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EFFECT OF NPK AND TRACE ELEMENTS FERTILIZATION ON GROWTH AND CHEMICAL COMPOSITION OF *Hedera canariensis*, Willd. PLANTS.

BY

Mona A. Darwish
Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Egypt.

ABSTRACT

This experiment was carried out in the glasshouse of the nursery of Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, during the two successive seasons of 2006 and 2007. The objective of this investigation was to study the effect of NPK fertilization (500, 1000, 1500 or 2000 ppm at the formula of 3:2:1) in addition to trace elements (Fe, Zn and Mn) on vegetative growth and chemical composition of Algerian Ivy plants. The results indicated that NPK fertilization at the rate of 1000 ppm/2 weeks gave the best results. This treatment significantly increased the average plant height, stem diameter, number of leaves/ plant, leaf area, fresh and dry weight of foliage and roots, as well as chlorophyll, N, P, K, Fe, Zn and Mn contents in the leaves. Also, NPK fertilization at the rate of 1500 ppm/3 weeks increased the vegetative growth. This treatment was followed by NPK fertilization at either 500 ppm/one week or 2000 ppm/4 weeks.

Spraying the plants with trace elements at the rate of 50 ppm/one month or 100 ppm/ 2 months encouraged the vegetative growth as compared to the untreated plants; trace elements at the rate of 50 ppm/ one month was the most effective treatment.

The interaction between NPK fertilization and trace elements showed that NPK at 1000 ppm/2 weeks treatment × trace elements at 50 ppm/one month could be recommended for Algerian Ivy plants.

Key words: *Hedera canariensis*, trace elements, chlorophyll, NPK fertilizers, NPK content.

INTRODUCTON

Algerian Ivy (*Hedera canariensis*, Willd.) Fam. *Araliaceae* is used as indoor and outdoor plant, many investigators studied the effect of NPK fertilization on the vegetative growth and chemical composition of foliage plants. Magnani and Malorgio (1995) fertilized *Spathiphyllum wallisii* and *Dracaena glauca* plants with mineral NPK fertilizers weekly, they found that NPK fertilization improved the vegetative growth and increased chlorophyll content and N, K content in the leaves. Chauhan *et al.* (2005) found that NPK (1: 1: 1) improved the growth of *Chlorophytum borivilianum*. Dorgham (2005) on *Dieffenbachia maculata*, found that NPK fertilization gave the highest values of leaf area, plant height and dry matter, compared with the control plants. Also, Segura *et al.* (2005) reported similar results on the same plant. Similar results were obtained by El-Hanafy and El-Khateeb (1999) on *Syngonium podophyllum* plants, Jensen *et al.* (2001) on *Hedera helix* and *Fatsia japonica*, Mikkelsen (2003) on *Aglaonema commutatum*, Minuto and Devecchi (2004) on *Cyclymen* and *Pelargonium* plants and Srinivasa (2006) on *Anthurium andraeanum*.

Other researchers studied the effect of trace elements (Fe, Zn and Mn). Toppe and Thinggaard (2000) on *Hedera helix*; Stamps and Rock (2000) on *Asparagus virgatus* and Mosquera – Losada *et al.* (2002) on *Hedera helix*. They found that trace elements had a considerable effect on the vegetative growth. Also, trace elements increased leaf chlorophyll content and the uptake of macro and micro elements.

MATERIAL AND METHODS

This experiment was carried out in the glasshouse of the nursery of Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, during the two successive seasons of 2006 and 2007. On January 1st, rooted cuttings of *Hedera canariensis* were planted in 20 cm plastic pots filled with sand and peat moss (1: 1 v/ v), the plants were covered with white polyethylene plastic sheets during winter months. On February 1st, plants were fertilized with the following treatments: NPK at the formula of 3: 2: 1 at the rate of 500, 1000, 1500 or 2000 ppm every 1, 2, 3 or 4 weeks, respectively, in addition to the control plants. Each fertilization treatment was divided into 3 sub treatments, each sub treatment was sprayed with trace elements (Fe, Zn and Mn) at 50 or 100 ppm every 1 or 2 months, respectively, in addition to the untreated plants. Each plant was irrigated at the rate of 1/2 l/ pot, containing 500, 1000, 1500 or 2000 ppm.

Ammonium sulfate (20% N), calcium superphosphate (15% P_2O_5), and potassium sulfate (48% K_2O) were used as sources of N, P and K, respectively. In addition, Fe EDTA 6%, Zn chelated 13 % and Mn chelated 13 % were used as a source of iron, zinc and manganese, respectively. The statistical layout of this experiment was factorial experimental design as NPK levels represented the main factor, and trace elements represented the sub main factors. The experiment contained 180 potted plants. Each NPK treatment included 36 plants at three levels of trace elements which replicated three times (4 plants/ replicate). On September 1st the following data were recorded: plant height (cm), stem diameter (mm.), leaf area (cm^2), number of leaves/ plant, fresh and dry weights of foliage and roots (g/plant). The data were statistically analyzed using New L.S.D. test according to Steel and Torrie (1980). Chlorophyll content was determined according the method described by Saric *et al.* (1967). Also, N and P content were determined in the dry leaves according to Pregel (1945) and King (1951), respectively. K, Fe, Zn and Mn content was determined by flamphotometer method as described by Piper (1950).

