most effective ones in this respect, resulting 17.43, 6.89,17.20 and 6.51g, respectively, whereas, the lowest values (12.32 and 3.98 g) were recorded in the untreated plants.

TABLE 2. Influence of foliar spray with Mg and micronutrients Mn and Zn on stem and roots characteristics of Schefflera cv. Gold Cablella plants.

Treatments	FW of stem (g)	DW of stem (g)	Roots No / plant	Root length (cm2)	FW of roots (g)	DW of roots (g)

Control	48.21	13.27	10.67	26.00	12.32	3.98
Mg sulphate	54.72	15.24	12.17	32.00	14.48	4.28
Mg-Chelated	48.44	15.30	12.00	33.67	13.78	5.09
Mg Nano	49.72	16.94	13.27	28.67	13.37	4.75
Mn sulphate	54.33	17.79	13.40	30.00	14.18	5.32
Mn-Chelated	52.96	17.52	13.00	37.33	14.97	5.12
Mn nano	59.88	19.98	13.87	39.33	15.66	5.83
Zn sulphate	62.00	21.08	16.67	34.67	17.43	6.89
Zn-Chelated	65.34	22.21	14.00	35.00	17.20	6.51
Zn nano	67.36	22.90	13.90	33.67	16.14	6.07
LSD 5 %	4.25	2.22	1.45	3.55	2.45	1.27

Element source: Sulphate at 250 ppm, Chelated et 250 ppm, and Nano at 50 ppm.

The content of pigments of the fresh leaves of Schefflera in response to the foliar application of Mg, Mn and Zn, from different sources (Fig.1), indicated that the content of chlorophyll plants treated with manganese (regardless the source) markedly contained the higher values, followed by the treatment of nano-Z more than the other treatments and the control plants. Concerning the carotenoids content, the data revealed that applying Mg, Mn and Zn, from as sulphate sources followed by Nano-particles of these elements were more effective in this regard, than the other treatments. The highest values were obtained in plants treated with Zn-salt and Mg-salts (1.22 and 1.20 mg/g, respectively).

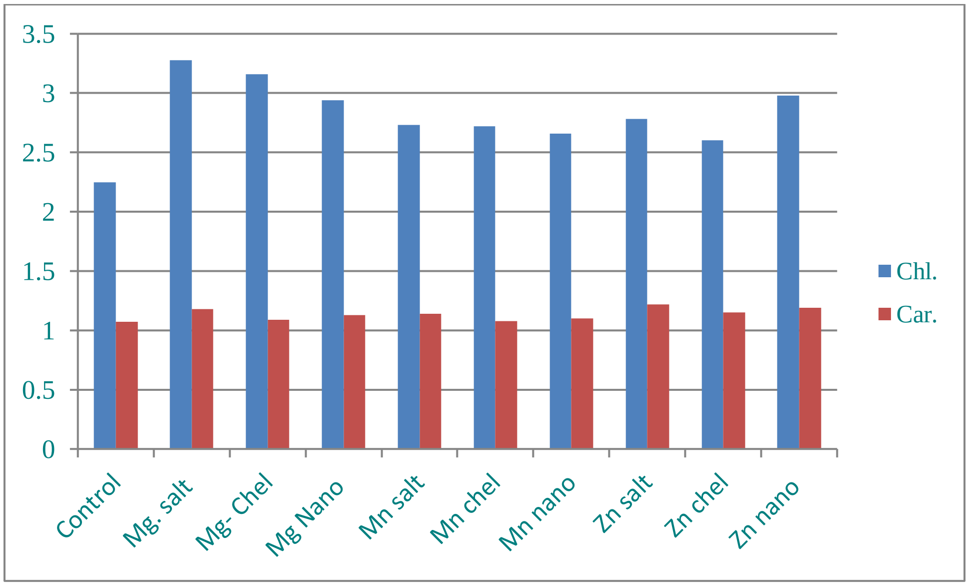

Fig.1. **Chlorophyll and carotenoids contents as affected by the foliar application of Mg, Mn and Zn from different sources.**

