DWARFING OF *FICUS BENJAMINA* L. PLANT BY PACLOBUTRAZOL

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ABSTRACT

This work was carried out in the greenhouse at the nursery of Ornamental Horticulture Department, Faculty of Agriculture, Cairo University during the two successive seasons, 2003 / 2004 and 2004 / 2005 in plastic pots (30 cm diameter) filled with mixture of Sphagnum peat moss and sand at the ratio of 1 : 1 (v/v). The experiment was conducted to study the influence of different paclobutrazol concentrations (0, 250, 500 or 750 ppm) on vegetative growth and chemical constituents of *Ficus benjamina* plant. A comparative microscopical study was carried out on plant material, to elucidate the effect of paclobutrazol on treated plants. The results showed that the lowest concentration (250 ppm) of paclobutrazol was the most effective in controlling plant growth which led to a desirable plant height with attractive vegetative growth. The anatomical features of these plants showed that dwarfing of different plant organs (stem, petiole and leaf) may be due to the decrease in number of cell layers as well as thickness of tissues of these organs. Moreover, number of stmata/mm^2 increased in leaves of treated plants, while dimensions of stomata decreased compared with the control plants. Treating the plants with cultar kept the plants dwarf for more than a year.

Key words: *Ficus benjamina*, paclobutrazol, cultar, anatomy.

INTRODUCTION

Ficus benjamina L. Family Moraceae is native to tropical and sub-tropical regions. It is a tree or shrub, epiphytic when young (Bailey and Bailey, 1976). Ficus is one of the most commonly grown indoor plants. Its shape, canopy, deep green leaves and drooping branches make it graceful for the art of bonsai. Treating the plants with growth retardants would make them desirable pot plants with best quality (in terms of compactness, greenness, bushiness, etc.).

Plant growth rate and final height varies among species and cultivars. Some growth regulation is beneficial to most species and cultivars, but essential for those growing too tall for a quality product. Plant growth regulator can be applied as a foliar spray or as drench. Paclubutrazol (as cultar) is a synthetic growth retardant that is capable of controlling plant size. It acts as gibberellin synthesis inhibitors, frequently referred as growth retardant, which is used in ornamental plant production systems. Cultar is absorbed directly by stem and root tissues then translocated mainly through xylem to the terminal bud where causing its effect (Barrett and Bartuska, 1982).The major modifications to plants induced by growth retardants are shorter internodes, less height, reduced cambial growth and somewhat smaller, darker green leaves (Bai *et al.,* 2004). These effects are thought to arise from inhibition of various steps in the isoprenoid pathway leading to gibberellins (Rademacher, 2000). The mode of action involves further alterations in the isoprenoid biosynthetic pathway related to inhibition of sterols and promotion of abscisic acid (Chaney, 2002). Rademacher (2000) mentioned that degradation of ABA is inhibited by paclobutrazol. The response of plants to paclobutrazol involves more than just the inhibition of gibberellin biosynthesis and the reduction of cell elongation and growth in height. Effects on the production of metabolic energy via the electron transport chain in the final phase of respiration could be an additional mode of action for growth retardants. These growth retardants act like inhibitors of cytochrome oxidase (Chaney and Bai, 2005). The ability of paclobutrazol to control the growth of some plants was investigated by some workers. Rizzitelli *et al.* (2000) found that paclobutrazol (50 ppm a.i.) as soil drench reduced plant size in *Pittosporum tobira* and *Osmanthus heterophyllus* plants. Matysiak (2002) pointed out that paclobutrazol was effective in stimulating the branching of magnolia shrubs. BAnon *et al.* (2003) mentioned that paclobutrazol at 0.5 mg / plant as soil drench was the most effective treatment in reducing plant height of *Reichardia tingitana.* Matsoukis *et al.* (2004) showed that paclubutrazol (0.2 mg) significantly reduced plant width and aerial part dry weight of

Lantana camara. Growth regulators affect the internal structure of treated plants as mentioned by some workers. Mansour (1989) found that treating *Peperomia obtusifolia* plants with paclobutrazol at 0.4 mg active ingredient/pot reduced stem diameter, ground tissue parenchyma and vascular bundles size, while increased number of vascular bundles. This treatment also reduced thickness of the leaf blade and the midrib region due mainly to a reduction in thickness of the hypodermis as well as the vascular bundle. In addition, the number of stomata/field was increased in the lower epidermis of treated plants, but stomata were smaller in size than in untreated plants. El-Sagai and El-Sayed (1999) noticed that, spraying okra plant with 500 ppm of paclobutrazol caused considerable thickness of stem internode diameter due to the increase in thickness of the epidermis, cortex, vascular cylinder and number of cortical layers. Also, this treatment increased the thickness of lamina and midrib compared with the control, which was attributed to the increase of the thickness of mesophyll and the size of middle bundle. Sabbour (2002) stated that, application of paclobutrazol at 3000 ppm on rice plants grown under stress of 68.4 mM NaCl showed a decrease in stem diameter. This reduction was accompanied with a decrease in bundle length and width, bundle sheath and phloem tissue thickness, diameters of air cavities and xylem vessels. In addition, this treatment induced a decrease in midvein and lamina thickness. The reduction of lamina thickness was due to the decrease of spongy tissue, upper and lower epidermis. Bai *et al.* (2004) showed cambial growth suppression following treatment with paclobutrazol. The present investigation was conducted to evaluate the effect of paclobutrazol as growth retardant on growth and internal structure of *Ficus benjamina* plant.

MATERIALS AND METHODS

This experiment was carried out in the greenhouse during two successive seasons of 2003 / 2004 and 2004 / 2005 to study the effect of paclobutrazol as cultar (250 g/l paclobutrazol, manufactured by I.C.I. Americas, Inc.) on growth and the main constituents of *Ficus benjamina* L. plant. In addition, a comparative microscopical study was carried out on plant material, to elucidate the effect of paclobutrazol on treated plants. Homogenous plants (45 – 47 cm height, 5 – 6 mm stem diameter and 10 -11 branches /

plant) were obtained from the nursery of Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, and planted in pots (30 cm diameter), filled with a mixture of Sphagnum peat moss and sand (1:1 v/v) on February 18th of both seasons. The plants were fertilized with NPK at the ratio of 1: 1: 1 at the rate of 5 g / pot. The application started on March 18th and repeated every 4 months till the termination of the experiment. The fertilizers used were ammonium sulphate (20%N), calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48 % K_2O). Three concentrations of paclobutrazol (cultar) plus the control (tap water) were used as follows: 0, 250, 500 or 750 ppm. Fifty ml of each concentration were added to each plant as soil drench every four months during the period of the investigation. The application started in April. The plants were irrigated whenever required. The plants were left to grow for 12 months every season. Data were taken in following February in the two seasons. The following data were recorded:

1- Vegetative growth:-

Plant height (cm), number of branches / plant, stem diameter (mm) at the rim of the pot, number of internodes / plant, 4th internode (below the apical bud) length (cm), number of leaves / plant, leaf length (cm), leaf width (cm), leaf area (cm^2), fresh and dry weights (g) of leaves and stems.

2- Microscopical studies:-

It was intended to carry out a comparative microscopical study on plant material, which showed the most prominent response of plant growth to investigated treatments with paclobutrazol (cultar). The lowest level (250 ppm) resulted in the most remarkable effects; therefore the effect of the lowest level was studied. Plants used for examination were taken at the end of the second season (2004 / 2005). Specimens were taken from the middle of the fourth internode of the main stem as well as the leaf petiole and blade on the same internode. Study of stomata in surface view was made by using a print for the upper epidermis of the leaf using an adhesive (Amir alpha) for this purpose.