RESULTS AND DISCUSSION

Plant height:

Data presented in Table (1) show that, NPK fertilization significantly increased the average plant height of *Hedera canariensis*. In the first season, the average plant height ranged from 72.8 to 107.5 cm, as compared to 52.9 cm in the control plants. NPK at the rate of 1000 ppm/2 weeks gave the best result (107.5 cm), followed by NPK at the rate of 1500 ppm/3 weeks which resulted in 101.3 cm. Also, NPK at the rate of 500 ppm/one week significantly increased the average plant height resulting in 79.5 cm, followed by NPK at the rate of 2000 ppm/4 weeks which resulted in 72.8 cm. Similar results were obtained in the second season, as the average plant height varied from 75.5 to 105.2 cm compared with 51.7 cm in the control plants, and these results were in the agreement with those obtained by Segura *et al.* (2005) on *Dieffenbachia maculata*.

Spraying the plants with trace elements (Fe, Zn and Mn) at the rate of 50 ppm/ one month significantly increased the average plant height resulting in 88.1 and 83.7 cm in the first and second season, respectively, as comparing to 75.5 and 75.1 cm in the untreated plants. Whereas, trace elements at the rate of 100 ppm/ 2 months significantly increased the average plant height resulting in 84.8 and 83.0 cm in both seasons, respectively. These results were in the harmony with those obtained by Mosquera – Losada *et al.* (2002) on *Hedera helix* plant.

The interaction between NPK fertilization and trace elements treatments show that, in the first season, the highest value (113.9 cm) was obtained from the plants which were fertilized with NPK at the rate of 1000 ppm/2 weeks and sprayed with trace elements at the rate of 50 ppm/one month. Meanwhile the lowest value (45.1 cm) was obtained from the untreated plants. Similar results were obtained in the second season.

Table (1): Effect of NPK and trace elements fertilization on plant height (cm) of *Hedera canareinsis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments (F)	Trace elements (T), ppm				Trace elements (T), ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Control	45.1	57.5	56.0	52.9	44.7	56.4	54.1	51.7
NPK(500 ppm)	72.5	84.1	81.8	79.5	72.9	75.9	77.8	75.5
NPK(1000 ppm)	98.9	113.9	109.7	107.5	97.0	110.0	108.5	105.2
NPK(1500 ppm)	93.2	107.4	103.4	101.3	94.1	104.4	101.9	100.1
NPK(2000 ppm)	67.8	77.4	73.1	72.8	66.7	71.7	72.8	70.4
Mean	75.5	88.1	84.8		75.1	83.7	83.0	
New LSD (5 %)								
F		4.1				4.7		
T		3.4				3.6		
F × T		6.0				6.2		

Stem diameter:

Data presented in Table (2) show that, NPK fertilization at the rate of 1000 ppm/2 weeks produced the thickest stems 4.98 and 5.04 mm in the first and second seasons, respectively, compared with 3.64 and 3.39 mm in the control plants. Also, NPK at the rate of 1500 ppm/3 weeks significantly increased the average stem diameter resulting in 4.74 and 4.73 mm in both seasons, respectively. Also, NPK at either 500 ppm/one week or 2000 ppm/4 weeks significantly increased the average stem diameter in both seasons.

Regarding the effect of trace elements on the stem diameter of Algerian Ivy, the results show that trace elements at the rate of 50 ppm/ one month significantly increased stem diameter resulting in 4.68 and 4.80 mm in the first and second seasons, respectively, as comparing to 3.63 and 3.73 mm in the untreated plants. Also, the difference between trace elements at the rate of 100 ppm/ 2 months and the untreated plants was significant in both seasons.

The interaction between NPK fertilization and trace elements show that the highest values were obtained with NPK at the rate of 1000 ppm/2 weeks compared with trace elements at 50 ppm/one month; this treatment recorded 5.27 and 5.36 mm in the first and second seasons, respectively, as compared with 2.80 and 3.93 mm in the untreated plants.

Number of leaves/plant:

Data presented in Table (3) show that, fertilization with NPK significantly increased the average number of leaves/ plant; NPK at the rate of 1000 ppm/2 weeks produced the greatest number of leaves 52.8 and 51.1/ plant in the first and second seasons, respectively, as comparing to 21.3 and 24.2 in the control plants. NPK at the rate of 1500 ppm/ 3 weeks gave large number of leaves/ plant 44.3 and 46.4 in both seasons, respectively, followed by NPK at either 500 ppm/one week or 2000 ppm/4 weeks.

Regarding the effect of trace elements on average number of leaves/ plant, the results show that trace elements at the rate of 50 ppm/ one month significantly increased the average number of leaves/ plant resulting in the same value (40.6) in the first and second season, compared with 36.0 and 36.8 in the untreated plants. Meanwhile, the difference between trace elements at the rate of 100 ppm/2 months and the untreated plants were insignificant in the second season.