The total carbohydrate content in the leaves, reached to the highest content (23.43 %DW) was recorded in leaves from plants treated with Mn-sulphate, followed by nano-Mg and nano Zn, (22.95and 22.13%DW). The lowest value (17.19%) was obtained in control plants. The indoles content in response to the foliar application of different sources of Mg, Mn and Zn (Table 3), showed that treating plants with all sources Zn (Sulphate, Chelated and Nano) were the most effective in increasing the content of total soluble indoles (0.508, 0.586 and 0.612 mg/g FW, respectively), which followed by the treatment of Mg-sulphate (0.498612mg/g FW). The lowest one (0.336) was recorded in leaves of untreated plants. In response to the foliar application of different sources of Mg, Mn and Zn (Table 3), the content of phenolic compounds in Schefflera leaves indicated that using Chelated source of Zn, Mn as well as Mg were the most effective treatments in increasing the content of phenolic compounds (0.592, 0.569 and 0.553 mg/g FW, respectively), in comparison with other sources, followed by the treatments of nano -Zn- and Mg-sulphate treatments. The lowest one (0.392 mg) was recorded in leaves of untreated plants.

TABLE 3. Influence of foliar spray with Mg and micronutrients Mn and Zn on carbohydrate, indoles and phenol and N, P and K contents of Schefflera cv. Gold Cablella plants.

Treatments	Total Carbohydrate % DW	Indoles mg/g FW	Phenol mg /g FW	N%	P%	K%
Control	17.19	0.336	0.392	1.55	0.237	1.95
Mg sulphate	20.26	0.498	0.510	1.21	0.325	2.05
Mg-Chelated	21.33	0.474	0.553	1.45	0.314	1.94
Mg Nano	22.95	0.372	0.434	1.58	0.350	2.19
Mn sulphate	23.43	0.366	0.427	1.75	0.300	2.21
Mn-Chelated	19.79	0.402	0.569	1.73	0.325	2.37
Mn nano	19.62	0.406	0.477	2.35	0.338	2.37
Zn sulphate	19.77	0.508	0.476	1.46	0.275	2.27
Zn-Chelated	21.84	0.586	0.592	1.54	0.250	2.33
Zn nano	22.13	0.612	0.524	1.95	0.275	2.24
LSD 5 %	4.25	2.22	1.45	3.55	2.45	1.27

Element source: Sulphate at 250 ppm, Chelated et 250 ppm, and Nano at 50 ppm.

The highest N-content in leaves (2.35 %DW) was recorded with treatment of nano- Mn, followed by nano –Zn (1.95%). The lowest one (1.21 %) was obtained with Mg- sulphate treated plants. The application of different elements in the form of nano Pls, was more effective in increasing N-content than the other sources used. The highest P-content (0.350 and 0.338 %DW) were estimated in plants treated with Nano-Mg and Nano -Mn, respectively. In case of K-content, it was found that treating Schefflera plants with Chelated and Nano- Mn as well as Zn-chelated gave the highest contents. and the lowest ones were recorded in untreated plants and plants treated with Mg-chelated.

Discussion

The foliar application of Zn, Mg and Mn significantly affected plant growth parameters (plant height, stem diameter, leaf area, numbers of leaves, and fresh and dry weights). Treating plants with different sources of Zn significantly affected the plant height, the tallest plants was recorded with Zn-chelated. Moreover, the thickest stem diameters were found in plants treated with Mg and Zn, in the form of sulphate salts. The use of Zn in different stages of plant growth can affect plant performance in different ways (Alloway 2008). This element is used as part of the structure of enzymes or acts as regulator cofactors in a number of enzymes ,it is used in the building of at least four enzymes(carbonic anhydrase ,Cu-Zn superoxide dismutase, alcohol dehydrogenase, RNA polymerase)and other enzymes need Zn for their activity. Zinc has an important relationship with plant protein metabolism and it is an essential element of RNA polymerase necessary for protein synthesis (Falchuk et al., 1978).

Also, Zinc affects photosynthesis and sugar transport in plants, and regulating carbohydrate metabolism. Zinc and manganese function in many plant enzyme systems, they connect the enzyme with the substrate upon which it is meant to act. (Brady and Weil 1999). Gomaa and Ragab (2005) on *Codiaeum variegatum*, Abd El-Aziz and Balbaa (2007) on *Salvia farinacea* and Farahat et al (2007) on *Cupressus sempervirens*. EL Sayed, et al (2009) on *Dracaena marginata* reported that spraying the plants with micro elements resulted in the greatest vegetative growth parameters compared to control.