Specimens were killed and fixed for at least 48 hours in F.A.A. solution (10 ml formalin, 5 ml glacial acetic acid, 50 ml ethanol 95% and 35 ml distilled water). Then, samples were softened in glycerol and lactic acid (1:1) for a week, washed in 50% ethanol, dehydrated in n-butyl alcohol series and embedded in paraffin wax 56-58 °C mp. Sections, 20μ thick were cut by a rotary microtome.

The slides were smeared with Haupt solution before mounting the ribbon. Sections were stained by crystal violet/erythrosin combination, cleared in xylene and mounted in Canada balsam (Sass, 1967). Slides were microscopically examined and measurements and counts were taken and averages of 9 readings from 3 slides were calculated.

3- Plant main constituents:-

Pigments content, total carbohydrates percentage and elements (N, P & K) in leaves, stems and branches were determined. The chemical analyses were performed as follows:

- Pigments content determination was carried out in fresh leaves according to Saric *et al.* (1967).
- Total carbohydrates in different plant organs were determined according to Herbert *et al.* (1971).
- Nitrogen percentage was determined using micro-Kjeldahl method (Pregl 1945 and Piper 1947).
- Phosphorus content was determined according to Troug and Meyer (1939).
- Potassium content was carried out by using operation chart for Shimadzu Atomic Absorption Flame Spectrophotometer AA-646 with a boiling air-acetylene burner and recorded readout.

The layout of the experiment was a complete randomized blocks with four treatments, each treatment contained five replicates. Each replicate consisted of ten plants, i.e. 50 plants in each treatment. The obtained data were statistically analyzed using the analysis of variance between the averages according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

A- Vegetative growth:

From the data shown in Tables (1 – 4) it can be noticed that, in both seasons, all concentrations of cultar led to a significant decrease in plant characteristics than the control, except the length of the 4th internode in the first season. The rate of 250 ppm was the most effective in this concern.

1- Plant height:

Data in Table (1) revealed that, in the two seasons, the lowest rate of cultar (250 ppm) resulted in the shortest plants. The tallest plants were those of the control. Increasing cultar concentration led to a gradual increase in plant height. These results are in agreement with those reported by many workers. Hashim *et al.* (1991) on *Hibiscus rosa sinensis* mentioned that the lowest growth rate was obtained from spraying the plants with 250 ppm pp_{333}. The growth rate consequently increased as the concentration of pp_{333} was raised. The growth stimulation was presumably due to degradation of paclobutrazol in the plant, such that the concentration was so low that it stimulated rather than reduced growth. Paclobutrazol reduces ethylene, indole-3-acetic acid and degradation of ABA. While, it increases cytokinin levels and inhibits cytochrome oxidase (Chaney and Bai, 2005). Helal and Khalil (1998) on geranium found that paclobutrazol at 25 ppm restricted plant height. Maloupa *et al.* (2001) pointed out that application of 1000 mg / l paclobutrazol resulted in a significant reduction of the shoot length of *Vitex agnus-castus* plants. BAnon *et al.* (2003) concluded that the most effective treatment in reducing plant height of *Reichardia tingitana* was 0.5 mg / plant of paclobutrazol. This reduction in plant height may be due to its effect on reducing the auxin – like substances activity (Suh and Kwack, 1990).

2- Number of branches / plant:

From Table (1) it may be observed that, in both seasons, there was a gradual decrease in number of branches / plant as a result of increasing the rate of cultar. Control plants had the greatest number of branches / plant. However, the least number of branches resulted from treating the plants with the highest concentration of cultar (750 ppm). These results are in line with those of Hashim *et al.* (1991) on *Hibiscus rosa sinensis* who found that the highest of branches was obtained from the control, while the lowest number was found on the plants treated with pp_{333} at 2000 ppm.

3- Stem diameter:

As shown in Table (1) the data on stem diameter revealed that the thickest stems in the two seasons were those of the control plants. Whereas, the plants supplied with cultar at 750 ppm had the thinnest stems, in both seasons same as the number of branches. A gradual decrease in stem diameter was observed as a result of raising the concentration of cultar. These results were coincided with those of Maloupa *et al.* (2000) on *Vitex agnus-castus* and Matsoukis *et al.* (2004) on *Lantana camara.*

Table (1): Effect of cultar on plant height (cm), number of branches/ plant and stem diameter (mm) of *Ficus benjamina* L. plant during the two seasons of 2003 / 2004 and 2004 / 2005.

Cultar conc.	Plant height (cm)		Number of branches / plant		Stem diameter (mm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	131.48	140.92	35.50	40.71	11.55	11.71
250 ppm	69.29	72.10	28.22	33.24	10.16	10.82
500 ppm	73.13	75.55	26.41	29.70	9.08	9.91
750 ppm	73.18	77.07	24.93	26.03	8.87	9.46
L.S.D.0.05	2.53	2.79	2.91	2.09	0.40	0.57

4- Internodes number and length:

Data presented in Table (2) indicated that application of cultar as soil drench resulted in a decrease in number of internodes/ plant and the internode length in both seasons. In the two seasons, the greatest number of internodes was formed on control plants. While, the least number of internodes was found on the plants treated with cultar at 250 ppm. The tallest internodes were formed on the control plants. Meanwhile, application of cultar at 250 ppm led to the formation of the shortest internodes. There was a gradual increase in internodes number and length with increasing the concentration of cultar yet, less than control plants. These results agreed with those obtained by some workers. Helal (1993) on poinsettia noticed that paclobutrazol treatments decreased number of nodes / stem. Martinez *et al.* (2000) on *Lotus* ssp. observed that paclobutrazol shortened the internodes. However, Arnold and Davis (1994) found that 800 mg/L paclobutrazol applied to the foliage of Chinese chestnut increased internode elongation.

5- Number of leaves:

The data in Table (2) showed that, in both seasons, same as the number of branches / plant and stem diameter, control plants had the greatest number of leaves/ plant. Application of cultar at 750 ppm led to the formation of the least number of leaves. There was a gradual decrease in number of leaves/plant as the dose of cultar increased from 250 to 750 ppm. These results were in accordance with those recorded by some investigators. Hashim *et al.* (1991) on *Hibiscus rosa sinensis*, Helal (1993) on poinsettia and Wang and Gregg (1994) on golden pothos pointed out that the number of leaves was decreased by treating the plants with paclobutrazol as spray or drench.

Table (2): Effect of cultar on number of internodes / plant, 4th internode length (cm) and number of / leaves/ plant of *Ficus benjamina* L. plant during the two seasons of 2003 / 2004 and 2004 / 2005.

Cultar conc.	Number of internodes / plant		4th internode length (cm)		No. of leaves/ plant	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	50.00	53.42	4.11	4.36	407.78	425.33
250 ppm	34.33	39.52	2.28	2.53	199.67	201.58
500 ppm	36.38	42.28	2.68	2.78	175.00	183.11
750 ppm	38.44	46.37	2.77	2.93	167.56	178.47
L.S.D.0.05	3.83	2.85	1.79	1.00	4.73	4.38

6- Leaf length:

In Table (3) the data indicated that, in the two seasons, the tallest leaves were those of control plants. While, the shortest ones resulted from the application of the lowest rate of cultar (250 ppm), same as in plant height and 4th internode length.

