

Effect of Paclobutrazol and Its Method of Application on The Growth of *Pentas lanceolata* Plants

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ABSTRACT: This study was carried out during the two successive seasons of 2013 and 2014 at Antoniades Research Branch, Horticulture Research Institute, A.R.C. Alexandria, Egypt. The experiment was carried out to investigate the effect of paclobutrazol (PBZ) at the concentrations of (30,60,90 and 120 mg/L) and its application method (drench and spray) on the growth, flowering and chemical composition of *Pentas lanceolata*, L. plants. The results showed that all the treatments caused a positive effect on the reduction of the vegetative growth of pentas plants and the treatment of 120 mg/L PBZ caused the highest significant reduction on most studied characters of vegetative growth. While there was insignificant effect after PBZ application at all concentrations on the flowering characteristics. For roots dry weight, the chlorophyll content and total carbohydrate content there was a significant increase after the application of PBZ at different concentrations. Drench application of PBZ was more effective than foliar application of in reduction of the most studied vegetative growth characters and increasing roots dry weight, the chlorophyll content and total carbohydrate content.

Key words: *Pentas lanceolata* L., paclobutrazol, soil Drench, foliar spray

INTRODUCTION

Growth retardants are commonly used in floriculture for height control and increasing the number of lateral shoots or suppressing the growth of shoots developing beneath the flower, resulting in a larger number of inflorescences (Whealy *et al.*, 1988, Keever and Foster 1989).

Plant growers use chemical growth retardants to produce quality plants that can be held in greenhouse if needed, shipped properly, look appealing in the stores and grow out well for the end consumers (Sanchita, 2015).

Paclobutrazol is a plant growth regulator which inhibits the gibberellin biosynthesis or action. It is very effective for dwarfing a wide range of crops including tulips (Lever *et al.*, 1982, Menhenett and Hanks 1982). It is used primarily for reducing the extension of shoot growth, to increase the root growth, produce uniform compact plants, with enhancement of foliage colour and flowering in certain species. The response of plants to paclobutrazol applications differs depending on the time of application, method of application, concentration and plant species (Tsegaw *et al.*, 2005). It is used on ornamental plants grown in containers in nurseries, green houses, shade houses and interior scape in the crops like azaleas, hibiscus, poinsettias, chrysanthemum, and roses. It is mostly applied in the form of drench or spray (Sanchita, 2015).

Pentas lanceolata L. is a common plant, originating from tropical East Africa to Arabia. The most widely used names are "Egyptian Star Cluster" or "Pentas". As a decorative plant, it has been spread all over the tropics and subtropics. The flowers can be white, pink, purple, or red. This species belongs to the family Rubiaceae (Mongrand *et al.*, 2005).

The aim of this work was to study the effect of paclobutrazol and its application methods on vegetative growth, flowering and chemical composition of *Pentas lanceolata*.L.

MATERIALS AND METHODS

The present investigation was carried out during the two successive seasons of 2013 and 2014 at Antoniadis Research Branch, Horticulture Research Institute, A.R.C., Alexandria.

Stem cuttings of *Pentas lanceolata* (semi-hard wood cuttings) with an average length of 15-17 cm were planted in plastic pots of 10 cm diameter using a mixture of sand and clay soils at ratio of (1:1 by volume) on 15th March 2013 and 1st April 2014 in the two seasons respectively. After six weeks, each rooted cutting was transplanted in 20 cm clay pots containing peat moss, clay and sand (1:1:1 v/v). The plants were pinched to the height of 20 cm. and two lateral shoots were left on each plant, while all other shoots or breaks were removed.

Five foliar treatments of paclobutrazol (PBZ) at concentrations of 0, 30, 60, 90 and 120 mg/L were applied till run off point at 20ml of PBZ per plant. The top of the pot was covered with plastic to keep the medium out of growth retardant contact, all treatments were applied using a hand sprayer.

Five drench treatment of PBZ at the same concentrations were also applied 7 days after of final transplanting. No water was applied for two days before the drenching. Each experimental unit received 90 ml of PBZ solutions. The control plants were sprayed or drenched with water only.