The formation of leaves was responded significantly to the application of Zn from different sources as well as Nano-Mn. Also, the average leaf area was the greatest with Zn-chelated and Mg –sulphate treatments, this can be attributed to the role of Zn as an essential trace element for plant growth and development (El-Khateeb, et al, 2014). Zn plays an important role in plant physiology (Zhang et al., 2017), it can affect auxin synthesis, has a positive effect on potassium concentration in plants (Wang et al., 2018). Mn is an essential element as enzyme cofactor (Andresen et al., 2018), it enhances physiological and bio -chemical processes (photosynthetic proteins and enzymes), growth, and plant development (Marschner, 2012 & Zhao, et al. , 2017). The heaviest dry weight of leaves was obtained in plants treated with chelated (250 ppm) and Zn-sulphate. The foliar application of Zn from different sources, followed by Mn significantly affected the fresh and dry weights of stem. Treating plants with Zn in the form of nano –Zn followed by chalet-Zn then zinc salts exhibited significantly the highest values of fresh and dry weights of stem. The foliar spray of Nano-element is rapidly and completely absorbed by plants and fix nutrient shortage, leading to an increased efficiency of the element applied, more than other forms (Naderi, et al., 2011). Roots growth of *Schefflera* plants showed great responses to the foliar application of Zn and Mn, the highest number of roots were recorded in plants treated with Zn salt and Mn chelated, whereas Mg in the form of nano-Mg was more effective in increasing the root number than the other two Mg- sources with no significance differences with the control. The highest values fresh and dry weights of roots were found in plants treated with the different sources of Zn and Zn-sulphate at 250 ppm, was the most effective in this respect. Zinc has an important role in plant protein metabolism and synthesis, it affects photosynthesis, carbohydrate metabolism and sugar transport within plants (Broadley et al., 2012). The obtained results showed that the foliar application of Mg and Zn (regardless the source) markedly increased the chlorophyll content more than Mn, and control plants. Mg-salts and Mg-chelated were more effective in this regard. The carotenoids content was the highest in plants treated with Mg –chelated and Mn-sulphate then Zn-sulphate. The role of Mg in improving green pigmentation can be attributed to its role as a component in the formation of chlorophylls, as an activator of chloroplast matrix and enzymes which promote the operation of photosynthesis, Li Yan et al (2001) showed that magnesium deficiency decreased photosynthetic pigment content, chloroplast light absorption capacity, carboxylation efficiency, and increased the light compensation point and CO2 compensation point. Mohsenzadeh and Moosavian (2017) found that the foliar application of Zinc sulphate and Nano-Zinc increased the contents of chlorophyll and carotenoids.

Additionally, spraying safflower with Zn increased chlorophyll, illustrating the significant role in the N-metabolism and chlorophyll production (Movahhedi Dehnavi, M, 2004). Zinc by protection of sulfhydryl groups caused synthesized chlorophyll (Cakmak ,2000). The highest content of total carbohydrate was recorded in plants treated with Mn-sulphate followed by Mg or Zn in Nano form. In this regard, Mg plays a ke role in carbohydrate formation as it depends on the plant’s Mg status, it is the central atom of chlorophyll a/b (Marschner 2012),Also, zinc can affect the transportation of plant sugars by participating in starch metabolism, its deficiency was found to reduce starch metabolism , Fan et al (2021) showed that the net photosynthetic rate, Chl A and Chl B levels of leaves increased as the concentration of zinc increased, they suggested that exogenous zinc may promote the accumulation of carbohydrate components in D. nobile. It was also found that polysaccharides could combine well with zinc to form a polysaccharide-zinc chelate and transform inorganic zinc into organic form, stored in the form of polysaccharide. All sources of Zn were the most effective treatments in increasing the content of indoles content, followed by Mg-sulphate. The effect of zinc on auxin is related to the synthesis of tryptophan, which may be owing to the influence of zinc on the activity of tryptophan synthase. Carbonic anhydrase that plays an important role in photosynthesis is a zinc metal coenzyme (Castillo-González, et al, 2018). The content of phenolic compounds increased in response to the foliar application of different sources of Mg, Mn and Zn, over the control. Using Chelated source of Zn, Mn as well as Mg, followed by Nano -Zn and Mg-sulphate treatments, were the most effective in this regard, in comparison with other sources and control. The foliar spray of Nano-element is rapidly absorbed by plants and increased efficiency of the element applied (Naderi et al ,2011). Mohsenzadeh and Moosavian (2017) found that the foliar application of Zinc Sulphate and Nano-Zinc increased the content of phenolic compounds in rosemary plants. The highest N-content was attained with nano- Mn, followed by nano –Zn. The application of Mg, Mn and Zn in the form of nano Pls, was more effective in increasing the content of N than the other sources. The highest P-content was estimated in plants treated with Nano-Mg and Nano-Mn, respectively. In case of K-content, it was found that treating Mn in chelated and nano forms, as well as nano-Zn. The nano elements change the physical, chemical, biological features and catalytic activities of them, and become higher solubility, capable of penetrating the cell membrane and chemical activity (Mazaherinia et al 2010)