NPK at the rate of 1000 ppm × trace elements at the rate of 50 ppm/ one month resulted in the greatest number of leaves (54.9 and 53.6) in both seasons, respectively, compared with the untreated plants which produced the lowest values 19.8 and 20.7 leaves/ plant. These results were in the agreement with those obtained by Wazir *et al.* (2004) on *Schefflera actinophylla* plants.

Table (2): Effect of NPK and trace elements fertilization on stem diameter (mm) of *Hedera canareinsis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments (F)	Trace elements (T), ppm				Trace elements (T), ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Control	2.80	3.69	3.64	3.38	2.93	3.82	3.43	3.39
NPK(500 ppm)	3.68	4.93	4.80	4.47	3.82	5.07	4.92	4.60
NPK(1000 ppm)	4.51	5.27	5.15	4.98	4.59	5.36	5.17	5.04
NPK(1500 ppm)	4.12	5.10	5.01	4.74	4.10	5.14	4.96	4.73
NPK(2000 ppm)	3.15	4.40	4.22	3.92	3.21	4.61	3.99	3.94
Mean	3.63	4.68	4.56		3.73	4.80	4.50	
New LSD (5 %)								
F		0.49				0.47		
T		0.30				0.34		
F × T		0.65				0.67		

Table (3): Effect of NPK and trace elements fertilization on number of leaves/plant of *Hedera canareinsis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments (F)	Trace elements (T), ppm				Trace elements (T), ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Control	19.8	22.5	21.6	21.3	20.7	23.4	22.6	24.2
NPK(500 ppm)	34.9	38.8	36.6	36.8	36.9	40.7	38.1	38.6
NPK(1000 ppm)	49.7	54.9	53.9	52.8	48.9	53.6	50.9	51.1
NPK(1500 ppm)	42.0	46.9	44.1	44.3	44.7	48.6	46.0	46.4
NPK(2000 ppm)	33.5	39.7	36.9	36.7	32.7	36.9	34.5	34.7
Mean	36.0	40.6	38.6		36.8	40.6	38.4	
New LSD (5 %)								
F		3.4				3.5		
T		2.5				2.5		
F × T		4.5				4.3		

Leaf area:

Data presented in Table (4) show that, NPK fertilization has a slight effect on leaf area. In the first season, the average leaf area ranged from 26.7 to 30.8 cm^2, as comparing to 25.3 cm^2 in the control plants. NPK at the rate of 1000 ppm/2 weeks and 1500 ppm/3 weeks produced the highest values resulting in 30.8 and 30.1 cm^2, respectively. Also, NPK at the rate of 500 ppm/one week and 2000 ppm/4 weeks slightly increased the average leaf area resulting in 27.6 and 26.7 cm^2, respectively.

Similar results were recorded in the second season, as the average leaf area varied from 24.8 to 28.9 cm^2, as comparing to 24.4 cm^2 in the control plants.

Regarding the effect of trace elements on leaf area, the results show that trace elements at the rate of 50 ppm/one month significantly increased the average leaf area resulting in 29.2 and 27.7 cm^2 in the first and second seasons, respectively, compared with 26.6 and 25.3 cm^2 in the untreated plants. Slight increases in leaf area were obtained by spraying trace elements at the rate of 100 ppm/2 months resulting in 28.5 and 26.5 cm^2 in both seasons, respectively.

The results of the interaction between NPK fertilization and trace elements confirmed the above mentioned results, as the highest values were recorded with NPK at the rate of 1000 ppm/2 weeks × trace elements at 50 ppm/one month. Meanwhile, the lowest value was recorded with the untreated plants.

Table (4): Effect of NPK and trace elements fertilization on leaf area (cm^2) of *Hedera canareinsis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments (F)	Trace elements (T), ppm				Trace elements (T), ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Control	23.4	27.1	25.4	25.3	22.0	26.7	24.4	24.4
NPK(500 ppm)	26.2	28.7	27.8	27.6	25.7	26.8	26.9	26.5
NPK(1000 ppm)	29.3	31.9	31.3	30.8	27.9	30.2	28.6	28.9
NPK(1500 ppm)	28.9	30.9	30.5	30.1	27.5	29.3	28.3	28.4
NPK(2000 ppm)	25.2	27.5	27.4	26.7	24.8	25.3	24.4	24.8
Mean	26.6	29.2	28.5		25.3	27.7	26.5	
New LSD (5 %)								
F		0.7				0.8		
T		0.5				0.6		
F × T		0.9				1.1		

Foliage fresh weight:

Data presented in Table (5) show that the average fresh weight of foliage varied from 44.5 to 64.3 g/ plant in the first season, and from 45.1 to 66.2 g/ plant in the second one. NPK at the rate of 1000 ppm/2 weeks produced the heaviest foliage fresh weight resulting in 64.3 and 66.2 g/plant in both seasons, respectively, followed by NPK at the rate of 1500 ppm/ 3 weeks resulting in 59.1 and 62.4 g in both seasons, respectively. It was observed that NPK at either 500 ppm/one week or 2000 ppm/ 4 weeks, significantly increased the average fresh weight, as comparing to the control plants.

