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INFLUENCE OF LEAF POSITION, MEDIUM TYPE AND BORON ACCUMULATION ON LEAF TIPBURN IN *Chlorophytum comosum* (THUNB) JAQUES "*VARIEGATUM*".

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ABSTRACT

During two successive seasons, complete randomized design experiments were conducted under natural conditions in plastic house on one-year-old *Chlorophytum comosum* (Thunb) Jaques "*Variegatum*" plants to :

(1) study the effect of Ca (as calcium hydroxide), P (as treble superphosphate, 48% P_2O_5), F (as sodium fluoride) and B (as boric acid, 17% B) on the leaf tipburn in *Chlorophytum*. The rates were 0, 2, 4 and 6 g/l. of medium for Ca and P; 0, 3, 6 and 9 mg/l. F in solution and 0,5,10 and 15 mg/l. B in solution. Plants were grown in a mixture of 1 soil : 1 peat : 1 perlite (by volume) or in sphagnum peat moss. Ca significantly raised the pH and reduced the leaf tipburn area in both media. P significantly reduced the pH of the mixture and raised it in sphagnum peat, but did not reflect a consistent effect on the leaf tipburn. F significantly raised the pH both media in the 1st season and did not affect the leaf tipburn. At 10 and 15 mg/l. B the pH of both media was significantly reduced, while the burning of the tip on the oldest leaves was significantly developed with increasing B rates. The concentrations of the tested elements in the leaf tissues showed an increasing trend with increasing elements in the medium. As B accumulation increased in the oldest leaves, the tipburn area increased. Leaf tissues of every treatment contained Na which may be related to the lamina tipburn.

(2) study the B distribution through the plant foliage using plants grown in sandy culture treated with (a) a complete Hoagland and Arnon' solution; (b) a second without B or (c) a third containing 20x the recommended amount of B. With increasing B amount in the solution the B leaf tissue content and the tipburn area on the oldest leaves were increased. The uppermost leaves did not exhibit lamina tipburn. B accumulation in the oldest leaves was more than that in the uppermost ones. B distribution in the various parts of the oldest leaves was not uniform and most of B accumulated in the distal parts, which resulted in the appearance of tipburn on it.

INTRODUCTION

Chlorophytum comosum (Thunb) Jaques "*Variegatum*" (Fam. *Liliaceae*) is one of the familiar foliage greenhouse plants. It is a valuable plant for pots, indoor decoration, hanging baskets, miniature gardens, window gardens and sometimes used in borders. The leaves are freely produced from the crown, broad linear, flattish, sessile and bright green with white lines along the lamina. Roots are fleshy and white. Flowers are small, white, soon fading and produced on branched runners (stolons). The plant is propagated by separation and/or plantlets formed on branched runners. The leaves occasionally exhibit tipburn symptoms which decrease the plant quality. This injury has been characterized as a necrosis which starts at the tips of the lower leaves moving inward on the leaves and upward on the plant.

Several researchers referred the leaf tipburn in *Chlorophytum* to such diverse factors as fluorine toxicity (Peterson, 1975) or boron toxicity (Sheely and White, 1980). Matkin (1977) stated that the plants grown in soil with high fluorine level showed no measurable degree of leaf tipburn. Commercial plant growers have attributed tipburn injury to pesticide phytoxicity or improper watering as mentioned by Sheely and White (1980).

The leaf tipburn was recorded on other plants: Kohl and Oertli (1961) found that high concentration of boron caused marginal necrosis in lilies. Poole and Conover (1973 and 1975) mentioned leaf necrosis in *Cordyline terminalis*, Kunth and *Dracaena dermensis*, Engler may has been related to fluorine toxicity. Honma and Bert (1975) reported that physiological factors such as light, moisture relations and temperature have produced tipburn in lettuce. Gimmler *et al.* (1998) demonstrated that boron concentration was close to the limits of phytotoxicity when accumulated in leaves of *Vitis vinifera*, L. Lima (1998) stated that toxicity symptoms were apparent on seedlings of *Pisum sativum*, L. as a result of seed germination under boron concentrations more than 2mg/l. Ramirez (1998) found that boron caused necrosis on leaves of coffee plants. Also, maize, carrot, tomato and lucerne exhibited toxicity symptoms on leaves when grown with boron-enriched water (Banuelos *et al.*, 1999). Some ornamental species exhibited boron toxicity symptoms including burning of the tip and margin of old leaves (Brown *et al.*, 1999).

The present work was conducted to study the effect of different levels of each of calcium (Ca), phosphorus (P), fluorine (F) and boron (B) on the development of leaf tipburn in *Chlorophytum comosum* (Thunb) Jaques "*Variegatum*" plants (spider plant) and identify which element of them is responsible for the appearance of this injury on the plants and its distribution in different leaves of the plant.

MATERIALS AND METHODS

The present work was carried out between the beginning of April and the end of October during two successive seasons of 1999 and 2000 in the Flowers and Ornamental Plants Research Gardens of the Faculty of Agriculture, Alexandria University, Egypt.