7- Leaf width:

As shown in Table (3) the data pointed out that, in both seasons, there was a gradual decrease in leaf width as a result of increasing the rate of cultar. The control plants had the widest leaves during the two seasons. The narrowest leaves were formed on the plants treated with cultar at 750 ppm.

8- Leaf area:

The data presented in Table (3) showed that all concentrations of cultar led to a significant decrease in leaf area compared to the control plants. There was a gradual increase in leaf area as a result of increasing the rate of cultar, but without significant difference between all concentrations. In both seasons, the largest leaves were formed on the control plants. Application of cultar at 250 ppm led to the formation of the smallest leaves. The obtained results were in agreement with those of Adham (2001) on *Althaea rosea*, Osman (2002) on *Nerium oleander* and Matsoukis *et al.* (2004) on *Lantana camara* who found that paclobutrazol had a significant effect on reducing leaf area.

Table (3): Effect of cultar on leaves characteristics of *Ficus benjamina* L. plant during the two seasons of 2003 / 2004 and 2004 / 2005.

Cultar conc.	Leaf length (cm)		Leaf width (cm)		Leaf area (cm^2)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	10.24	10.43	4.44	4.68	30.08	31.13
250 ppm	8.02	8.25	3.78	3.86	20.47	20.57
500 ppm	8.36	8.56	3.49	3.57	20.69	20.72
750 ppm	9.28	9.49	3.42	3.39	20.87	21.17
L.S.D.0.05	0.85	0.86	0.64	0.41	2.57	2.25

9- Fresh and dry weights of leaves:

As shown in Table (4) the data revealed that, in the two seasons, the heaviest fresh and dry leaves were those of the control plants. Meanwhile the least fresh and dry weights of leaves were due to the application of cultar at 250 ppm. There was a gradual increase in fresh and dry weights of leaves as the rate of cultar was increased.

10- Fresh and dry weights of stem and branches:

The data in Table (4) indicated that stem and branches fresh and dry weights followed the same trend of leaves fresh and dry weights. The control plants had the heaviest fresh and dry weights.

While, the least fresh and dry weights of stem and branches were obtained from the plants supplied with cultar at 250 ppm. There was a gradual increase in fresh and dry weights of stem and branches with increasing the concentration of cultar. The effect of paclobutrazol on fresh and dry weights of plants was reported by some investigators. Wang and Gregg (1994) stated that paclobutrazol as soil drench produced lower fresh weight of golden pothus than the untreated plants. Ruter (1996) found that pp-333 decreased shoot dry weight of *Lantana camara*. Youssef (1997) on *Callistephus chinensis* mentioned that pp-333 decreased fresh and dry weights of leaves.

Table (4): Effect of cultar on fresh and dry weights (g) of leaves, stems and branches of *Ficus benjamina* L. plant during the two seasons of 2003 / 2004 and 2004 / 2005.

Cultar conc.	Leaves fresh weight (g)	Leaves dry weight (g)	Stem and branches fresh weight (g)	Stem and branches dry weight (g)
	First season			
Control	148.56	42.67	111.58	39.78
250 ppm	50.49	16.88	39.98	18.54
500 ppm	55.18	18.47	44.98	20.97
750 ppm	57.53	19.26	45.58	21.35
L.S.D.0.05	1.89	0.83	3.19	1.96
	Second season			
Control	151.38	46.78	126.33	41.86
250 ppm	52.31	18.99	41.89	20.77
500 ppm	58.23	21.54	48.49	23.84
750 ppm	60.13	22.37	50.53	24.70
L.S.D.0.05	2.96	0.80	2.55	2.28

B- Microscopical studies:-

1- Anatomy of the main stem:-

Microscopical measurements (in microns) of certain characters in transverse and longitudinal sections through the fourth internode of the main stem are given in Table (5). Also, (Figs. 1and 2) illustrated the differences between the lowest level treatment of cultar (250 ppm) and the control treatment either in transverse or longitudinal sections.

In cross sections (Table 5 and Fig. 1) it is apparent that relative to the control, the cultar treatment reduced main stem diameter by 26.1%. This decrease could be attributed chiefly to the noticeable decrease in thickness of cortex by 10.0%, fiber strands by 20.0%, vascular cylinder by 56.4% as well as thickness of pith by 12.7%. The decrease in vascular cylinder thickness was due mainly to the low amount of conducting elements (20 and 62.5% below the control for phloem and xylem tissues, respectively). Despite the decrease of stem thickness, compared with the control the thickness of periderm was increased by 42.1%. This increment could be attributed to the increase in thickness of phellem layers by 50.9 %, phellogen by 37.5% and phelloderm by 33.3% higher than the control. There are stone cells permeate the phelloderm. The cortex consists of two regions; immediately below the phelloderm is a zone of collenchyma cells and the inner one, which are chlorenchymatous cells. It is worthy to note that, the most negative effects of cultar on anatomical structure of stem were observed in both xylem tissue thickness and vessel diameter, which were decreased by 62.5 and 54.5 % below the control, respectively. Thus, this treatment delayed the secondary growth in xylem tissue as the cambial activity was reduced in the stems treated with cultar, which may indicate slower growth rate in such stems. Also, such treatment induced less thickening in xylem tissue. Nevertheless, the diameter of pith cell was decreased by 35.0 % than the control, and treatment caused thickening of pith cells.

Longitudinal sections in the main stem (Table5 and Fig. 2) showed that cortical cells were considerably smaller in dimensions; both length and width, being 44.3 and 17.1%, respectively, relative to the control. Similarly, pith cells were reduced in length by 41.6% and in width by 30.0 % compared with the control. Regarding the number of cells, spraying cultar increased number of cortical cells, being 78.4 and 21.1% higher than the control in both vertical and horizontal dimensions, respectively, due to the stimulation of cell division. Concerning pith cells, treating plants with the lowest level of cultar increased the number of cells in vertical direction by 68.0 % and in horizontal one by 41.3 % higher than the control. Thus, dwarfing *Ficus benjamina* stem as the result to cultar treatment may be due mainly to the decrease in both length and width of cortical and pith cells.

Table (5): Averages of counts and measurements (in microns) of certain anatomical characters in transverse and longitudinal sections through the middle part of the 4th internode of the main stem of *Ficus benjamina*, as affected by cultar treatment at 250 ppm (averages of 9 readings).

Treatment / Character	Control	Cultar at 250 ppm	± % to control
Transverse section:			
Stem diameter (μ)	2300.0	1700.0	-26.1
Thickness of periderm (μ)	107.0	152.0	+42.1
No.of phellem layers	2.0	2.0	0.0
Thickness of phellem (μ)	53.0	80.0	+50.9
Thickness of phellogen (μ)	24.0	33.0	+37.5
Thickness of phelloderm (μ)	30.0	40.0	+33.3
Thickness of cortex (μ)	98.0	88.2	-10.0
No.of cortical layers	8.0	7.0	-12.5
Thickness of fiber strands (μ)	52.5	42.0	-20.0
Thickness of vascular cylinder(μ)	441.0	192.2	-56.4
Thickness of phloem tissue (μ)	63.0	50.4	-20.0
Thickness of xylem tissue (μ)	378.0	141.8	-62.5
Vessel diameter (μ)	42.0	19.1	-54.5
Thickness of pith (μ)	441.0	385.0	-12.7
Pith cell diameter (μ)	42.0	27.3	-35.0
Longitudinal section:			
Cortical cells: Length	27.3	15.2	-44.3
Number*	3.7	6.6	+78.4
Width	10.5	8.7	-17.1
Number*	9.5	11.5	+21.1
Pith cells: Length	40.6	23.7	-41.6
Number*	2.5	4.2	+68.0
Width	16.0	11.2	-30.0
Number*	6.3	8.9	+41.3

*Number of cells/100μ.