The requirement of plants for fertilization was covered by the addition of NPK chemical fertilization 19-19-19 at the rate of 2.5 g/pot. Each fertilization dose was repeated at 21 days intervals.

The layout of the experiment was randomized complete block design in a factorial experiment, containing three replicates. The experiment contained 10 different treatments (5 PBZ X 2 methods).

Three pots were used as an experimental unit for each treatment in each replicate. The data were subjected to statistical analysis of variance and the means were compared using the "least significant difference (L.S.D)" test at the 5% level of probability according to (Snedecor and Cochran, 1989).

The following data were recorded; the vegetative growth parameters including plant height (cm), stem diameter (cm), number of branches /plant, number of leaves/ plant, leaves dry weight (g), stem dry weight (g) and leaf area (cm²), roots dry weight (g), The flowering characteristics, included the time taken to showing color stage from planting date (day), flowers longevity (days) as a day from the showing color stage to fading and roots dry weight (g), Chemical analysis of fresh leaf samples at showing coloring stage was conducted to determine their leaves total content of chlorophyll (a and b) (mg/g fresh weight) as described by Moran (1982). Also, total carbohydrate content in dried leaf samples was determined according to Dubios *et al.*(1956) in the second season.

RESULTS

Vegetative growth characteristics

1. Plant height (cm)

Data in Table (1) showed that raising the PBZ concentration caused a significant reduction in plant height. The highest significant reduction was obtained from the concentration of 120 mg/L PBZ which gave (43.85 and 42.79 cm) in the first and second seasons, respectively. Table (1) also clarified that drench application of PBZ was more effective in plant height reduction. As for the effect of the combinations of PBZ and application method the highest significant decrease in plant height was obtained from the drench application of 120 mg/L PBZ (24.09 % and 30.77%) in the first and second seasons respectively.

2. Stem diameter (cm)

The data recorded in Table (1) showed that stem diameter of treated plants with different concentrations of PBZ decreased significantly. The thinnest stem was obtained from the treatments (90 and 120 mg/L) in the two seasons. Table (1) also clarified that there was insignificant difference between the two PBZ application methods. Concerning the interaction effect between PBZ concentration and application method the drench application of 120 mg/L PBZ caused the thinnest stem which recorded (0.42 cm) in both seasons.

3. Number of branches per plant

Results presented in Table (1) showed that there was significant difference between the concentrations of PBZ. The treatment 60 mg/L caused the highest significant increase in the number of branches per plant (13.70 and 14.00) ,while the treatment 120 mg/L PBZ caused the lowest significant number of branches (11.37 and 10.67) in the first and second seasons, respectively . With respect to the effect of application method, the table showed that soil drench caused a significant decrease in the number of branches per plant in the first season, while in the second one there was insignificant difference between the two application methods. Concerning the interaction effect between application method and PBZ concentrations, the lowest significant number of branches was recorded after the treatment 90 and 120 mg/L soil drench (8.56 and 9.17) in the first season and the treatment 90 mg/L soil drench (8.39) in the second one.

Table (1). Average of plant height (cm), stem diameter (cm) and number of branches /plant of *Pentas lanceolata* plants as influenced by paclobutrazol concentrations (C) , Method of application (M) and their interaction in the two seasons of 2013 and 2014.