One-year-old *Cholorophytum* plants, grown in 25 cm diameter, clay pots under natural light in plastic house in the Research Gardens mentioned before, were used. The plants were removed outside the clay pots. Using the tap water, root systems were washed gently and much soil as possible was removed. Plant clusters were separated to individual plants. All lower (oldest) leaves which have tipburn or necrotic tissues were removed and the remainder leaf number ranged from 13 to 16 leaves. The plants were repotted individually in 20 cm diameter, black plastic pots. Half of the pots contained a mixture of 1 soil : 1 peat moss : 1 perlite (by volume) with no preplant fertilization. The rest half of the pots contained fine genuine sphagnum peat moss without any admixtures nutrients. Plastic dishes were put under the pots to retain the drainage solution and return it to the pots again. The plants were irrigated every two days with a distilled water. A complete Hoagland and Arnon's nutrient solution as stated by Hoagland and Arnon (1950), Sheely and White (1980) and Brown *et al.* (1999) was applied to the plants twice a week using 150 ml per pot. Irrigation with the distilled water was stopped on the day of Hoagland and Arnon's solution application and one day after it.

The constituents of the nutrient solution in ppm were N-167, P-31, K-280, Ca-179, Mg-49, SO_4-332 , B-0.25, Cu-0.01, Fe-0.28, Mn-0.25, Zn-0.027 and Mo-0.81. Solution pH was adjusted to 6.0. After 8 days from replanting, where the plants were irrigated two times with the distilled water and two times with Hoagland and Arnon's solution, the following nutrient treatments were applied for both media:

Calcium treatments: calcium hydroxide was used as a source of calcium (Ca). The rates were 0, 2, 4 and 6 g Ca/l of medium.

Phosphorus treatments: treble superphosphate (48% P_2O_5) was utilized as a source of phosphorus (P). The rates were 0, 2, 4 and 6 g P/l of medium.

Fluorine treatments: sodium fluoride was used as a source of fluorine (F). The application rates were 0, 3, 6 and 9 mg/l F in solution (distilled water was used).

Boron treatments: boric acid (17% B) was used as a source of boron (B). The rates were 0,5,10 and 15 mg/l B in solution (distilled water was used).

Calcium and phosphorus were applied once and the plants were irrigated directly. Fluorine and boron solutions were added 5 times (200 ml/time) day after day where the plants were not irrigated, then the irrigation was applied 1 day after the final time of fluorine and boron addition. Afterwards irrigation with the distilled water was made every three days.

Plants within each nutrient treatment were arranged under plastic house in a complete randomized design (Snedecor and Cochran, 1974) with 6 plants per treatment. The plastic house was covered with plastic shade cloth to produce about 10.8 klx (1000 ft-c) of light at plant level. Plastic house temperature extremes generally ranged from 24 to 32°C but infrequently registered 36°C.

At experiments termination, August 31, 1999 and 2000 in the 1st and 2nd seasons; respectively, tipburn was measured on the basal (lower) leaves for each nutrient treatment (expressed in mm of necrotic tissue), where the lowest 6 leaves from each plant in each treatment were used (36 leaves per treatment). The same leaves were sampled for the chemical analysis to determine Ca, P, F, Na and B contents. Leaf samples of Ca and P treatments were washed several times with tap water then rinsed 4 times in distilled water, dried at 70°C for 72 h and ground through a 20 mesh plastic screen (Chapman, 1964). A sample of 0.5 g per each treatment was digested in sulphoric acid and hydrogen peroxide, made up to volume, filtered and analysed for P as described by Jackson (1958). Ca and Na were determined with atomic absorption spectrophotometer. F was determined by the method of Volhard (1956).

Leaf samples of B treatments were not washed because B is easily leached from leaves during washing procedures (Nyomora *et al.*, 1997 and Brown *et al.*, 1999). Leaves were dried and ground as described previously then digested in 1% nitric acid. B concentration in samples was determined as described by Brown and Hu (1994). Throughout the analysis, borosilicate glass was avoided.

The determination of each element was repeated 3 times for each treatment and the mean was calculated.

To detect the final pH of each medium, a soil sample was taken from the middle third part of each pot in each treatment, and the mean of 6 determinations was calculated for each treatment (US Salinity Laboratory Staff, 1969).

Because the main objective of the present study was to detect responsible element for the leaf tipburn in *chlorophytum* plants, neither fresh nor dry weights were studied.