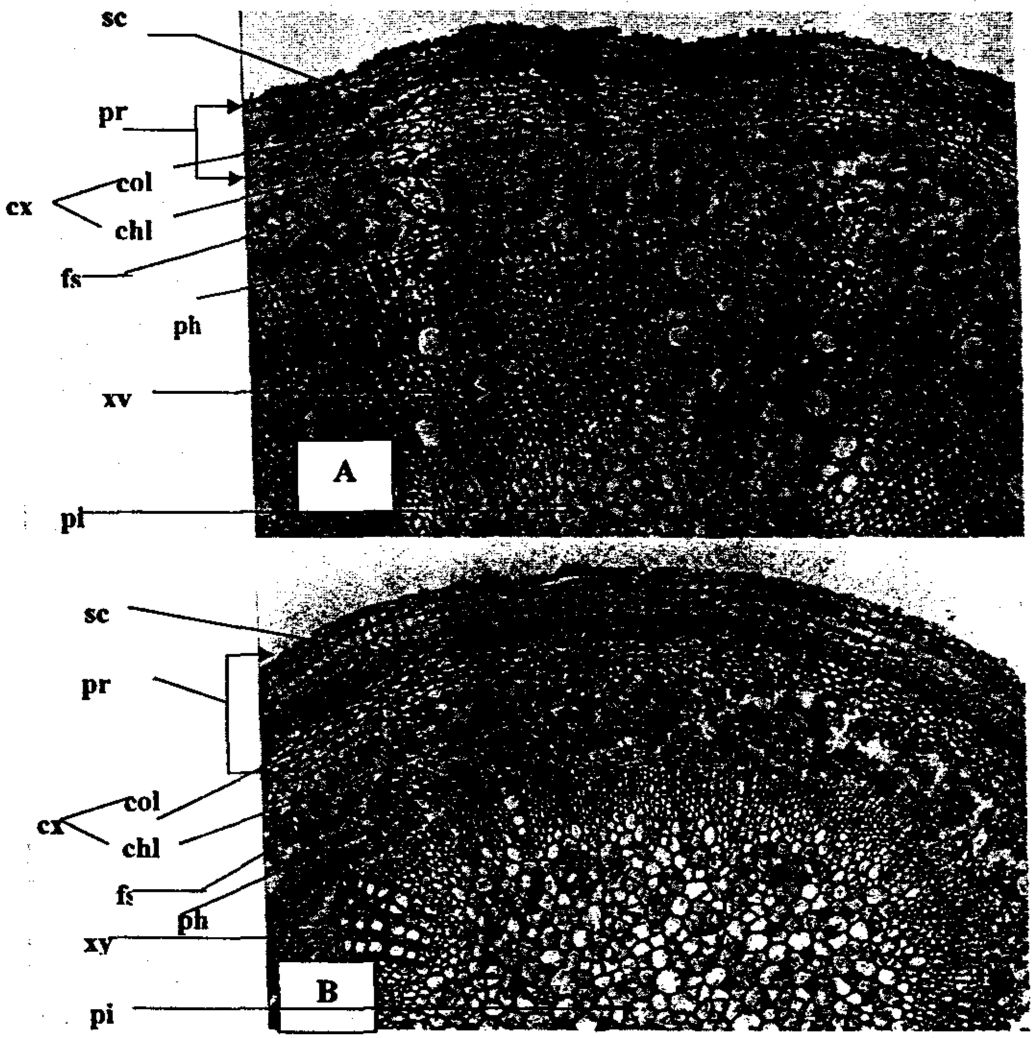

Fig. (1): Transverse sections through the fourth internode of the main stem of *Ficus benjamina*, as affected by cultar treatment at 250 ppm.

A) Untreated plant.
B) Treated plant with cultar at 250 ppm

Details: chl,chlorenchyma; col, collenchyma; cx, cortex; fs, fiber strands; ph, phloem; pi, pith; pr, periderm;sc, stone cells; xy, xylem. **(X 100)**