Treatments		Plant height (cm)		Stem diameter (cm)		Number of branches / plant	
Method of application	Concentration (mg/L)	2013	2014	2013	2014	2013	2014
Drench	0	51.15	52.72	0.65	0.64	12.00	11.50
	30	46.93	48.04	0.60	0.59	13.20	12.67
	60	45.33	45.89	0.60	0.61	14.50	14.67
	90	42.34	44.44	0.50	0.48	8.56	8.39
	120	38.83	36.50	0.42	0.42	9.17	8.67
	Average of drench method		44.92	45.52	0.55	0.55	11.48
Spray	0	52.83	55.28	0.64	0.56	11.56	12.00
	30	49.83	53.11	0.56	0.55	11.72	12.33
	60	50.77	51.56	0.54	0.54	12.89	13.33
	90	48.38	50.89	0.45	0.48	16.44	15.00
	120	48.86	49.07	0.52	0.54	13.56	12.67
	Average of spray method		50.14	51.98	0.54	0.53	13.23
Average of application methods	0	51.99	54.00	0.65	0.60	11.78	11.75
	30	48.38	50.58	0.58	0.57	12.46	12.50
	60	48.05	48.39	0.57	0.58	13.70	14.00
	90	45.36	47.67	0.48	0.48	12.50	11.70
	120	43.85	42.79	0.51	0.48	11.37	10.67
L.S.D. at 0.05	Method of application (M)	0.95	0.97	N.S	N.S.	0.95	N.S.
	Concentration (C)	1.50	1.53	0.053	0.047	1.51	0.05
	M × C	2.13	2.17	0.074	0.067	2.14	0.07

4. Number of leaves per plant

Data in Table (2) showed that the highest significant decrease in leaves per plant was obtained from the concentration 120 mg/L which gave (134.75 and 132.72) in the first and second seasons respectively. The table also clarified that foliar spray application of PBZ caused a significant decrease in number of leaves per plant. For the interaction effect of application method and PBZ concentration the treatment 120 mg/ L PBZ as drench or foliar spray caused the lowest significant number of leaves per plant (136.5 and 133.11) and (133.00 and 132.33) in the first and second seasons respectively.

5. Leaves dry weight (g)

It is clear from Table (2) that the treatments 90 and 120 mg/L PBZ resulted in the highest significant decrease in leaves dry weight which recorded (7.20 ,6.43 and 6.46 ,6.24 g) in the first and second seasons respectively. The table showed that drench application of PBZ was more effective in reduction of leaves dry weight. For the effect of different combination of application method and PBZ concentration the drench application of 90 and 120 mg/L PBZ resulted in significant decrease of leaves dry weight which were (28.67 % , 23.58%) and (27.04% , 24.61 %) less than the control in the first and second seasons respectively .

6. Stem dry weight (g)

Table (2) showed that the treatment 30 mg/L PBZ resulted in the highest significant decrease in stem dry weight which recorded (10.72 and 8.37 g) for dry weight in the first and second seasons respectively. The table also cleared that foliar spray application of PBZ was more effective in reduction of stem dry weight. For the effect of different combination of application method and PBZ concentration the lightest stem dry weight (8.90 and 6.12 g) in the first and second seasons respectively were obtained from foliar spray of 30 mg/L PBZ.

Table (2). Average of number of leaves /plant, leaves dry weight (g) and stem dry weight (g) of *Pentas lanceolata* plants as influenced by Paclobutrazol concentrations (C) , Method of application (M) and their interaction in the two seasons of 2013 and 2014.

Treatments		Number of leaves/ plant		Leaves dry weight (g)		Stem dry weight (g)	
Method of application	Concentration (mg/L)	2013	2014	2013	2014	2013	2014
Drench	0	181.00	174.00	9.95	8.32	12.35	10.40
	30	184.10	181.17	8.32	7.51	12.53	10.62
	60	199.60	194.11	8.18	6.64	17.30	12.39
	90	163.20	151.00	5.39	5.36	14.53	11.29
	120	136.50	133.11	4.58	4.97	13.06	10.41
Average of drench method		173.00	167.00	7.28	6.56	13.96	11.02
Spray	0	180.30	172.33	10.19	8.29	12.64	10.49
	30	171.00	162.83	9.10	8.14	8.90	6.12
	60	152.30	150.15	9.06	7.90	9.28	6.19
	90	144.70	142.33	9.01	7.55	9.83	7.54
	120	133.00	132.33	8.28	7.51	9.89	8.56
Average of spray method		156.00	152.00	9.13	7.88	10.11	7.78
Average of application methods	0	180.65	173.17	10.07	8.31	12.50	10.45
	30	177.55	172.00	8.71	7.83	10.72	8.37
	60	175.95	172.13	8.62	7.27	13.29	9.29
	90	153.95	146.67	7.20	6.46	12.18	9.42
	120	134.75	132.72	6.43	6.24	11.48	9.49
L.S.D. at 0.05	Method of application (M)	2.78	1.74	0.58	0.31	0.51	0.44
	Concentration (C)	4.39	2.75	0.91	0.48	0.81	0.69
	M × C	6.21	3.89	1.29	0.68	1.14	0.98