Based on the observations from the foregoing experiemtns, the development of leaf tipburn of the oldest leaves in *Chlorophytum* plants as a consequence of B treatments and B accumulation in these leaves resembled B toxicity in other plants. Therefore, a sand culture experiment was devised to test this hypothesis and to investigate the possibility of a boron gradient throughout *Chlorophytum* plant. This experiment continued for 2 months (September and October) during each of both experimental seasons of 1999 and 2000. One-year-old plants similar to those used in the previous experiments were utilized and prepared as mentioned before. Black plastic pots of 20 cm diameter were filled with equal volumes of sharp sand and sieved perlite. This medium was washed 2 times with distilled water to remove contaminants such as boron and fluoride, followed by 2 thorough leachings with 2% hydrochloric acid and 3 rinses again with distilled water to remove any traces of acid. Selected uniformly plants were individually repotted and irrigated 3 times a week with the distilled water. After 8 days the treatments were applied which consisted of : (a) a complete Hoagland and Arnon's nutrient solution as a control; (b) a second without B and (c) a third containing 20 x the recommended amount of B, to detect possible toxicity symptoms. The treatments were applied weekly with solutions sufficient to drain thoroughly (200 ml per plant in each application). The pots were arranged in plastic house under the same conditions of lighting, while temperature ranged from 23 to 29 °C. the layout of experiment was complete randomized design with 6 plants per treatment.

At the end of the experiment, leaf tipburn was measured (in mm of necrotic tissue) on the lowest 6 leaves of each plant (36 leaves per treatment). The leaves were sampled over different positions of the plant to study the possibility of a bororn gradient throughout the plant, where 36 leaves of the lowest (basal) ones and 36 leaves from the upper (terminal) ones were sampled from each treatment (6 lowest ad 6 uppermost per plant). The lowest leaves were also divided into 2 equal parts in length (basal and distal part). B content was detected in the various parts of leaves as mentioned before, then B content in each leaf type was calculated.

Data of the different experiments were statistically analyzed. differences between means were calculated and tested by least significant difference at 1% level of probability. Angular transformation was settled for all percentages. the statistical analysis was conducted using values resulting in form transformation and the original values were marked with the letters of significance.

RESULTS AND DISCUSSION

Calcium. In both seasons, the addition of Ca as calcium hydroxide, significantly raised the pH of the media and the differences among the treatments were highly significant. This pH change was more pronounced in sphagnum peat moss. The greatest changes were recorded at the rate of 6 g per liter Ca in both media during the two seasons (Table 1). Similar results were mentioned by Sheely and White (1980) and kotur (1998).

It was noticed in both media and during both seasons that the concentrations of Ca in leaf plants increased as the added rate of Ca to the medium increased (Table 1). Highly significant differences were detected between the treatments in both seasons. There was a significant difference between each of the Ca rates from 2 to 6 g on one side, and the control on the other side, in both media during the two seasons. The present results are supported by Sheely and White (1980).

Regarding the leaf tipburn area, the results of the two seasons showed that the differences among the treatments were highly significant. Ca was able to reduce the leaf tipburn area in the plants grown in both media (Table 1). The reduction was significant in sphagnum peat moss at all tested Ca rates comparing with the control during both seasons. In the case of the soil peat perlite medium, all Ca rates in the 1st season and that of 6 g in the 2nd one significantly reduced the area of tipburn as compared with the control (Table 1). The tipburn area in the plants grown in soil peat perlite was less than that in the plants grown in sphagnum peat moss. The lowest tipburn area in the case of soil peat perlite was observed at 4 and 6 g Ca in the 1st and 2nd seasons; respectively. Also, the greatest reduction in the tipburn area in the case of spagnum peat moss was recorded at 6 g Ca in both seasons. These results are in agreement with those reported by Sheldrake *et al.*, (1978), Sheely and White (1980) and Kotur (1998).

Kobayashi *et al.*, (1999) mentioned that the formation of borate rhamnogalacturonan II (RG-II) complex in higher plant cell walls was stimulated by Ca^{2+}. This complex formed in the presence of Ca^{2+} was more stable than that without Ca^{2+}. A naturally occurring boron (B-RG-II) complex isolated from radish cells contained equimolar amounts of Ca^{2+} and B. Thus Ca^{2+} is a normal component of (B-RG-II) complex. The formation and bonding of this complex is reinforced by Ca^{2+}. Thus the reduction in the leaf burnt area in the presence of Ca may be ralated to the formation and stability of (B-RG-II) complex which clinchs B, consequently B toxicity symptoms will reduce.

Table (1): Effect of calcium hydroxide rates added to soil peat perlite and sphagnum peat moss media on pH of medium, leaf Ca levels and tipburn of *Chlorophytum comosum* "Variegatum" 1)

Treatments		Final pH x)		Ca % leaf dry weight y)		Leaf tipburn area (mm) z)	
Medium	Ca (g/l of medium)	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Soil Peat perlite 1 : 1 : 1	Control	7.1 b	7.0 b	2.1 d (8.33)	2.2 e (8.52)	15 a	12 b
	2	7.7 a	7.5 a	2.9 ab (9.81)	2.8 abc (9.63)	9 b	11 bc
	4	7.8 a	7.7 a	3.0 a (9.98)	2.9 ab (9.81)	8 b	9 bc
	6	7.9 a	7.8 a	3.2 a (10.31)	3.1 a (10.14)	10 b	8 c
Sphagnum peat moss	Control	4.0 d	4.2 d	1.5 e (7.02)	1.7 f (7.48)	17 a	16 a
	2	6.3 c	5.9 c	2.4 cd (8.91)	2.5 cde (9.09)	11 b	12 b
	4	7.0 b	6.8 b	2.3 cd (8.71)	2.4 de (8.91)	11 b	10 bc
	6	7.2 b	7.0 b	2.6 bc (9.27)	2.7 bcd (9.45)	10 b	9 bc
LSD.		0.25	0.25	0.63	0.61	3.24	3.71