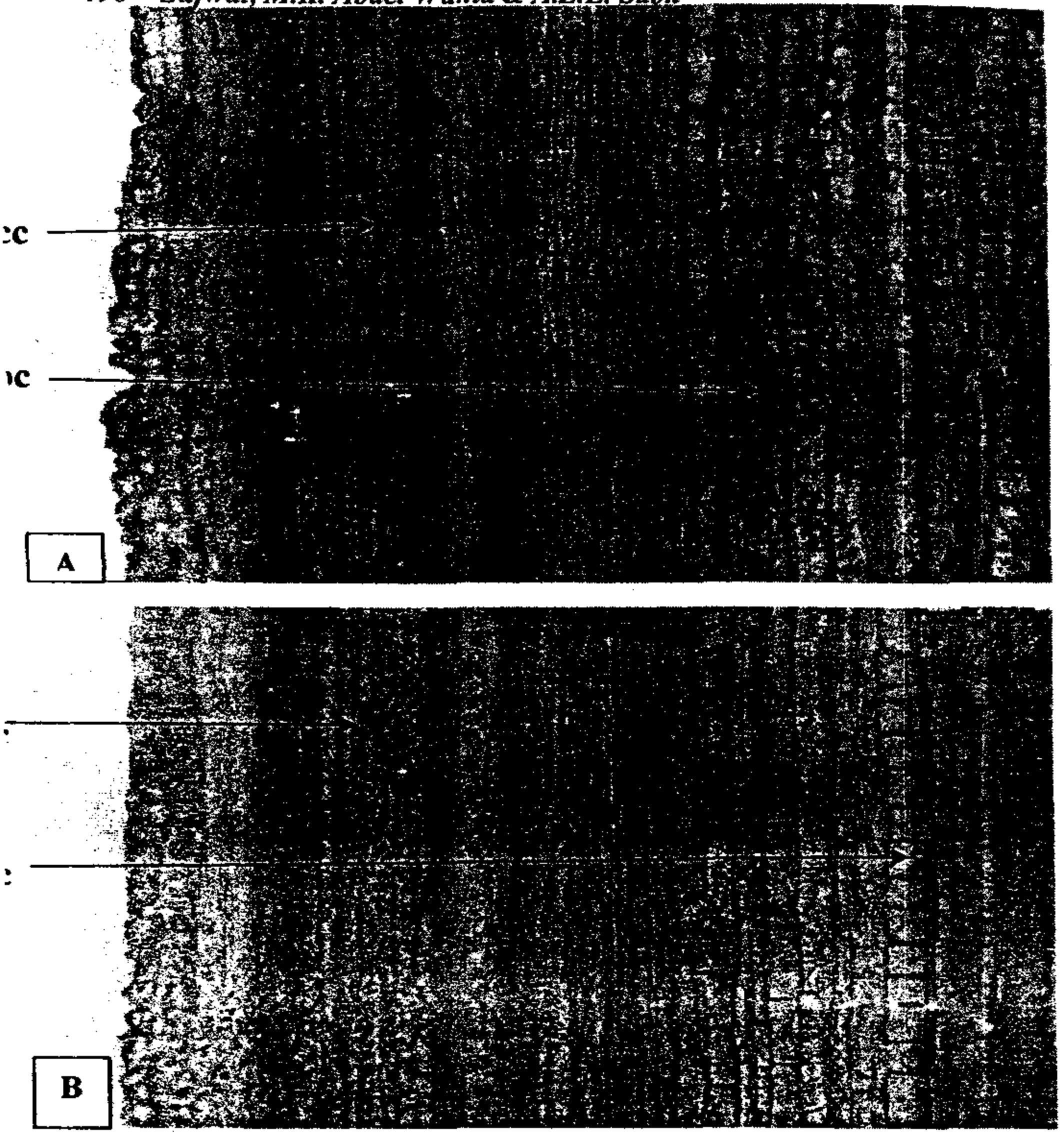

Fig. (2): Longitudinal sections through the fourth internode of the main stem of *Ficus benjamina*, as affected by cultar treatment at 250 ppm.
A) Untreated plant.
B) Treated plant with cultar at 250 ppm
Details: cc, cortical cells; pc, pith cells. (X 160)

2-Anatomy of the leaf petiole:

Microscopical counts and measurements of certain traits in transverse sections through the middle portion of leaf petiole on the fourth internode of the main stem are given in Table (6). Photomicrographs depict these leaf petioles are given in Fig. (3).

It is obvious that the dimensions of the leaf petiole in cross sections of plants treated with cultar (250 ppm) were less than those of control plants. The reduction percentages were 23.6 and 31.2% less than the control in length and width of leaf petiole, respectively. Thickness of epidermis and cuticle layer of treated plants decreased by 14.3 % and 40.0 %, respectively, relative to the control. The cortex of untreated plants consisted of 7 angular collenchymatous subepidermal layers followed by chlorenchyma cells of 7 layers. However, thickness of cortex of treated plants was reduced by 21.6 % less than the control due to the decrease of number of cell layers which amounted to 21.4 % below the control. Dimensions of the vascular cylinder decreased in length and in width by 5.7 and 16.7 %, respectively below the control. The vascular tissue consisted of a cylinder of xylem, accompanied externally by phloem. The vascular tissue was surrounded by a complete sheath of fibrous cells. Inspite of increasing number of vessels per petiole by 11.1% in treated plants as compared with the control, yet vessel diameter was decreased by 19.8 %. Regarding the pith dimensions, the treated plants decreased below the control by 41.2 % in length and 21.1% in width.

From the previous results, it is clear that the reduction in leaf petiole dimensions as a result to cultar treatment (250 ppm) was attributed mainly to the decrease in thickness of cuticle, epidermis, cortex, vascular cylinder and pith compared to the control plants.

Table (6): Averages of counts and measurements (in microns) of certain anatomical characters in transverse sections through the middle part of leaf petiole on the 4th node of the main stem of *Ficus benjamina*, as affected by cultar treatment at 250 ppm.(averages of 9 readings)

Character \ Treatment	Control	Cultar at 250 ppm	± % to control
Dimensions of petiole:			
Length (µ)	1155	882	-23.6
Width (µ)	1505	1036	-31.2
Thickness of cuticle layer (µ)	10.5	6.3	-40.0
Thickness of epidermis (µ)	14.7	12.6	-14.3
Thickness of cortex (µ)	357	280	-21.6
No. of cortical layers	14	11	-21.4
Dimensions of vascular cylinder:			
Length (µ)	490	462	-5.7
Width (µ)	840	700	-16.7
No. of vessels/petiole	108	120	+11.1
Vessel diameter (µ)	25.2	20.2	-19.8
Dimensions of pith:			
Length (µ)	238	140	-41.2
Width (µ)	532	420	-21.1

3- Anatomy of the leaf blade:

Results in Table (7) represent certain measurements and counts of microscopical features of the leaf blade on the fourth node of the main stem as affected by cultar treatment. Figure 4 shows cross sections in leaf blades of treated *Ficus benjamina* plants and the untreated control plants.

It is clear that, application of cultar on *Ficus benjamina* plants induced a decrease of 17.1 and 25.0 % in midvein and lamina thicknesses, respectively. However, thickness of multiple epidermis (3 layers) in the upper surface as well as multiple epidermis (2 layers) in the lower surface were decreased by 31.1 and 2.7 % less than the untreated control, respectively. In addition, relative to the control, thickness of both upper and lower epidermis was reduced by 11.1 and 7.7 %, respectively, as a result of cultar treatment. The hypodermal cells varied in size, as the length and width were decreased by 25.0 and 15.8%, respectively, in treated plants less than the control plants. In the meantime, plants treated

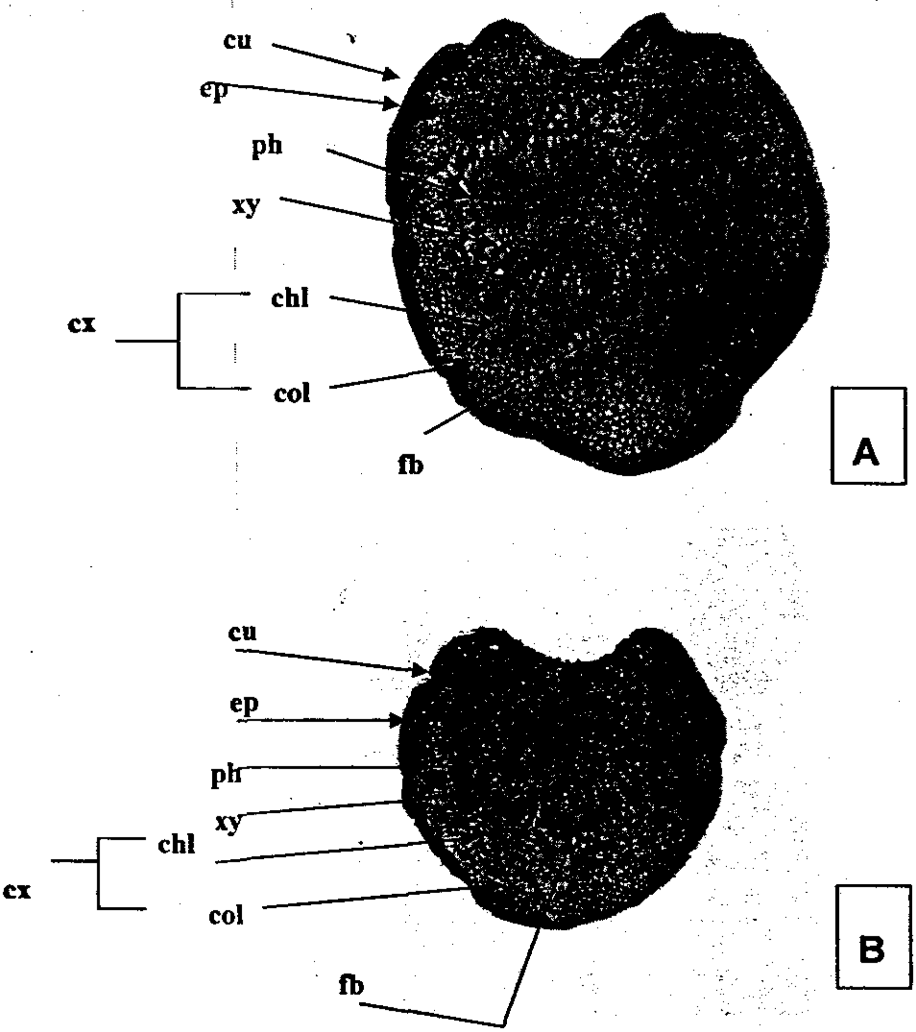

Fig. (3): Transverse sections through the leaf petiole on the fourth node of the main stem of *Ficus benjamina,* as affected by cultar treatment at 250 ppm.