Trace elements had a slight effect on foliage fresh weight of *Hedera canariensis* plants, compared with the other characters of vegetative growth, i.e. plant height and number of leaves/ plant. The lower level of trace elements (50 ppm)/ one month produced the highest values 54.1 and 54.8 g/ plant in the first and second season, respectively, as comparing to 47.9 and 50.1 g/ plant in the untreated plants. Whereas the higher level of trace elements (100 ppm)/ 2 months slightly increased the average fresh weight and its difference was significant in the first season but it was insignificant in the second one.

The data of interaction confirmed the above mentioned results, since NPK at the rate of 1000 ppm/2 weeks x trace elements at the rate of 50 ppm/one month produced the highest value 67.8 and 69.0 g/ plant in the first and second season, respectively, whereas the untreated plants produced the lowest values 38.1 and 36.9 g/ plant in both seasons. These results agreed with the finding of Moghazy and Zaghloul (2001) on *Yucca aloifolia* and *Philodendron domesticum* plants.

Root fresh weight:

Data presented in Table (6) show that, all NPK treatments significantly increased the average root fresh weight; NPK at the rate of 1000 ppm/2 weeks produced the highest values 30.4 and 27.5 g in the first and second seasons, respectively, as comparing to 20.6 and 18.7 g in the control plants. Also, NPK at the rate of 1500 ppm/3 weeks and NPK at the rate of 500 ppm/one week gave heavier roots than NPK at the rate of 2000 ppm/4 weeks.

Trace elements have no significant effect on root fresh weight; trace elements at the rate of 50 ppm/one month slightly increased the average fresh weight resulting in 26.0 and 24.8 g in both seasons, respectively. Also, trace elements at the rate of 100 ppm/2 months recorded insignificant differences. This treatment resulted in 25.2 and 24.2 g in the first and second seasons, respectively, as comparing to 24.2 and 23.7 g in the untreated plants.

Table (5): Effect of NPK and trace elements fertilization on foliage fresh weight (g) of *Hedera canareinsis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments (F)	Trace elements (T), ppm				Trace elements (T), ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Control	38.1	43.0	40.6	40.6	36.9	39.0	37.8	37.9
NPK(500 ppm)	45.7	49.4	48.6	47.9	48.4	53.5	50.6	50.8
NPK(1000 ppm)	60.5	67.8	64.7	64.3	62.7	69.0	66.9	66.2
NPK(1500 ppm)	54.0	63.5	59.8	59.1	58.4	65.7	63.0	62.4
NPK(2000 ppm)	41.2	46.8	45.4	44.5	43.9	46.9	44.6	45.1
Mean	47.9	54.1	51.8		50.1	54.8	52.5	
New LSD (5 %)								
F		3.8				3.7		
T		2.5				2.7		
F × T		4.2				4.3		

Table (6): Effect of NPK and trace elements fertilization on root fresh weight (g) of *Hedera canareinsis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments (F)	Trace elements (T), ppm				Trace elements (T), ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Control	19.3	21.9	20.7	20.6	18.3	19.9	18.7	18.7
NPK(500 ppm)	24.3	25.4	25.3	25.0	23.7	25.4	23.9	24.3
NPK(1000 ppm)	29.0	31.3	30.9	30.4	27.5	27.1	27.9	27.5
NPK(1500 ppm)	26.4	28.5	27.2	27.4	26.3	27.5	27.3	27.0
NPK(2000 ppm)	21.8	22.7	22.1	22.2	22.8	24.2	23.1	23.4
Mean	24.2	26.0	25.2		23.7	24.8	24.2	
New LSD (5 %)								
F		2.8				2.7		
T		1.9				1.8		
F × T		3.3				3.2		

The results of the interaction between NPK fertilization and trace elements confirmed that NPK at the rate of 1000 ppm/2 weeks × trace elements at the rate of 50 ppm/one month gave the highest value (31.3 g) in the first season. Whereas, NPK at the rate of 1000 ppm/2 weeks × trace elements at the rate of 100 ppm/2 months gave the highest value (27.9 g) in the second season. Meanwhile, the lowest values 19.3 and 18.3 g were recorded with the unfertilized plants which did not spray with trace elements.

Foliage dry weight:

Data presented in Table (7) show that, in the first season, the average foliage dry weight ranged from 15.1 to 21.3 g, as comparing to 13.0 g in the control plants. NPK at the rate of 1000 ppm/2 weeks gave the heaviest foliage dry weight (21.3 g). This treatment was followed by NPK at 1500 ppm/3 weeks which resulted in, 18.3 g, compared with 13.0 g in the control plants. Also, NPK at the rate of 500 ppm/one week significantly increased the average foliage dry weight resulting in 17.3 g, whereas NPK at the rate of 2000 ppm/4 weeks resulted in 15.1 g. In the second season, the average foliage dry weight varied from 14.2 to 21.7 g, as comparing to 11.8 g in the control plants, and a similar trend was recorded.