1) Values marked with the same alphabetical letters, within comparable group of means, do not differ significantly, using L.S.D. at the 1% level.

x) Each value is the mean of 6 determinations taken from 6 pots/treatment.

y) Each value is the mean of 3 determinations taken from 6 plants/treatment (6 leaves/plant, with a total of 36 leaves/treatment). Parenthetical values are angles corresponding to the mean percentages and were used in ANOVA and comparisons.

z) Each value is the mean of 36 leaves taken from 6 plants/treatment (6 leaves/plant).

Phosphorus. Considering the final pH value, there were highly significant differences between the treatments in the two seasons. The addition of P to the soil peat perlite medium in both seasons resulted in a gradual reduction in the pH of medium and this reduction was significant at the rates from 2 to 6 g P in the 1st season and at those of 4 and 6 g P in the 2nd one as comparing with the control. However, the highest reduction was noticed at the rate of 6 g P (Table 2). The addition of P to sphagnum peat moss medium gradually and significantly raised the final pH at the tested rates from 2 to 6 g P with the greatest change occurring at the rate of 6 g P in both seasons (Table 2). These results are in accordance with those mentioned by Sheely and White (1980) and Acharya *et al.* (1998).

For P content in the leaf tissues, there were highly significant differences among the treatments during both seasons. The increased rates of P added to the media significantly increased the concentrations of P in the leaf tissues to a greatest extent in the presence of 4g P in the 1st season and 6 g P in the 2nd one in both medium types (Table 2). Similar results were reported by Sheely and White (1980) and Acharya *et al.* (1998).

Table (2): Effect of treble superphosphate rates added to soil peat perlite and sphagnum peat moss media on pH of medium, leaf P levels and tipburn of *Chlorophytum comosum* "variegatum.[1]

Treatments		Final pH medium[x)]		P% leaf dry weight[y)]		Leaf tipburn area[z)] (mm)	
Medium	P g/Liter of medium)	1st season	2nd season	1st season	2nd season	1st season	2nd season
Soil peat	Control	7.1a	7.0a	0.6d (4.42)	0.5d (4.01)	15abc	12c
Perlite	2	6.8b	6.9a	1.5b (7.02)	0.9c (5.43)	12c	17a
1:1:1	4	6.4c	6.5b	2.1a (8.32)	1.2bc (6.27)	13bc	15abc
	6	6.3c	6.4b	1.9a (7.91)	1.4b (6.78)	12c	13bc
Sphagnum	Control	4.0g	4.2e	0.5d (3.99)	0.5d (3.99)	17a	16ab
Peat	2	4.8f	4.9d	1.1c (5.99)	1.4b (6.79)	18a	14abc
Moss	4	5.1e	5.0d	2.0a (8.12)	2.0a (8.12)	16ab	15abc
	6	5.8d	5.6c	2.0a (8.12)	2.1a (8.33)	16ab	17a
LSD		0.26	0.26	0.89	0.86	3.66	3.59

[1)] Values marked with the same alphabetical letters, within comparable group of means, do not differ significantly, using LSD at the 1% level.,

[x)] Each value is the mean of 6 determinations taken from 6 pots/treatment

y) Each value is the mean of 3 determinations taken from 6 plants/treatment (6 leaves/plant, with a total of 36 leaves/treatment). Parenthetical values are angles corresponding to the mean percentages and were used in ANOVA and comparisons.

[z)] Each value is the mean of 36 leaves taken from 6 plants/treatment (6 leaves/plants).

With regard to the burning area in the leaf tip of the old leaves, it was observed that the differences among the treatments were highly significant in both seasons. Insignificant differences were detected among the different rates of P in the case of soil peat perlite medium in the 1st season and in the case of sphagnum peat moss medium in both seasons (table 2). Application of 2g P in the 2nd season significantly increased tipburn injury in plants grown in the soil peat perlite medium comparing with the control and the rate of 6g P (table 2). In general, the necrotic areas in plants grown in the sphagnum peat moss medium were greater than those in plants grown in the soil peat perlite medium. However, the addition of P as superphosphate did not reflect a consistent effect on the leaf tipburn in plants grown in the mixture of soil peat perlite (table 2). Similar results were mentioned by Sheely and White (1980).