7. Leaf area /plant (cm²)

Table (3) showed that the treatments 90 and 120 mg/L PBZ (1812.46 and 1920.40 cm²) in the first season and the treatment 120 mg/L (1662.06 cm²) in the second season caused the highest significant reduction in leaf area. The soil drench of PBZ was more effective in reduction of leaf area. Concerning the interaction between the application method and PBZ concentrations the Table cleared that the treatment 120 mg/L as a soil drench caused the least leaf area which recorded (1264.42 and 1226.65 cm²) in the first and second seasons respectively.

Root characteristics

1. Roots dry weight

Table (3) cleared that raising the PBZ concentrations caused a significant increase in roots dry weight. The highest significant root dry weight was obtained from the concentrations of 90 and 120 mg/L PBZ which gave (10.58 and 10.68 g) in the first season and (8.90 and 9.53g) in the second one. The table also cleared that drench application of PBZ was more effective in increasing roots dry weight. Concerning the effect of the different combination of application method and PBZ concentration the table showed that the drench application of PBZ at 90 and 120 mg/L led to a significant increase of root dry weight which were (95.02% and 92.46 %) in the first season and (61.97 % and 73.62%) in the second one .

Flowering characteristics

Concerning the flowering date (days) and flowers longevity (days), Table (4) showed that there were insignificant difference between treatments.

Table (3). Average of leaf area (cm²) and roots dry weight (g) of *Pentas lanceolata* plants as influenced by paclobutrazol concentrations (C), Method of application (M) and their interaction in the two seasons of 2013 and 2014.

Treatments		Leaf area (cm ²)		Roots dry weight (g)	
Method of application	Concentration (mg/L)	2013	2014	2013	2014
Drench	0	2769.72	2648.58	6.23	6.18
	30	1480.83	1960.67	8.61	7.91
	60	1562.69	1862.06	10.73	8.62
	90	1312.95	1792.52	12.15	10.01
	120	1264.42	1226.65	11.99	10.73
Average of drench method		1678.12	1898.10	9.94	8.69
Spray	0	2693.54	2617.08	6.71	6.09
	30	2482.26	2432.64	8.00	7.40
	60	2604.74	2054.34	8.16	7.43
	90	2311.96	2188.21	9.01	7.78
	120	2576.37	2097.47	9.36	8.33
Average of spray method		2533.77	2277.95	8.25	7.41
Average of application methods	0	2731.63	2632.83	6.47	6.14
	30	1981.55	2196.66	8.31	7.66
	60	2083.72	1958.20	9.45	8.03
	90	1812.46	1990.37	10.58	8.90
	120	1920.40	1662.06	10.68	9.53
L.S.D. at 0.05	Method of application (M)	133.15	131.16	0.49	0.41
	Concentration (C)	210.53	207.39	0.77	0.65
	M × C	297.74	293.29	1.09	0.92

Table (4). Average of flowering date (days) and flowers longevity (days) of *Pentas lanceolata* plants as influenced by paclobutrazol concentrations (C), Method of application (M) and their interaction in the two seasons of 2013 and 2014.