Conclusion

Zinc foliar application from various sources significantly improved Schefflera plant growth parameters and Zn-chapleted gave the tallest plants. The thickest stems with Zn and Mg each as sulphate. Nano–Zn or chelated-Zn gave the heaviest stem weights. Roots growth showed great responses to Zn sulphate and Mn-chelated. Nano-Mg significantly increased root number than other Mg- sources. Chlorophyll was the highest Mg and nano-Zn, and total carbohydrate with Mn-sulphate and Zn-chelated. The total soluble indoles all sources Zn (Sulphate, Chelate and Nano). The application of Mg, Mn and Zn as nano Pls, was more effective in increasing N-content than other sources. The highest carbohydrate content was recorded in Mn-sulphate and Zn-chelated treated plants. The highest K-content, was found in Mn- chelated, Mn nano forms and nano-Zn treatments.

References

1. Abd El-Aziz, N.G., Balbaa , L.K. (2007) Influence of tyrosine and zinc on growth, flowering and chemical constituents of Salvia farinacea plants. J. Appl. Sci. Res., **3** (11), 1479-1489.
2. Albano, J., Merhaut,D.J. (2012)Influence of FeEDDS , FeEDTA, FeDTPA, FeEDDHA, and FeSO4 on marigold growth and nutrition, and substrate and runoff chemistry. HortScience, **47**(1), 93-97.
3. Alloway, B.J. (2008) Zinc in Soil and Crop Nutrition. 2nd Edition, IZA and IFA Brussels, Belgium and Paris, 114 p.
4. Andresen, E., Peiter, E., and Küpper, H. (2018) Trace metal metabolism in plants. J. Exp. Bot**. 69,** 909–954.
5. Brady, N.C. Weil, R.R. (1999) The Nature and Properties of Soils. 12th Edition, Prentice Hall Publishers, London, 1-9, 453-536, 727, 739-740.
6. Broadley, M., Brown, P., Cakmak, I., Rengel, Z. (2012) Function of Nutrients. In book: Marschner's Mineral Nutrition of Higher Plants (191-248).
7. Broschat, T.K. and Moore, K.K. (2003) Influence of fertilizer placement on plant quality, root distribution growth in container-grown-tropical ornamental plants. Hort Technology, **13** (2): 305-308.
8. Cakmak, I. (2000) Possible Roles of Zinc in Protecting Plant Cells from Damage by Reactive Oxygen Species. New Phytology, **146**, 185-205.
9. Cakmak, I and Kirkby, E.A. (2008) Role of magnesium in carbon partitioning and alleviating photo-oxidative damage. Physiol Plant, **133**(4), 692-704.
10. Castillo-González, E., Hernández, R. A., González-Franco, A.C, Robles, G.H., López, R. (2018) Zinc metal-enzymes in plants. Interciencia, **43**, (4), 242-248.
11. Chapman, H.D. and Pratt, P.F. (1961) Methods of Analysis for Soils, Plants and Waters. University of California, Los Angeles, **60**, 150-179.
12. Chen, N. J., Henny, R.J., McConnell, D.B. (2002) Development of new foliage plant cultivars,466-472. In:Trends in New Crops. AHSH Press, Alexandria, USA