A) Untreated plant.

B) Treated plant with cultar at 250 ppm.

Details: chl, chlorenchyma; col, collenchyma; cu, cuticle; cx, cortex; ep, epidermis; fb, fibers; ph, phloem; xy, xylem. (X 40) with cultar showed a remarkable decrease in thickness of palisade tissue beneath both upper (2 layers) and lower (1 layer) epidermis, as well as spongy tissue (4-5 layers) by 46.2, 25.0 and 29.4 %, respectively, compared with the untreated control. Dimensions of midvein bundle greatly differed in both treated and untreated plants, since length and width of midvein bundle of treated plants were decreased by 34.8 and 33.3 %, respectively, less than the control. Moreover, relative to the control, the treatment decreased numbers of both vessels and fibers of midvein bundle by 64.3 and 11.1 % as well as their diameters by 50.0 and 14.3 %, respectively.

Studying the stomata of the upper epidermis in the surface view (Table 7 and Figs. 5 and 6) clarified that, the number of stomata/mm^2 was larger in treated leaves by 50 % than the control leaves. However, both length and width of stomata in control leaves were larger than those in treated plants being 28.6 and 20.0 %, respectively, less than the control.

From the previous data, it could be concluded that application of cultar at 250 ppm on *Ficus benjamina* plants showed a considerable decrease in thickness of leaf lamina and midvein. This decrease in leaf lamina as a result of cultar treatment could be attributed to the decrease occurred in the thickness of both upper and lower multiple epidermis as well as thickness of mesophyll tissue (palisade and spongy) as a result of the decrease of cell sizes. Furthermore, vascular bundle dimensions were decreased due to the considerable reduction of number of vessels as well as vessel diameter. This matches with the thinner stem and leaf petiole of the same treatment.

The aforementioned results are in agreement with those obtained by Mansour (1989) on *Peperomia obtusfolia*, Sabbour (2002) on rice and Bai *et al.* (2004) on trees, while in contradiction with the results obtained by El-Sgai and El-Sayed (1999) on okra.

Table (7): Averages of counts and measurements (in microns) of certain anatomical characters in transverse sections through leaf blade on the 4th node of the main stem of *Ficus benjamina*, as affected by cultar treatment at 250 ppm.(averages of 9 readings)

Character \ Treatment	Control	Cultar at 250 ppm	± % to control
Thickness of midvein (µ)	490.0	406.0	-17.1
Thickness of lamina (µ)	280.0	210.0	-25.0
Thickness of upper epidermis (µ)	12.6	11.2	-11.1
Thickness of lower epidermis (µ)	9.1	8.4	-7.7
Thickness of multiple epidermis: In upper surface (µ)	126.0	86.8	-31.1
In lower surface (µ)	25.9	25.2	-2.7
No. of multiple epidermis layers:			
In upper surface	3.0	3.0	0.0
In lower surface	2.0	2.0	0.0
Dimensions of hypodermal cells: Length (µ)	100.8	75.6	-25.0
Width (µ)	79.8	67.2	-15.8
Thickness of palisade tissue: In upper epidermis (µ)	54.6	29.4	-46.2
In lower epidermis (µ)	16.8	12.6	-25.0
Thickness of spongy tissue (µ)	71.4	50.4	-29.4
No. of fibers/midvein bundle	126.0	112.0	-11.1
Fiber cell diameter (µ)	14.7	12.6	-14.3
Dimensions of midvein bundle: Length (µ)	322.0	210.0	-34.8
Width (µ)	378.0	252.0	-33.3
No. of vessels/midvein bundle	98.0	35.0	-64.3
Vessel diameter (µ)	25.2	12.6	-50.0
No. of stomata/mm^2	18.0	27.0	+50.0
Dimensions of stoma: Length (µ)	7.0	5.0	-28.6
Width (µ)	5.0	4.0	-20.0

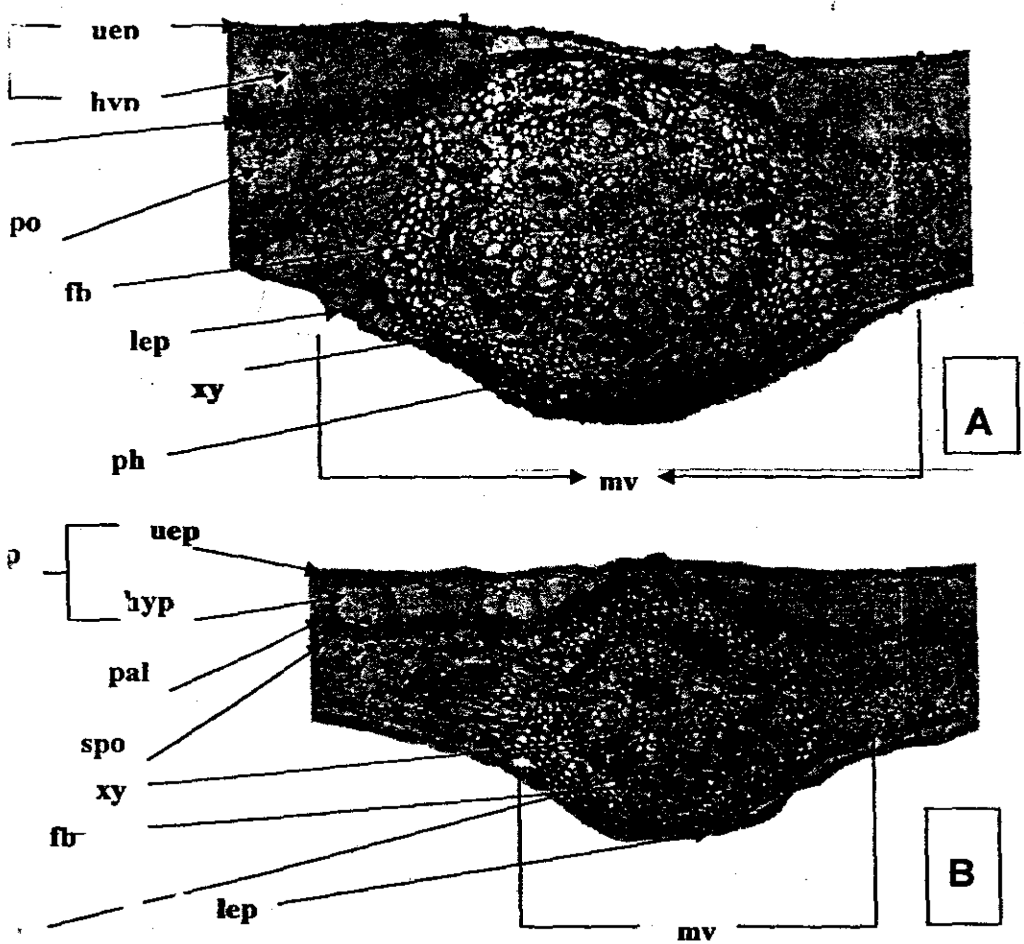

Fig. (4): Transverse sections through leaf blade on the fourth node of the main stem of *Ficus benjamina,* as affected by cultar treatment at 250 ppm.
A) Untreated plant.
B) Treated plant with cultar at 250 ppm.
Details: fb, fibers; hyp, hypodermis; lep, lower epidermis; mep, multiple epidermis; mv, midvein; pal, palisade tissue; ph, phloem; spo, spongy tissue; uep, upper epidermis; xy, xylem. (X 100)