Treatments		flowering date (days)		flowers longevity (days)	
Method of application	Concentration (mg/L)	2013	2014	2013	2014
Drench	0	274.22	284.89	36.13	32.11
	30	275.34	299.1	35.63	24.89
	60	276.2	297.89	41.77	29.45
	90	281.33	293.67	34.67	32.00
	120	281.11	291.67	33.90	36.67
Average of drench method		277.64	293.45	36.42	31.02
Spray	0	272.89	285.22	38.11	31.44
	30	275.00	293.00	39.03	26.67
	60	277.11	294.11	43.20	29.89
	90	277.78	300.89	39.57	27.11
	120	280.78	300.44	37.20	25.56
Average of spray method		276.71	294.73	39.42	28.13
Average of application methods	0	273.56	285.06	37.12	31.78
	30	275.17	296.06	37.33	25.78
	60	276.67	296.00	42.49	29.67
	90	279.56	297.28	37.12	29.56
	120	280.95	296.06	35.55	31.12
L.S.D. at 0.05	Method of application (M)	N.S	N.S	N.S	N.S
	Concentration (C)	N.S	N.S	N.S	N.S
	M × C	N.S	N.S	N.S	N.S

Chemical composition

1. Total chlorophyll content (mg/g fresh weight)

Data represented in Table (5) cleared that there was a significant increase after the application of different PBZ concentrations, the treatments 60,90 and 120 mg/L resulted in the highest increase in total chlorophyll content (32.19 , 32.51 and 33.05 mg/g) in the first season and in the second one the treatment 90 mg/L caused the highest increase in total chlorophyll (35.24 mg/g).Drench application of PBZ was more effective in increasing the total chlorophyll content in both seasons . Concerning the effect of the interaction between the application method and PBZ concentration Table (6) showed that the highest chlorophyll content (83.58 mg/g) was obtained after the soil drench of 120 mg/L PBZ in the first season and soil drench of 90 mg/L PBZ in the second one (40.01 mg/g) .

2. Total carbohydrate content (mg/g dry weight of leaves)

Data in Table (5) showed that the highest significant increase in total carbohydrate content was obtained after the treatment 90 mg/L PBZ which recorded (16.94 mg/g) in the second season. Concerning the application method soil drench of PBZ was more effective in increasing total carbohydrate content. For the effect of different combination of application method and PBZ concentration Table (6) showed that were insignificant different between treatments.

Leaves distortions

Figure (1) illustrated that there was some leaves distortion after the treatment of 120 mg/L PBZ in both foliar spray and soil drench application method.

Table (5). Average of total Chlorophyll (mg/g fresh weight) in the two seasons of 2013 and 2014 and total Carbohydrate (mg/g dry weight of leaves) in the season of 2014 of *Pentas lanceolata* plants as influenced by paclobutrazol concentrations (C) , Method of application (M) and their interaction in the two seasons of 2013 and 2014.

Treatments		Total Chlorophyll (mg/g fresh weight)		Total Carbohydrate (mg/g dry weight of leaves)
Method of application	Concentration (mg/L)	2013	2014	2014
Drench	0	24.57	26.65	15.35
	30	27.50	29.28	16.02
	60	35.62	33.00	16.17
	90	34.49	40.01	17.81
	120	38.58	34.39	16.03
Average of drench method		32.15	32.67	16.28
Spray	0	24.54	25.92	14.43
	30	25.09	28.78	16.13
	60	28.75	30.16	16.23
	90	30.52	30.47	16.07
	120	27.52	28.89	15.63
Average of spray method		27.28	28.84	15.70
Average of application methods	0	24.56	26.29	14.89
	30	26.30	29.03	16.08
	60	32.19	31.58	16.20
	90	32.51	35.24	16.94
	120	33.05	31.64	15.83
L.S.D. at 0.05	Method of application (M)	0.80	0.87	0.92
	Concentration (C)	1.27	1.38	1.46
	M × C	1.79	1.95	N.S