Table (7): Effect of NPK and trace elements fertilization on foliage dry weight (g) of *Hedera canareinsis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments (F)	Trace elements (T), ppm				Trace elements (T), ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Control	11.7	14.2	13.1	13.0	10.8	13.2	11.3	11.8
NPK(500 ppm)	16.1	18.7	17.2	17.3	15.3	18.9	16.9	17.0
NPK(1000 ppm)	21.6	22.0	20.2	21.3	20.0	23.7	21.3	21.7
NPK(1500 ppm)	17.3	19.4	18.3	18.3	19.0	22.2	20.6	20.6
NPK(2000 ppm)	14.3	15.8	15.3	15.1	12.5	15.7	14.3	14.2
Mean	16.2	18.0	16.8		15.5	18.7	16.9	
New LSD (5 %)								
F		1.6				1.5		
T		1.0				0.8		
F × T		1.9				1.8		

Trace elements have a slight effect on foliage dry weight, compared with the other characters of vegetative growth. Trace elements at the rate of 50 ppm/one month produced the highest values 18.0 and 18.7 g in the first and second seasons, respectively, as comparing to 16.2 and 15.5 g in the untreated plants. Whereas, trace elements at the rate of 100 ppm/2 months slightly increased the average dry weight, this treatment resulted in 16.8 and 16.9 g in both seasons, respectively.

Regarding the interaction between NPK fertilization and trace elements, the results show that the heaviest foliage dry weight was recorded with the plants which were fertilized with NPK at the rate of 1000 ppm/2 weeks and sprayed with trace elements at the rate of 50 ppm/one month, whereas the lowest foliage dry weight were obtained from the untreated plants in both seasons.

Root dry weight:

Data presented in Table (8) show that, in the first season, the average dry weight of roots ranged from 9.5 to 13.3 g, as comparing to 7.0 g in the control plants. NPK at the rate of 1000 ppm/2 weeks produced the heaviest dry roots (13.3 g). This treatment was followed by NPK at the rate of 1500 ppm/3 weeks which resulted in 10.6 g. Also, heavy weights were obtained by fertilizing plants with NPK at the rate of 500 ppm/one week and 2000 ppm/4 weeks which recorded the same value (9.5 g), compared with the control plants. Similar results were obtained in the second season, as the average dry weight varied from 7.8 to 12.0 g, as comparing to 6.0 g in the control plants.

Table (8): Effect of NPK and trace elements fertilization on root dry weight (g) of *Hedera canareinsis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments (F)	Trace elements (T), ppm				Trace elements (T), ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Control	6.4	7.4	7.1	7.0	5.4	6.5	6.0	6.0
NPK(500 ppm)	9.6	9.3	9.5	9.5	8.4	8.8	8.9	8.7
NPK(1000 ppm)	12.2	14.0	13.6	13.3	11.7	12.5	11.9	12.0
NPK(1500 ppm)	10.3	11.3	10.2	10.6	11.8	11.8	11.6	11.7
NPK(2000 ppm)	9.8	9.9	8.8	9.5	7.0	8.7	7.8	7.8
Mean	9.7	10.4	9.8		8.9	9.7	9.2	
New LSD (5 %)								
F		0.8				0.9		
T		0.4				0.4		
F × T		1.0				1.1		

Trace elements at the rate of either 50 or 100 ppm slightly increased the average dry weight of roots; trace elements at the rate of 50 ppm/one month gave the highest values 10.4 and 9.7 g in the first and second seasons, respectively, as comparing to 9.7 and 8.9 g in the untreated plants. Trace elements at the rate of 100 ppm/one month resulted in 9.8 and 9.2 g in the first and second seasons, respectively.

Regarding the interaction between NPK fertilization and trace elements the results show that, NPK at the rate of 1000 ppm/2 weeks × trace elements at the rate of 50 ppm/one month produced the heaviest dry roots 14.0 and 12.5 g in the first and second seasons, respectively. Whereas, the untreated plants produced the lowest dry weight 6.4 and 5.4 g in both seasons, respectively.

Total chlorophyll content:

Data presented in Table (9) show that, in the first season NPK at the rate of 1000 ppm/2 weeks produced the highest total chlorophyll content (4.17 mg /g F.W.), as comparing to 2.18 mg /g F.W. in the control plants; this treatment was followed by NPK at the rate of 1500 ppm/3 weeks resulting in 2.99 mg /g F.W. Also, both NPK at the rate of 500 ppm/one week and NPK at the rate of 2000 ppm/ 4 weeks increased the leaf chlorophyll content compared with the control plants. Similar trend was observed in the second season, since the average chlorophyll content ranged from 2.18 to 4.10 mg /g F.W. compared with 2.23 mg /g F.W. in the control plants. These results were in the agreement with those obtained by Saleh *et al.* (1998) on *Ficus benjamina* plants.

Trace elements at the rate of 50 ppm seemed to be an effective factor on chlorophyll synthesis, this treatment produced the highest total chlorophyll value 3.12 and 3.15 mg/ g F.W. in the first and second seasons, respectively, as comparing to 2.40 and 2.42 mg/g F.W. in the untreated plants. Slight increases in total chlorophyll content (2.99 and 3.00 mg/ g F.W.) were recorded with trace elements at the rate of 100 ppm as comparing to the untreated plants in both seasons, respectively.