Fluorine: Highly significant differences were detected between the different treatments in both seasons considering the final pH medium. The results revealed that the addition of sodium fluoride to both media did not give conspicuous trends for the changes in pH around the two seasons. For the soil peat perlite medium, it was noticed in the 1st season that the rates from 3 to 9 mg/l. F resulted in increases in the pH value and these increases were significant at the rates of 3 and 6 mg/l. F as compared with the control, but these marked effects disappeared in the 2nd season. Also, in the soil peat perlite medium and during the 1st season, insignificant differences were detected among the pH values at the rates from 3 to 9 mg/l. F, but in the 2nd one the pH value at the rate of 9 mg /l. F was markedly higher than that at the rate of 3 mg/l. F (Table 3). Considering the sphagnum peat moss medium, the rates from 3 to 9 mg /l. F significantly raised the pH value comparing with the control in the 1st season and the highest pH value was recorded at the rate of 9 mg/l. F which significantly differed from that at the rate of 3 mg/l. F (Table 3). During the 2nd season the changes in the pH values of the sphagnum peat moss were not marked as compared with the control (Table 3). Sheely and White (1980) found that F with 0 to 4 mg/l. did not change the pH of soil mixes and these results are similar to those obtained in the 2nd season and differ with those of the 1st season. The differences between the two seasons might be due to the difference in components of the sphagnum peat moss used in both seasons.

The concentrations of F element in the leaf tissues showed insignificant increasing trend with increasing the element in media in both seasons (data are not illustrated in Table 3).

Table (3): Effect of sodium fluoride rates added to soil peat perlite and sphagnum peat moss media on pH of medium and tipburn of *Chlorophytum comosum "Variegatum"*.(1)

Treatments		Final pH of medium^x		Leaf tiphurn area^y (mm)	
Medium	F (mg/l in solution)	1st season	2nd season	1st season	2nd season
Soil peat perlite 1:1:1	Control	7.1b	7.0ab	15	12bc
	3	7.3a	6.9b	17	11c
	6	7.3a	7.1ab	16	13bc
	9	7.2ab	7.2a	18	12bc
sphagnum peat moss	control	4.0e	4.2c	17	16ab
	3	4.3cd	4.4c	18	16ab
	6	4.2d	4.3c	18	19a
	9	4.4c	4.4c	19	20a
LSD.		0.19	0.29	N.S^z	4.36

1)Values marked with the same alphabetical letters, within comparable group of means, do not differ significantly, using LSD at the 1% level.

x) Each value is the mean of 6 determinations taken from 6 pots/ treatment.

y) Each value is the mean of 36 leaves taken from 6 plants/ treatment (6 leaves/ plant).

z) N.S.= Non- significant differences.

With respect to the leaf tipburn area there were highly significant differences among the treatments in the 2nd seson only. It was clear that sodium fluoride rates from 3 to 9 mg/l F as a soil drench did not significantly affect the area of tipburn in the F treated plants comparing with the untreated plants in each medium during both seasons (Table 3). These results are in accordance with those reported by Matkin (1977) and Sheely and White (1980). In the 2nd season, the area of the leaf tipburn in plants grown in sphagnum peat moss medium was greater than that in plants grown in the mixture of soil peat perlite and the plants treated with 6 or 9 mg/l. F in sphagnum peat moss exhibited leaf tipburn area significantly greater than that in plants grown in the soil peat perlite medium (Table 3). The reason may have been related to less available calcium in the sphagnum peat moss medium (Sheely and White, 1980). F and low pH of the sphagnum peat moss medium increase the toxicity of F (Poole and Conover, 1973). Generally, the results of the two seasons did not show a consistent trends. However, Poole and Conover (1973 and 1975) recommended the addition of lime to avoid F toxicity where media pH will increase. In the present study at the treatment of high Ca level, the plants still exhibited some tipburn (Table 1). Sheely and White (1980) stated that at pH 7.8 with about 84% Ca saturation in the soil, one would not expect F toxicity problems. Matkin (1977) suggested that the high level of F in the soil resulted in unmeasurable tipburn injury in *Chlorophytum* and the injury attributed to F toxicity was probable due to unfavourable conditions.

Sodium: The distilled water was used for plant irrigation and it contained about 26 mg/l. Na. Therefore, it was considered as a source of Na contamination. In every treatment the leaf tissues contained 0.16% Na or more. Sheely and White (1980) reported that *Chlorophytum* leaves acted as a Na sink and the presence of high leaf Na -contents suggested a possible selective absorption mechanism which may be related to lamina necrosis.

Boron: Considering the final pH values of media, the results indicated the presence of highly significant differences among the treatments in both seasons. In the case of the soil peat perlite medium, the pH value decreased with increasing the B rate and the lowering was significant at the rates of 10 and 15 mg/l. B comparing with the control in both seasons. The same effect was observed for the medium of sphagnum peat moss with significant reductions at the rate of 15 mg /l. B in the 1st season and at those of 10 and 15 mg/l. B in the 2nd one as compared with the control. (Table 4). These decreases in pH were similar to those mentioned by Acharya *et al.* (1998) and Kotur (1998).