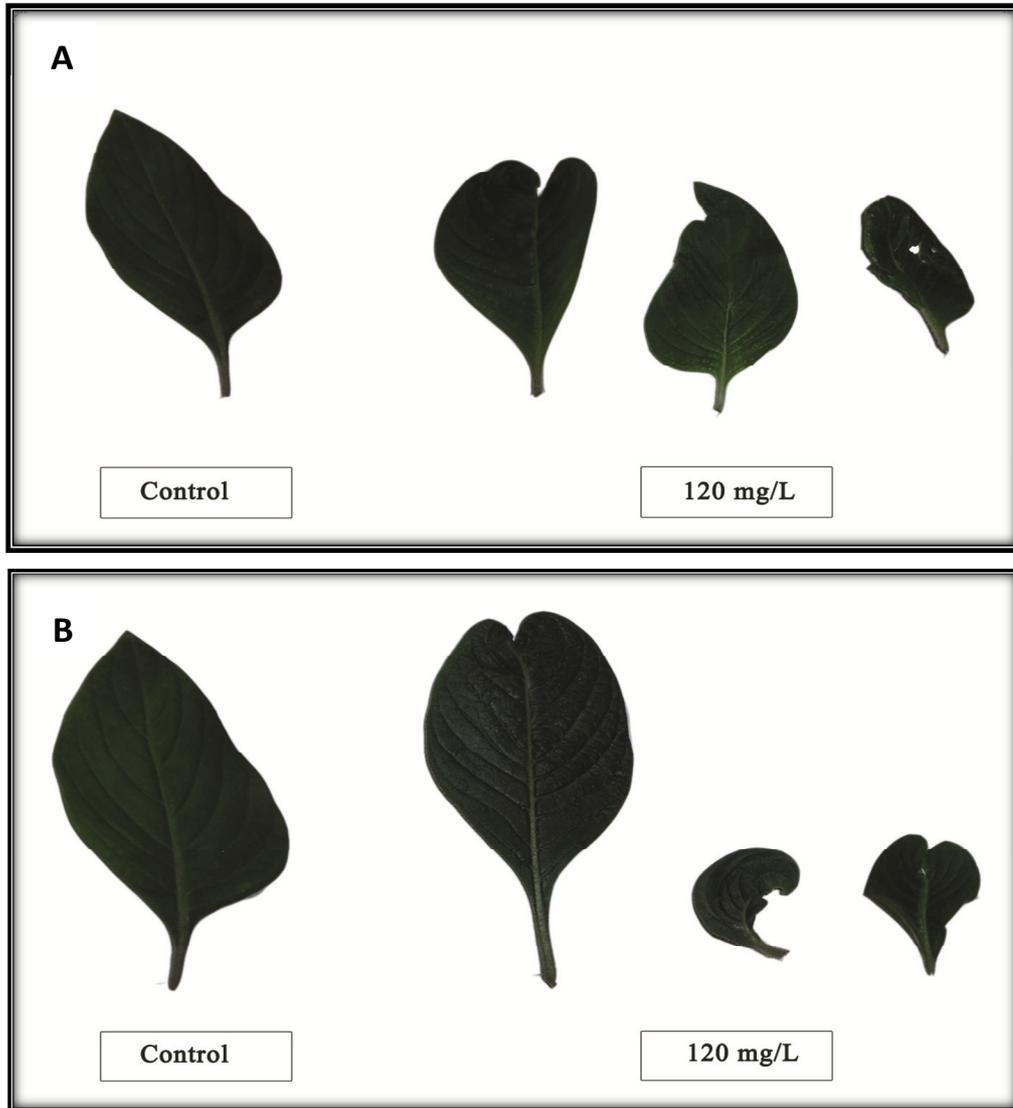


Figure (1). Leaves distortion after the treatment of 120 mg/L PBZ (A- drench application) and (B- foliar spray)

DISCUSSION

The present study showed that the high dose of PBZ caused a significant reduction in most studied vegetative growth parameters. This reduction may be due to fact that paclobutrazol inhibits gibberellins (GAs) biosynthesis in plant (Rademacher, 2000 and Sponzel, 1995) and hence, reduces cell elongation and retards the plant growth. The reduction in vegetative growth parameters is in agreement with the results obtained by Lenzi *et al.* (2015) who found that PBZ treatments caused a significant reduction of plant height of four cultivars of *Dianthus barbatus* x *chinesis*. Also, Ahmad (2012) mentioned that PBZ treatments reduced plant height and leaf area of *Hibiscus rosa-sinensis* plants and Adam and Božena (2005) on rhododendron and azalea shoot length.