Regarding the interaction between NPK fertilization and trace elements, the results show that the highest values were obtained with NPK at the rate of 1000/ 2 weeks and sprayed with trace elements at the rate of 50 ppm, compared with the untreated plants.

Table (9): Effect of NPK and trace elements fertilization on leaf chlorophyll content (mg/g F.W.) of *Hedera canareinsis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments	Trace elements, ppm				Trace elements, ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Control	1.76	2.41	2.38	2.18	1.73	2.54	2.41	2.23
NPK(500 ppm)	2.29	3.07	2.80	2.72	2.30	2.98	2.85	2.71
NPK(1000 ppm)	3.31	4.63	4.57	4.17	3.24	4.59	4.48	4.10
NPK(1500 ppm)	2.68	3.21	3.08	2.99	2.81	3.29	3.09	3.06
NPK(2000 ppm)	1.97	2.26	2.11	2.11	2.01	2.36	2.17	2.18
Mean	2.40	3.12	2.99		2.42	3.15	3.00	

NPK contents:

Data presented in Table (10) show that, in the first season, leaf N content ranged from 2.47 to 4.13 %, as comparing to 2.16 % in the control plants. NPK fertilization at 1000 ppm/ 2 weeks produced the highest N content resulting in 4.13 %. Meanwhile high concentration of NPK (2000 ppm/4 weeks) resulted in 2.47 %, as comparing to 2.16 % in the control plants. Similar results were obtained in the second season, as the average N content ranged from 2.80 to 4.38 %, as comparing to 2.33 % in the control plants. Trace elements at the low level (50 ppm/one month) produced the highest N content 3.04 and 3.30 % in the first and second seasons, respectively, as

comparing to 2.60 and 2.98 % in the untreated plants. Whereas, trace elements at the rate of 100 ppm/2 months resulted in 2.89 and 3.20 % in both seasons, respectively.

The effect of NPK fertilization on leaf P content had no obvious trend. In the first season, NPK at the rate of 1500 ppm/3 weeks produced the highest P content (1.09 %) followed by NPK at the rate of 1000 ppm/2 weeks which resulted in 1.05 %, as comparing to 0.88 % in the control plants. Meanwhile NPK at both 500 ppm/ one week and 2000 ppm/4 weeks resulted in the same value (0.90 %). The results in the second season proved that there was no definite trend in this respect, as the results were in narrow range from 1.08 to 1.24 %, as comparing to 0.93 % in the control plants. Also, the effect of trace elements on P content had no obvious trend. In the first season, trace elements at 50 and 100 ppm resulted in 1.00 and 0.97 %, respectively, compared with 0.93 % in the untreated plants. Similar results were obtained in the second season.

The effect of NPK fertilization on leaf K content had the same trend of N content. In the first season, K content ranged from 0.89 to 1.53 %, as comparing to 0.47 % in the control plants. NPK at the rate of 1000 ppm/ 2 weeks produced the highest K content (1.53 %). This treatment was followed by NPK at the rate of 1500 ppm/ 3 weeks which resulted in 1.41 %. Meanwhile, NPK at the rate of 500 ppm/one week resulted in 1.30 followed by NPK at the rate of 2000 ppm/ 4 weeks resulting in 0.89 %. Similar trend was recorded in the second season, as the average K content ranged from 1.22 to 1.69 %, as comparing to 0.65 % in the control plants. Trace elements at the low level (50 ppm/one month) produced the highest K content 1.21 and 1.42 % in the first and second seasons, respectively, as comparing to 1.04 and 0.99 % in the untreated plants. Whereas, trace elements at the rate of 100 ppm/2 months resulted in 1.12 and 1.30 % in both seasons, respectively. These results were in the harmony with the findings of Srinivasa (2006) on *Anthurium* cv. Chaco plants.

Table (10): Effect of NPK and trace element fertilization on NPK contents (%) of *Hedera canariensis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments	Trace elements, ppm				Trace elements, ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
N content								
Control	2.12	2.20	2.15	2.16	2.19	2.43	2.36	2.33
NPK(500ppm)	2.25	2.83	2.71	2.60	2.95	3.07	3.02	3.01
NPK(1000ppm)	3.89	4.40	4.11	4.13	4.03	4.63	4.49	4.38
NPK(1500ppm)	2.67	3.04	2.88	2.86	3.18	3.36	3.24	3.26
NPK(2000ppm)	2.06	2.75	2.61	2.47	2.54	2.99	2.87	2.80
Mean	2.60	3.04	2.89		2.98	3.30	3.20	
P content								
Control	0.79	0.93	0.93	0.88	0.87	0.99	0.93	0.93
NPK(500ppm)	0.86	0.95	0.88	0.90	0.98	1.13	1.14	1.08
NPK(1000ppm)	1.09	1.08	0.99	1.05	1.14	1.29	1.28	1.24
NPK(1500ppm)	1.01	1.14	1.13	1.09	1.05	1.19	1.11	1.12
NPK(2000ppm)	0.89	0.91	0.91	0.90	1.01	1.14	1.12	1.09
Mean	0.93	1.00	0.97		1.01	1.15	1.12	
K content								
Control	0.41	0.55	0.46	0.47	0.49	0.78	0.67	0.65
NPK(500ppm)	1.18	1.39	1.32	1.30	0.98	1.41	1.35	1.25
NPK(1000ppm)	1.37	1.68	1.55	1.53	1.37	1.93	1.78	1.69
NPK(1500ppm)	1.35	1.46	1.42	1.41	1.29	1.51	1.37	1.39
NPK(2000ppm)	0.87	0.95	0.86	0.89	0.82	1.48	1.35	1.22
Mean	1.04	1.21	1.12		0.99	1.42	1.30	