Regarding the leaf B concentration, the differences among the treatments were highly significant during the two seasons. In the two types of media the addition of B significantly increased B accumulation in the lea tissues. The highest B concentrations was recorded in both seasons with the highest B rate (15 mg/l.) applied to the media (table 4). The present results are in agreement with those reported by Sheely and White (1980) on *Chlorophytum* plants treated with B solutions contained from 0 to 20 mg/l. B. Also, Gimmler *et al.* (1998) stated that B was particularly accumulated in leaves of *Vitis* grown in an alkaline soil. Similar results were mentioned by Sotiropoulos *et al.* (1998a) on the shoots of *Actinidia*, produced in vitro using MS medium with different rates of B. The same trend was detected by Banuelos *et al.* (1999) on seedlings of maize, carrot, tomato and lucerne grown with B-enriched water. Günes *et al.* (1999) reported that as application levels of B increased, the B concentrations increased in tomato plants.

For the leaf tipburn, the statistical analysis revealed that the different treatments had highly significant effects on the leaf tipburn area during both experimental seasons. It was noticed for the two types of media and in both seasons that the addition of B significantly increased the leaf tipburn area on the oldest leaves. As exposure to B increased, greater portions of the oldest leaves became burnt (Table 4). The highest amount of tipburn in both media was recorded at the rate of 15 mg/l. B followed by those of 10, 5 and 0 mg/l. B; respectively, in both seasons. Symptoms of the tipburn began to appear on the oldest leaves within 2 and 3 weeks from the beginning of treatments depended on the application rate of B. The tipburn area at each rates from 5 to 15 mg /l. B significantly differed from that at the check treatment in each medium. The comparisons between the two media at the same rate of B showed at the rate of 10 mg/l. the tipburn area in the case of sphagnum peat moss medium was significantly greater than that in the mixture of soil peat perlite (Table 4). These results are supported with those reported by Oertli (1960); Sheely and White (1980); lima (1998); Brown *et al.* (1999) and Günes *et al.* (1999).

Table (4): Effect of boric acid (17.%B) rates added to soil peat perlite and sphagnum peat moss media on pH of medium, leaf B levels and tipurn of *Chlorophytum comosum* "variegatum".(1)

Treatments		Final pH of medim(x)		B concen in leaves(y) ppm		Leaf tipburn area(z) (mm)	
Medium	B (mg/l in solution)	1st season	2nd season	1st season	2nd season	1st season	2nd season
Soil peat perlite 1 : 1 : 1	Control	7.1a	7.0a	56d	51d	15e	12d
	5	7.ab	6.8ab	95c	105c	75d	81c
	10	6.8b	6.7b	120b	139b	110c	98b
	15	6.5c	6.3c	207a	221a	154a	144a
Sphagnum peat moss	control	4.0de	4.2d	49d	45d	17e	16d
	5	4.1d	4.2d	89c	115c	86d	95bc
	10	3.9de	3.9e	118b	130b	130b	150a
	15	3.9e	3.9e	210a	228a	158a	153a
LDS.		0.22	0.23	10.52	14.14	13.59	15.39

1) Values marked with the same alphabetical letters, within comparable group of means, do not differ significantly, using LSD at the 1% level.

x) Each value is the mean of 6 determinations taken from 6 pots/ treatment.

y) Each value is the mean of 3 determinations taken from 6 plants/ treatment (6 leaves/plant, with a total of 36 leaves/ treatment).

z) Each value is the mean of 36 leaves taken from 6 plants/ treatment (6 leaves/ plant).

It was clear that the addition of B to the media significantly increased B accumulation in the oldest leaves expressing B toxicity symptoms and greater portions of the oldest leaves became symptomatic. Data in Table 4 showed that the area of the tipburn on the oldest leaves reflects the amount of B accumulation. In other words, if the highest B accumulation is found in the oldest (basal) leaves, the leaf tipburn area will increase when the plant is subjected to high B treatment. This situation is in accordance with the results reported by Oertli (1960); Sheely and White (1980); Gimmler *et al.* (1998); Sotiropoulos *et al.* (1998a); Banuelos *et al.* (1999) and Brown *et al.* (1999). At higher concentrations of B, the chlorophyll content of leaves decreased and the treated plants develop ever necrosis (Sheely and White, 1980 with

Chlorophytum treated with 20 mg/l. B and Lee and Choi, 1998 with *Tulipa* treated with > 4mg//l. B).

Classical B toxicities, such as those described in most current texts, are exhibited as tip and margin burn in the oldest leaves (Brown *et al.*, 1999). This type of toxicity was observed in the present work, while the younger (upper) leaves did not exhibit B toxicity symptoms. The typical pattern of B accumulation in plants is for a higher concentration of B to be found in the oldest leaves. This distribution of B is typical of an element with limited phloem mobility and results in the development of leaf tip and margin burn of the oldest leaves as a consequence of the high B concentration in these tissues (Brown and Shelp, 1997 and Brown *et al.*, 1999).