13. Conover, C.A. (1992) Foliage Plants, pp. 571-598, In: Larson R.A. (ed.), Introduction to Floriculture. Academic Press, London, UK, pp. 636.
14. Dela Cruz, M., Christensen J.H., Dyrhauge Thomsenj, R., Muller R. (2014) Can ornamental potted plants remove volatile organic compounds from indoor air? A review. Environ. Sci. Pollut. Res., **21**(24), 13909-13928.
15. El-Khateeb, M.A.,El- Quesni, F., Farahat, M.M., El-Leithy, A.S. ,Hashish, K. (2014) Effect of some micro-elements of iron, manganese and zinc on vegetative growth and chemical composition of Paulownia kawakamii Seedlings. Middle East Journal of Agric. Res., **3**(4), 820-826.
16. EL Sayed, A.A., El-Leithy, A.S., Heide, S.M. (2009) Effect of growing media and chemical fertilization on growth and chemical composition of Dracaena marginata "Bicolor". J. Product. & Dev., **14**(3), 683-700.
17. Fan, I.Y., Jiang, T., Chun, Z., Kaigang, W., Tan, X. (2021) Zinc affects the physiology and medicinal components of Dendrobium nobile Lindl. Plant Physiology and Biochemistry , **162**,656-666.
18. Farahat, M.M., Soad, M.M., Lobna, S.T., Fatma, E.M. (2007) Response of vegetative growth and some chemical constituents of Cupressus sempervirens to foliar application of ascorbic acid and zinc at Nubaria. World. J. Agric., Sci.,**3**(4), 496-502.
19. Gilman, E.F., Watson, D.G. (1994) Schefflera arboricola, Fact Sheet ST-586. A series of the Environmental Horticulture Department, Florida Cooperative Extension Service, University of Florida, Florida, USA, pp.1-3.
20. Gomaa, S.A., Ragab, A.A.M. (2005) Studies on effect of microelements and gibberellic acid on Codiaeum variegatum cv. Redii. Egypt. J. Appl. Sci., **20** (5A), 272-289.
21. Herbert, D., Philipp, P.J., Strange, R.E. (1971) Chemical Analysis of Microbial Cells. Methods in Microbiology,**5** (B), Norris, J.R. & Ribbons, D.W., editors, 209-344. Academic Press, London
22. Larson, P.; A. Habo; Klungsour and Asheim T. (1962). On the biogenesis of some indoles compounds
23. in Acetobacter xylinum. Physiol. Plant., **15**, 552-565.
24. Li, Y., Liu, X.H., Zhuang, W.M. (2001) The effect of magnesium deficiency on photosynthesis of longan (Dimocarpus longan Lour.) seedlings. ActaHortSin , **28,** 101-106.
25. Maathuis, F.J.M. (2009) Physiological Functions of Mineral Macronutrients. Current Opinion in Plant Biology, **12**, 250-258.
26. Moreira, A., Cardoso, M.L., Reis, A. (2018) The Molecular Genetics of Zinc Uptake and Utilization Efficiency in Crop Plants. In book: Plant Micronutrient Use Efficiency, **87**-108.
27. Marschner, H. (2012) Marschner's Mineral Nutrition of Higher Plants, 3rd ed.; Academic Press: London, UK,; pp. 178–189.
28. Maurya, R.C., Kumar, A. (2014) Effect of micronutrients on growth and corm yield of gladiolus. Plant Archives, **14** (1), 529-531.
29. Mazaherinia, S., Astaraei, A.R., Fotovat, A., Monshi, A. (2010) Nano Iron Oxide Particles Efficiency on Fe, Mn, Zn and Cu Concentrations in Wheat Plant. World Applied Sciences Journal, **7**, 36-40.
30. Mengel, K., Kirkby, E.A. (1987) Principles of Plant Nutrition. International Potash Institute, Worblaufen-Bern, Switzerland.
31. Mohamadipoor, R., Sedaghthor, S., Khomami, A.M. (2013) Effect of application of iron fertilizers in two methods 'foliar and soil application' on growth characteristics of Spathyphyllum illusion. European J. of Exp.Biol., **3**(1), 232-240.
32. Mohsenzadeh, S., Moosavian, S. (2017) Zinc sulphate and nano-zinc oxide effects on some physiological parameters of Rosmarinus officinalis. American Journal of Plant Sciences, **8** (11), 2635-2649.
33. Movahhedi, D. M. (2004) Effect of Foliar Application of Micronutrients (Zinc and Manganese) on the Quantitative and Qualitative Yield of Different Autumn Safflower Cultivars under Drought Stress in Isfahan.Ph.D. Thesis, Faculty of Agriculture, Tarbiat Modarres University, Tehran,211 p.
34. Peyvandi, M., H. Parandeh, M. Mirza, 2011. Comparison effects of nano-iron chelated with iron chelate on growth parameters and antioxidant enzymes activity Basil (Ocimum basilicum). Journal of Cellular and Molecular Biotechnology new**, 1**(4): 89-99.
35. Piper,C.S. (1947) Soil and Plant Analysis. Interscience, New York. 368 p.
36. Plunkett, G.M., Frodin, D. G., Lowry,P.P., (2005) Scheffera (Araliaceae): Taxonomic history, overview and progress. Adv. Hort. Sci., **32**(2),205-212.
37. Pregl, F. (1945) Die Quantitative Organische Mikroanalyse, Berlin, 4th edition,121.
38. Roosta, H.R., Jalali, M., Shahrbabaki, S.M. (2015) Effect of nano Fe-chelate, Fe-Edha and FeSO4 on vegetative growth, physiological parameters and some nutrient elements concentrations of four varieties of Lactuca sativa L. Journal of Plant Nutrition, **38** (14), 2176-2184.
39. Saric, M., Kastrori, R., Curie, R., Cupina, T., Gerie, I. (1976) Chlorophyll Determination. Univ. Unoven Sadu Parktikum is fiziologize Bibjoke, Beagard, Hauncna, Anjig. Curr. Sci., **5**:23-25.
40. Sarwar, N., Bibi, S., Ahmad, M., Ok, Y.S. (2014) Effectiveness of zinc application to minimize cadmium toxicity and accumulation in wheat. Environ. Earth Sci., **71**, 1663-1672.
41. Singleton, V.L. and J.A., Rossi, E. (1965) Colorimetry of total phenolics with phosphor-molybdic-phospho-tungstic acid reagents. Amer. J of Enology and Viticulture, **16** (3), 144-158.
42. Snedecor, G., Cochran, W. (1989) Statistical Methods. (8th edition), Iowa State University Press. 503 pp.
43. Troug, E., Meyer, A.H. (1939) Improvement In Deiness Colorimetric Method For Phosphorous And Arsenic. Ind. Eng. Chem. Anal. Ed., **1**, 136-139.
44. Wang, Y., Zhang, T., Wang, R., Zhao, Y. (2018) Recent advances in auxin research in rice and their implications for crop improvement. Journal of Experimental Botany**, 69**(2), 255-263.
45. Zhang, Y., Wang, U., Ding, Z., Wang, H., Song, L., Jia, S., Ma, D. (2017) Zinc stress affects ion and metabolism in tea plants. Plant Physiol. Biochem, **10**(111), 318-328.
46. Zhao, J., Wang, W., Zhou, H., Wang, R., Zhang, P., Wang, H. (2017) Manganese toxicity inhibited root growth by disrupting auxin biosynthesis and transport in Arabidopsis. Front. Plant Sci., **8**:272.