Fe, Zn and Mn content:

Data presented in Table (11) show that, in the first season, the average Fe content ranged from 17.58 to 23.87 mg/ 100 g D.W., as comparing to 16.21 mg/ 100 g D.W. in the control plants. NPK at 1000 ppm/2 weeks produced the highest Fe content (23.87 mg/ 100 g D.W.). This treatment was followed by NPK at the rate of 1500 ppm/3 weeks which resulted in 23.22 mg/ 100 g D.W. Whereas the application of NPK at either 500 ppm/one week or 2000 ppm/4 weeks resulted in 20.83 and 17.58 mg/ 100 g D.W., respectively. A similar trend was recorded in the second season, as the average Fe content varied from 16.80 to 23.26 mg/ 100 g D.W., as comparing to 14.74 mg/ 100 g D.W. in the control plants. Spraying the plants with trace elements increased Fe content in the leaves, trace elements at the rate of 100 ppm/2 months produced the highest values 21.49 and 20.16 mg/100 g D.W. in the first and second seasons, respectively, as comparing to 19.02 and 18.03 mg/100 g D.W. in the untreated plants.

Table (11): Effect of NPK and trace element fertilization on Fe, Zn and Mn contents (mg/100 g D.W.) of *Hedera canariensis*, Willd. during two successive seasons (2006 and 2007).

Fertilization treatments	Trace elements, ppm				Trace elements, ppm			
	0	50	100	Mean	0	50	100	Mean
	First season (2006)				Second season (2007)			
Fe content								
Control	14.59	16.43	17.60	16.21	14.60	14.42	15.21	14.74
NPK(500ppm)	19.56	20.59	22.34	20.83	18.39	19.82	20.04	19.42
NPK(1000ppm)	22.61	24.45	24.55	23.87	21.35	23.71	24.72	23.26
NPK(1500ppm)	21.64	23.42	24.60	23.22	20.28	21.87	22.89	21.68
NPK(2000ppm)	16.70	17.67	18.38	17.58	15.70	16.74	17.95	16.80
Mean	19.02	20.51	21.49		18.03	19.35	20.16	
Zn content								
Control	1.09	1.42	1.71	1.41	0.93	1.12	1.26	1.10
NPK(500ppm)	1.64	1.84	1.86	1.78	1.60	1.81	1.83	1.75
NPK(1000ppm)	1.96	2.10	2.14	2.07	1.86	1.93	2.07	1.95
NPK(1500ppm)	1.85	1.95	2.03	1.94	1.77	1.86	1.94	1.86
NPK(2000ppm)	1.52	1.62	1.77	1.64	1.18	1.52	1.30	1.33
Mean	1.61	1.79	1.90		1.47	1.65	1.68	
Mn content								
Control	14.06	15.39	16.82	15.42	13.41	15.97	16.01	15.13
NPK(500ppm)	17.93	19.17	20.91	19.34	16.52	18.49	18.96	17.99
NPK(1000ppm)	19.23	21.90	22.38	21.17	19.63	20.41	21.80	20.61
NPK(1500ppm)	18.41	19.76	21.46	19.88	17.69	18.78	19.69	18.72
NPK(2000ppm)	15.29	16.33	17.52	16.38	16.84	16.93	17.65	17.14
Mean	16.98	18.51	19.82		16.82	18.12	18.82	

NPK fertilization at the rate of 1000 ppm/2 weeks produced the highest Zn content resulting in 2.07 and 1.95 mg/ 100 g D.W. in the first and second season, respectively, as comparing to 1.41 and 1.10 mg/ 100 g D.W. in the control plants. In addition, NPK at the rate of 1500 ppm/ 3 weeks increased Zn content in the leaves resulting in 1.94 and 1.86 mg/100 g D.W. in both seasons, respectively, compared with NPK at the rate of 500 ppm/one week and 2000 ppm/4 weeks. Trace element treatments increased Zn content in the leaves; trace elements at the rate of 100 ppm/2 months resulted in 1.90 and 1.68 mg/100 g D.W. in the first and second seasons, respectively, as comparing to 1.61 and 1.47 mg/100 g D.W. in the untreated plants.