Other workers have also demonstrated that some plant species do not accumulate high concentrations of B in their old leaves, and B toxicity is expressed as stem dieback and gum exudation in leaf axils and buds (El-Motaium *et al.*, 1994 on *Prunus* and Brown *et al.*, 1999 on *Contoneaster, Gardenia; Ligustrum; Pyracantha; Rhaphiolepis* and *Veronica)*. These unusual symptoms of B toxicity are the results of the high phloem mobility of B in these species (Brown and Hu, 1996 and Brown *et al.*, 1999).

To avoid B toxicity, Günes *et al.* (1999) recommended that Zn treatments were able to alleviate B toxicity in tomato plants and reduced the inhibitor effect of B on growth.

In the sand culture experiment, the statistical analysis proved that there were highly significant differences among the different treatments considering each studied criterion in both seasons. The results of the two seasons indicated that the lower (old) leaves in the plants treated with Hoagland and Arnon's solution that contained 20x the recommended amount of B had the highest concentration of B and the largest area of tipburn followed by those in the plants treated with complete nutrient solution then those in the plants treated with the nutrient solution without B (Table 5). There was a significant difference between each treatment and the other considering B concentration in the leaf tissue. Whereas, the treatment of the lower leaves treated with nutrient solution containing 20x amount of B significantly had the largest area of tipburn comparing with those teated either with complete solution or solution without B and the later two treatments did not significantly differ (Table 5). Regarding the younger (upper) leaves, insignificant differences were observed between them at the 3 solution treatments either for the leaf tissue B concentration or for the tipburn area in both seasons. Also, insignificant differences were detected between the older leaves and the upper ones each treated with nutrient solution without B in both seasons (Table 5). All younger (upper) leaves did not exhibit any leaf tipburn injury. Appearance of B toxicity in the sand culture experiment is in line with the results of boric acid experiment mentioned before, where the B toxicity symptoms developed on the oldest leaves as a results of B accumulation with high concentrations in these tissues as a consequence of the plant treatment with nutrient solution containing high concentration of B. The leaves in which B toxicity was observed were the oldest leaves of the plants treated with the nutrient solution containing B, while the younger (uppermost) leaves no B toxicity symptoms were observed. Thus, the position of leaves on *Chlorophytum* plants is an important factor affecting lamina tipburn in these plants and indicating also that B is an element with limited phloem mobility. In other words the present results support the conclusion that toxicity is related to the leaf position and high B concentration, but the position is species dependent as reported by Brown and Shelp (1997) and Brown *et al.* (1999).

Table (5): Boron concentration and tipburn area in *Chlorophytum comosum "Variegatum"* leaves as affected by leaf position and concentration of boron in Hoagland and Arnon's solution.[1]

Treatments		B conc in leaves[x] (ppm)		Leaf tiphurn area[y] (mm)	
Leuf type	Hougland solution	1st season	2nd season	1st season	2nd season
Lower leaves	Complete solution	30b	33b	7b	8b
	Without boron	10c	6c	2b	1bc
	With 20x boron	100a	110a	84a	89a
Upper leaves	Complete solution	7c	9c	0b	0c
	Without boron	5c	3c	0b	0c
	With 20x boron	10c	12c	0b	0c
LSD.		11.54	11.84	8.12	7.12

1) Values marked with the same alphabetical letters, within comparable group of means, do not differ significantly, using LSD at the 1% level.

x) Each value is the mean of 3 determinations taken from 6 plants/ treatment (6 leaves/ plant, with a total of 36 leaves/ treatment).

y) Each value is the mean of 36 leaves taken from 6 plants/ treatment (6 leaves/ plant).

In the sand culture experiment, various parts of the oldest leaves, treated with the different stated nutrient solutions, were sampled (basal and distal parts) and analysed for B concentrations. It was found that B concentrations in the leaf parts increased toward the distal part of an individual old leaf (Table 6). It was noticed in both seasons that the distal parts of leaves treated with nutrient solution containing 20x recommended amount of B had the highest B concentration and significantly differed from any other part, followed by the distal parts of the leaves treated with complete nutrient solution then the basal parts of the leaves treated with nutrient solution containing 20x amount of B. There was a significant difference between the basal and distal parts when the complete nutrient solution or that with 20x amount of B were used in both seasons (Table 6). It was observed that the greater burned areas were restricted in the distal parts of the oldest leaves in each status of the nutrient solution and the highest burned area was noticed on the distal part of the status of the nutrient solution containing 20 x amount of B which significantly differed with any other part (Table 6). The present results are consistent with those reported by Oertli (1960) on rough lemon; Kohl and Oertli (1961) on lilies; Francois and Clark (1979) on several ornamental shrubs; Sheely and White (1980) on spider plant and Sotiropoulos *et al.* (1998 b) on kiwifruit orchards. They reported that most B accumulated in the leaf tip or margin and B distribution in the various leaf parts was not uniform.