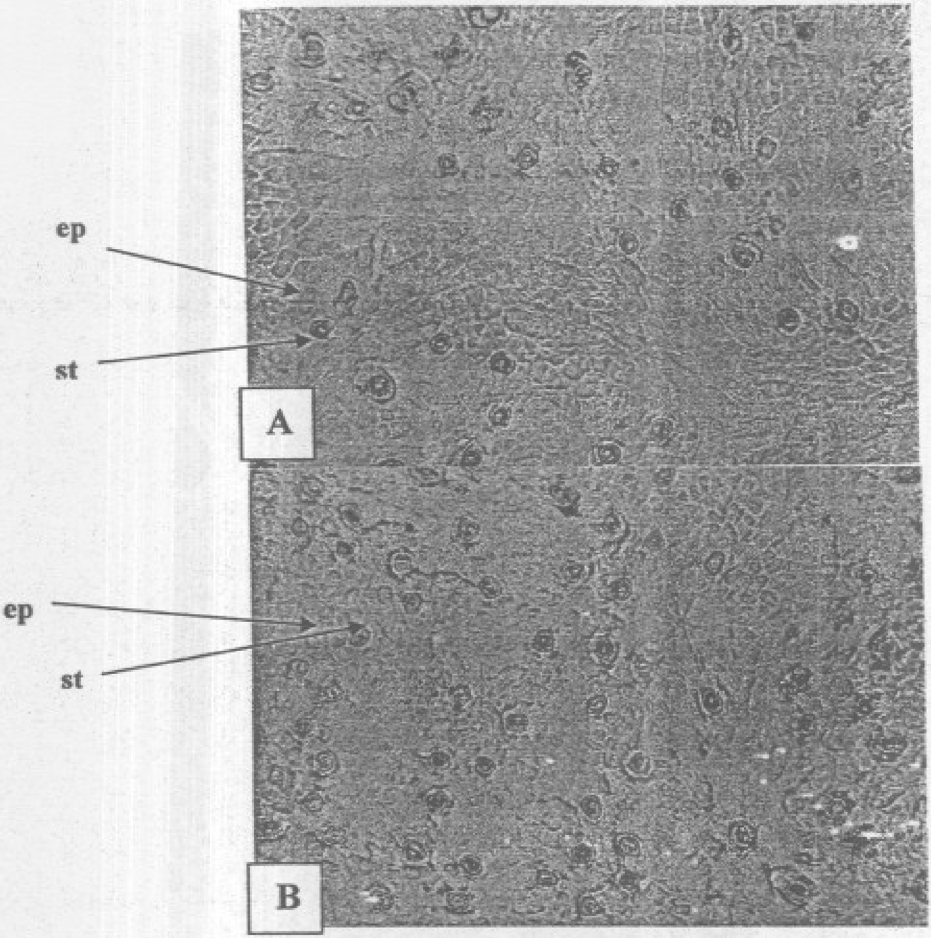

Fig. (5): Prints of the upper epidermis of leaf blade on the fourth node of the main stem of *Ficus benjamina*, as affected by cultar treatment at 250 ppm, showing the number of stomata in 1^2 millimeters.

A) Untreated plant.

B) Treated plant with cultar at 250 ppm.

Details: ep, epidermis; st, stoma. (X 160)

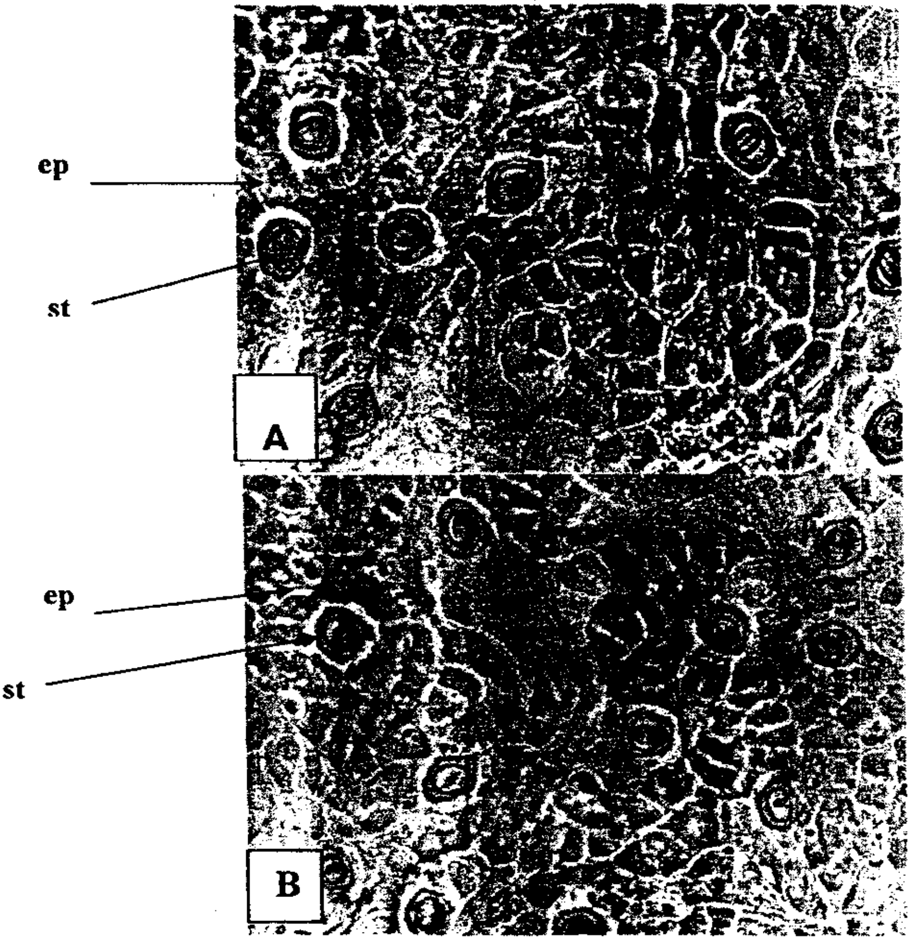

Fig. (6): Prints of the upper epidermis of leaf blade on the fourth node of the main stem of *Ficus benjamina*, as affected by cultar treatment at 250 ppm, showing the size of stomata.

A) Untreated plant.

B) Treated plant with cultar at 250 ppm.

Details: ep, epidermis; st, stoma. **(X 400)**

C- Main constituents:

1- Photosynthetic pigments:

Data shown in Table (8) revealed that chlorophyll (a), (b), chlorophylls (a + b) and carotenoides contents were affected by cultar treatments in both seasons. Their contents were decreased gradually as the concentration of the growth regulator was raised. The highest amounts of chlorophyll (a), (b), total chlorophylls and carotenoids were detected in leaves of the control plants. Treating the plants with cultar at 750 ppm led to the synthesis of the least amounts of chlorophyll (a), (b), total chlorophylls and carotenoids.

These results are in harmony with those obtained by Helal (1993) on *Euphorbia pulcherrima* who found that all pp-333 concentrations decreased the content of chlorophyll (a), (b) and carotenoids.