Regarding the effect of NPK fertilization on Mn content the results show that, in

the first season, the average Mn content ranged from 16.38 to 21.17 mg/ 100 g D.W., as comparing to 15.42 mg/ 100 g D.W. in the control plants. NPK fertilization at the rate of 1000 ppm/2 weeks produced the highest Mn content (21.17 mg/ 100 g D.W.). This treatment was followed by NPK at the rate of 1500 ppm/3 weeks and 500 ppm/one week which resulted in 19.88 and 19.34 mg/100 g D.W., respectively. Whereas NPK at the rate of 2000 ppm/4 weeks resulted in 16.38 mg/ 100 g D.W. A similar trend was recorded in the second season, as the average Mn content varied from 17.14 to 20.61 mg/ 100 g D.W., as comparing to 15.13 mg/ 100 g D.W. in the control plants. Trace element treatments increased Mn content in the leaves, trace elements at the rate of 100 ppm/2 months produced the highest value 19.82 and 18.82 mg/ 100 g D.W. in the first and second seasons, respectively, as comparing to 16.98 and 16.82 mg/ 100 g D.W. in the untreated plants. These results agreed with the findings of Abou-Taleb and Hassan (1995) on *Alocasia reginea* plants.

Conclusively, the interaction between NPK at 1000 ppm/2 weeks treatment × trace elements at 50 ppm/one month could be recommended for Algerian Ivy plants.

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تأثير التسميد المتكامل (نيتروجين – فوسفور – بوتاسيوم) والعناصر الصغرى على النمو والتركيب الكيماوى في نباتات الهيدرا المبرقشة

منى أحمد درويش قاسم

قسم بساتين الزينة – كلية الزراعة – جامعة القاهرة– مصر

أجرى هذا البحث داخل الصوبة الزجاجية بمشتل قسم بساتين الزينة بكلية الزراعة – جامعة القاهرة، خلال موسمين متتاليين (٢٠٠٦ و ٢٠٠٧)، حيث تم زراعة العقل المجذرة في أول يناير في أصص بلاستيك قطر ٢٠ سم مملوءة بالرمل والبيت بنسبة ١: ١ وتم تسميد النباتات في أول فبراير من كل موسم بالسماد المتكامل (ن – فو – بو) بالمعادلة السمادية (٣: ٢: ١) واستخدم سماد سلفات النشادر والسوبر فوسفات وسلفات البوتاسيوم كمصادر لهذه العناصر على الترتيب وكانت المعاملات كما يلي: ٥٠٠ جزء في المليون/أسبوع – ١٠٠٠ جزء في المليون/أسبوعين – ١٥٠٠ جزء في المليون/٣ أسابيع – ٢٠٠٠ جزء في المليون/أربعة أسابيع بالإضافة نباتات المقارنة، واشتملت كل معاملة سمادية على ٣٦ نبات تم تقسيمها إلى ثلاثة تحت معاملات كما يلي: الرش بالعناصر الصغرى (الحديد والزنك والمنجنيز) بتركيز ٥٠ جزء في المليون/شهر – الرش بالعناصر الصغرى بتركيز ١٠٠ جزء في المليون/شهرين بالإضافة إلى نباتات غير معاملة بالعناصر الصغرى.

وتم أخذ البيانات في أول سبتمبر من كل موسم وفيما يلي ملخصا لأهم النتائج المتحصل عليها:

أدى التسميد بالعناصر الثلاثة (ن – فو – بو) بتركيز ١٠٠٠ جزء في المليون/ أسبوعين إلى زيادة معنوية ملحوظة في النمو الخضري حيث أعطت أعلى القيم من حيث ارتفاع النبات وقطر الساق وعدد الأوراق ومساحة الورقة والوزن الطازج والجاف للمجموع الخضري والجذور بالإضافة إلى زيادة محتوى الأوراق من الكلوروفيل والنيتروجين والفوسفور والبوتاسيوم وكذلك الحديد والزنك والمنجنيز، كما أدت المعاملة بتركيز ١٥٠٠ جزء فى المليون/ ٣ أسابيع إلى زيادة معنوية في النمو الخضري، يليها المعاملة بتركيز ٥٠٠ جزء في المليون/أسبوع وكذلك المعاملة بتركيز ٢٠٠٠ جزء فى المليون/ ٤ أسابيع إلى زيادة معنوية في النمو الخضري.

أدى الرش بالعناصر الصغرى بتركيز ٥٠ جزء في المليون/شهر أو ١٠٠ جزء فى المليون كل شهرين إلى تحسين النمو الخضري بالمقارنة بالنباتات الغير معاملة وكان التركيز ٥٠ جزء فى المليون هو الأفضل.

أكدت نتائج التفاعل ما بين التسميد و الرش بالعناصر الصغرى النتائج السابقة حيث أن أفضل نمو خضري تم الحصول عليه من النباتات المسمدة بالسماد المتكامل بتركيز ١٠٠٠ جزء في المليون/أسبوعين والتي تم رشها بالعناصر الصغرى بتركيز ٥٠ جزء في المليون/شهر وهذه المعاملة يمكن التوصية بها.