Table (6): Boron concentration and burned area in leaf of *Chlorophytum comosum "Variegatum"* as affected by leaf part type and boron concentration in Hoagland and Arnon's solution.(1)

Treatments		B conc.(x) (ppm)		Burned area(y) (mm)	
Hougland and Arnon's solution	Leaf part	1st season	2nd season	1st season	2nd season
Complete solution	Basal	3d	2d	0b	0c
	Distal	27b	31b	7b	8b
Without boron	Basal	4d	2d	0b	0c
	Distal	6d	7cd	2b	1bc
With 20x boron	Basal	13c	11c	0b	0c
	Distal	87a	99a	84a	89a
LSD.		6.28	8.18	8.12	7.12

1) Values marked with the same alphabetical letters, within comparable group of means, do not differ significantly, using LSD at the 1% level.
x) Each value is the mean of 3 determinations taken from 6 plants/ treatment (6 leaves/ plant, with a total of 36 leaves/ treatment).
y) Each value is the mean of 36 leaves taken from 6 plants/ treatment (6 leaves/ plant).

From the previous results, the differences in B accumulation at which B toxicity occurs in *chlorophytum* plants depended not only on the leaf position, but also on the portion of leaf sampling. Also, B contents vary within leaf position and within leaf portions.

Symptoms of B toxicity in plant species sometimes interfere with those resulted from unfavourable culture conditions and some diseases and would not be recognized by plant growers. Avoidance of these situation, B analysis of the affected organs could help to identify the problem and produce plants of saleable quality.

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تأثير موقع الورقة-نوع التربة وتراكم البورون على إحتراق قمة الورقة فـــى الفلانجيـــم المخطط

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أجريت عدة تجارب عشوائية كاملة خلال موسمين تجريبين متتاليين تحت الظروف الطبيعية فـــى صوبة بلاستيك على نباتات الفلانجيم المخطط وذلك بغرض:

أولاً: دراسة تأثير كل من الكالسيوم والفوسفور بمعدل صفر، ٢، ٤، ٦ جرام / لـــتر بيئـــة لكــل منهما والفلورين بمعدل صفر، ، ٦، ٩ ملليجرام / لتر محلول والبورون بمعدل صفر، ١٠، ١٥ ملليجـــرام / لتر محلول على إحتراق قمم الأوراق فى نباتات الفلانجيم المخطط النامية إما فى مخلوط مكون من ١ تربـة : ١ بيت : ١ برليت (بالحجم) أو فى بيئة سفاجنم بيت موس. وقد أدت إضافة الكالسيوم فى البيئتين إلـــى رفـــع رقم حموضه البيئتين معنوياً مع نقص المساحة المحترقة من قمة الورقة معنوياً، وتسبب الفوسفور فى خفـض معنوى لرقم حموضة مخلوط التربة – البيت – البرليت وزيادة معنوية لرقم حموضة بيئة سفاجنم بيت مـوس ولم يكن له تأثيراً ثابتاً على إحتراق قمم الأوراق، وبالنسبة للفلورين فإنه أدى إلى زيادة معنويـــة فـــى رقـــم حموضة البيئتين فى الموسم الأول ولم يكن له تأثير على إحتراق قمم الأوراق، وقد أدت إضافـــة البـــورون بالتركيزين ١٠، ١٥ ملليجرم / لتر إلى إنخفاض معنوى فى رقم حموضـــة البيئتيـــن ولوحـــظ أن المســـاحة المحترقة من قمم الأوراق كانت تزداد معنوياً مع زيادة تركيز البورون، هذا وقد إرتفـــع تركـــيز العنـــاصر المدروسة فى أنسجة الأوراق مع زيادة معدلات إضافتها للبيئة، ولوحظ أن أنسجة الأوراق فى كل معاملة قـــد إحتوت على عنصر الصوديوم والذى ربما كان له علاقة باحتراق قمم أنصال الأوراق.

ثانياً: دراسة توزيع عنصر البورون خلال المجموع الخضرى للنباتات النامية فى بيئة تتكون مـــن حجمين متساويين من الرمل والبرليت وكانت تروى بإستخدام إما: (أ) محلول هوجلاند وأرنون كامل أو (ب) محلول هوجلاند وأرنون ينقصه عنصر البورون أو (جـ) محلول هوجلاند وأرنون يحتوى على ٢٠ ضعـف تركيز البورون. ولوحظ أنه مع زيادة تركيز البورون فى المحلول المغذى إزداد تركيزه فى أنســجة الأوراق وزادت مساحة الإحتراق فى قمم الأوراق القاعدية ولم تظهر أعراض الإحتراق على الأوراق العلوية، وكـــان تركيز البورون فى الأوراق القاعدية أعلى من مثيلة فى الأوراق العلوية كما أن توزيع البورون فى الأجـــزاء المختلفة للأوراق القاعدية لم يكن متماثلاً حيث أن معظمه قد تراكم فى الأجزاء العلوية منها مما تسبب فـــى ظهور إحتراق القمة عليها.