Table (8): Effect of cultar on photosynthetic pigments (mg / g fresh weight) in leaves of *Ficus benjamina* L. plant during the two seasons of 2003 / 2004 and 2004 / 2005.

Cultar conc.	Chlorophyll (a)	Chlorophyll (b)	Chlorophylls (a + b)	Carotenoids
	First season			
Control	1.18	0.62	1.80	0.80
250 ppm	0.89	0.44	1.33	0.60
500 ppm	0.84	0.41	1.25	0.59
750 ppm	0.83	0.41	1.24	0.57
L.S.D.0.05	0.03	0.02	0.04	0.02
Second season				
Control	1.37	0.75	2.12	0.93
250 ppm	1.04	0.53	1.57	0.73
500 ppm	0.96	0.48	1.44	0.66
750 ppm	0.94	0.45	1.39	0.59
L.S.D.0.05	0.03	0.03	0.06	0.05

2- Total carbohydrates percentage:

Table (9) showed the effect of cultar on total carbohydrates content in leaves, stem and branches of *Ficus benjamina* plant. Generally, data revealed that total carbohydrates content was increased with the lowest concentration of cultar, then tended to decrease as a result of increasing the rate of paclobutrazol. In both seasons, 250 ppm of cultar led to the highest accumulation of the total carbohydrates in leaves, stem and branches. The least carbohydrates percentage of leaves, stem and branches was found in the plants treated with the highest concentration of cultar (750 ppm), same as in photosynthetic pigments. These results are in accordance with those obtained by Ahmed (1997) on *Bougainvillea* Mrs. Butte, Helal and Khalil (1998) on geranium, Adham (2001) on *Althaea rosea* and Osman (2002) on *Nerium oleander* who stated that pp-333 treatments increased total carbohydrates of leaves and stems.

Table (9): Effect of cultar on total carbohydrates percentages in *Ficus benjamina* L. plant during the two seasons of 2003 / 2004 and 2004 / 2005.

Cultar conc.	Leaves		Stem and branches	
	1st season	2nd season	1st season	2nd season
Control	45.19	40.31	49.51	42.84
250 ppm	47.78	43.64	49.53	43.50
500 ppm	43.42	39.16	51.05	44.77
750 ppm	43.27	38.38	44.70	32.98
L.S.D.0.05	1.61	1.35	2.93	1.67

3- Nitrogen percentage:

The data on N % in leaves as shown in Table (10) indicated that the moderate concentration of cultar (500 ppm) was the most effective in the accumulation of nitrogen in leaves in both seasons, which led to the highest percentage of nitrogen. Treating the plants with the lowest concentration of cultar resulted in the least percentage of nitrogen in leaves. Concerning the stem and branches, the highest content of nitrogen in the two seasons was formed as a result of treating the plants with cultar at 250 ppm. While, the least percentage was found in the stem and branches of the plants received cultar at the rate of 750 ppm.

Table (10): Effect of cultar on nitrogen percentages in *Ficus benjamina* L. plant during the two seasons of 2003 / 2004 and 2004 / 2005.

Cultar conc.	Leaves		Stem and branches	
	1st season	2nd season	1st season	2nd season
Control	2.61	2.78	2.64	2.33
250 ppm	2.16	2.58	2.72	2.43
500 ppm	2.77	2.90	2.43	2.10
750 ppm	2.54	2.59	2.17	2.06
L.S.D.0.05	0.04	0.04	0.03	0.05

4- Phosphorus percentage:

Data in Table (11) indicated that, in the two seasons, phosphorus percentage was reduced in leaves as the plant was treated with cultar. The lowest percentage was obtained from 750 ppm of cultar. While, the highest content was detected in control plants, same as in photosynthetic pigments and total carbohydrates. In general, phosphorus percentage in leaves tended to decrease slightly as the concentration of cultar was increased. On the contrary, phosphorus percentage in the stem and branches had the opposite trend. A gradual increase in phosphorus percentage was observed as the rate of cultar was increased. The highest percentage of phosphorus was determined in the stem and branches of the plants received paclopotrazol at 750 ppm in both seasons. However, the control plants had the least percentage of phosphorus.

5- Potassium percentage:

Data presented in Table (11) pointed out that, in the two seasons, the highest content of potassium was found in the leaves of the plants treated with cultar at 750 ppm, whereas the least percentage was detected in the leaves of plants received cultar at 500 ppm. As for stem and branches, in the first season, control plants had the highest content of potassium, meanwhile cultar at 750 ppm resulted in the highest concentration of potassium in the second season. In both seasons, application of cultar at 250 ppm led to the lowest content of potassium in stem and branches.

The effect of paclopotrazol on N, P and K contents of different plants was observed by some investigators. Mansour

(1989) on *Peperomia obtusifolia*, El-Ghadban (1996) on *Pelargonium graveolens* and Helal and Khalil (1998) found that pacloputrazol treatments resulted in some increases in N, P and K percentage.

Table (11): Effect of cultar on phosphorus and potassium percentages in *Ficus benjamina* L. plant during the two seasons of 2003 / 2004 and 2004 / 2005.

Cultar conc.	Phosphorus %		Potassium %	
	Leaves	Stem and branches	Leaves	Stem and branches
	First season			
Control	0.42	0.34	2.70	3.63
250 ppm	0.33	0.37	2.00	1.27
500 ppm	0.30	0.45	1.88	1.43
750 ppm	0.27	0.47	2.76	2.68
L.S.D.0.05	0.02	0.03	0.03	0.04
Second season				
Control	0.33	0.32	2.61	2.45
250 ppm	0.32	0.32	1.98	1.28
500 ppm	0.29	0.36	1.74	1.44
750 ppm	0.28	0.43	2.71	2.70
L.S.D.0.05	0.03	0.04	0.03	0.07

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تقزيم نبات الفيكس بنجامينا بواسطة الباكلوبيوترازول

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أجرى هذا البحث داخل صوبة زجاجية في مشتل قسم بساتين الزينة – كلية الزراعة – جامعة القاهرة خلال الموسمين ٢٠٠٣ / ٢٠٠٤ و ٢٠٠٤ / ٢٠٠٥ فى أصص بلاستيك قطر ٣٠ سم مملوءة بخليط من سفاجنم بيت موس ورمل بنسبة ١ : ١ حجماً لدراسة تأثير التركيزات المختلفة من الباكلوبيوترازول (صفر ، ٢٥٠ ، ٥٠٠ ، ٧٥٠ جزء فى المليون) على النمو الخضرى والمحتوى الكيماوى والتركيب الداخلى لنبات الفيكس بنجامينا. أوضحت النتائج أن أقل تركيز من الباكلوبيوترازول (٢٥٠ جزء فى المليون) كان أفضل التركيزات للحصول على نباتات متقزمة مع نمو خضرى جذاب . كما أن اضافة الباكلوبيوترازول إلى النباتات أدى إلى استمرار تقزمها لأكثر من عام. والدراسة التشريحية لنباتات هذه المعاملة أوضحت أن تقزم أعضاء النبات المختلفة (ساق – عنق – ورقة) قد يعزى إلى نقص عدد طبقات الخلايا وسمك الأنسجة لتلك الأعضاء . بالإضافة إلى ذلك فقد زاد عدد الثغور / مم[2] من الورقة بينما قلت أبعاد الثغر فى النباتات المعاملة مقارنة بالكنترول .