الاستجابة الفسيولوجية والبيوكيميائية لنبات الشيفلليرا" صنف جولد كابلا" للرش الورقي بعناصر الماغنسيوم والزنك والمنجنيزمن مصادر مختلفة

محمد عبد الخالق الخطيب , سناء احمد اسماعيل ,ضحي قدري سعيد
قسم بساتين الزينة – كلية الزراعة –جامعة القاهرة – مصر.

اجري هذا البحث لمعرفة انسب مصدر للماغنسيوم والزنك والمنجنيز للحصول علي احسن جودة لنمو نبات شيفلليرا صنف جولد كابلا وذلك من ثلاث مصادر وهي النانوية واملاح السلفات والصورة المخلبية في صورة رش ورقي لهذه العناصر الغذائية تحت ظروف الصوب. دلت النتائج علي ان استخدام الزنك بصادره الثلاثة ادي الي زيادة منوية في قياسات النمو من حيث الطول وسمك الساق ومساحة الاوراق وعددها واوزانها الطازجة والجاف. تم الحصول علي اطول النباتات مع الزنك المخلبي .كما ان اكبر سمك للسيقان نتج من المعاملة بسلفات الماغنسيوم والزنك واكبر مساحة من الاوراق كانت مع معاملة الزنك المخلبي وكبريتات الماغنسيوم ومعاملة النباتات بمصادر الزنك والمنجنيز اعطي اكبر اوزان طازجة وجافة. وجميع مصادر الماغنسيوم والنانو-زنك ادت الي زيادة محتوي الكلوروفيل مقارنة بالمنجنيز والكنترول.واكبر محتوي كربوهيدرات نتج من معاملة سلفات المنجنيزوالزنك المخلبي.ومحتوي كل من الاندولات والفينولات كان مرتفعا عند معاملة النباتات بمصادر الزنك المختلفة واكبر محتوي النتروجين والفسفور زاد عند معاملة النباتات بالعناصر الثلاثة في صورة نانوية.بينما ارتفع محتوي البوتاسيوم مع ماملات المنجنيز المخلبي والزنك النانوي.