There was a significant increase in roots dry weight after the treatment of paclobutrazol. This increase may be explained on the rationale that its antagonize of GA biosynthesis or activity (GA is normally inhibitory to rooting) , (Davis and Sankhla, 1989) or an indirect effect resulting from shoot growth modification and a shift in carbohydrate allocation to the roots (Chaney, 2005) . This result is in harmony with those obtained by Chaturvedi, *et al.* (2009) on *Saussurea costus*.

Concerning the flowering parameters, the study showed that all the treatments caused insignificant difference compared to control .These results are in agreement with those obtained by Lenzi *et al.* (2015) on four cultivars of *Dianthus barbatus* x *chinesis* .

The increase in chlorophyll content by PBZ treatment could be explained on the basis of two facts: first, that the leaves of both treated and untreated plants may contain the same number of cells, but because the cells in treated ones are generally smaller, the chlorophyll is more concentrated inside the reduced cell volume. Second, there is also evidence that the amount of chlorophyll is actually increased due to increase in phytyl (an essential part of chlorophyll molecule), which is synthesized via the same terpenoid pathway as gibberellins (Dalziel and Lawrence, 1984). The obtained results are in agreement with those obtained by Lenzi *et al.* (2015) who mentioned that PBZ treatments enhanced leaf colour of four cultivars of *Dianthus barbatus* x *chinesis*. And Ahmad (2012) who found that PBZ treatments increased chlorophyll content of *Hibiscus rosa-sinensis* .

The increase in carbohydrate content after the PBZ treatments may be due to the increase in chlorophyll content which leads to a consequent increase in total carbohydrates. This result is in harmony with Azza *et al.* (2014) on *Schefflera arboricola* plants.

There was some leaf deformation after the treatment of 120 mg/L PBZ in both foliar spray or soil drench application method, this leaf deformation can be credited to the inhibitory impact of triazoles on gibberellin biosynthesis, which may cause harm or splitting of leaf primordia , unpredictable cell division or cell extension Mona (2001). These results are in agreement with those obtained by Matsoukis *et al.* (2001) who noticed some leaf distortion on *Lantana camara* plants treated with high concentrations of paclobutrazol and Joustra (1989) who found that paclobutrazol concentrations above approximately 125-250 mg/L can cause leaf deformation on some rhododendron cultivars.

The difference in the suppression of growth with the method of application may be due to the difference in uptake of paclobutrazol by either the root or foliage and also the ability of the plant growth regulator to translocate in xylem and phloem (Keever *et al.*, 1990). The primary translocation of paclobutrazol occurs through the xylem. Drench application of paclobutrazol was more effective maybe because of the rapid uptake of the plant growth regulator by the roots as the translocation occurs through the xylem quickly reducing the activity of gibberellic acid resulting in reduced stem length. Roots

have fewer barriers that prevent entry of plant growth regulators. Foliar applied plant growth regulators first accumulate in the leaves and moves to the phloem and translocate into the xylem and takes more time before they become effective (Barrett and Bartuska, 1982). These results are in harmony with those obtained by Cramer and Brigden (1998) on *Mussaenda erythrophylla* potted plants

Conclusion

In conclusion, *Pentas lanceolata* can be used as a flowering pot plant since its height can be controlled by PBZ treatment. Paclobutrazol was applied as soil drench is considered more effective than foliar spray in reducing height. While the 120 mg/L of PBZ was more effective in producing short plants, it caused some leaf deformations. The treatment 90 mg/L was more effective in producing short and compact plants with no side effects on the plant appearance (Figure 2).

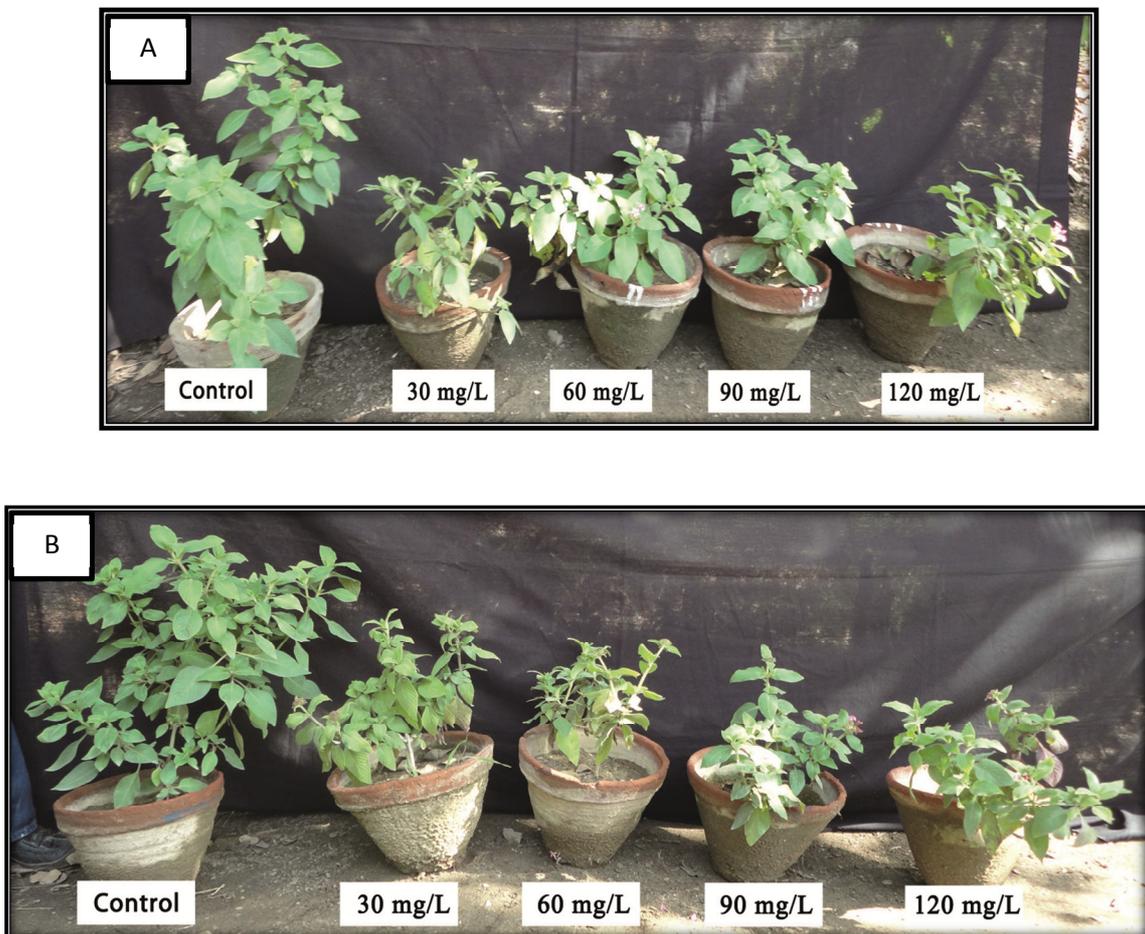


Figure (2). Effect of different paclobutrazol concentrations on the growth of *Pentas lanceolata* plants (A-drench application) and (B-foliar spray).

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الملخص العربي

تأثير الباكلوبيوترازول وطريقة اضافته على نباتات البنتنس

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فرع بحوث نباتات الزينة بأنطونيداس - الإسكندرية - معهد بحوث البساتين - مركز البحوث الزراعية

أجريت هذه الدراسة خلال الموسمين الزراعيين ٢٠١٣ و ٢٠١٤ بفرع بحوث الزينة وتنسيق الحدائق بحديقة انطونيداس التابع لمعهد بحوث البساتين- مركز البحوث الزراعية - وزارة الزراعة- الاسكندرية- مصر. وذلك لدراسة تأثير استخدام الباكلوبيوترازول بتركيزات (٣٠ ، ٦٠ ، ٩٠ و ١٢٠ ملجم / لتر) وطريقة إضافتها (رشاً على الأوراق أو إضافة إلى التربة) على النمو الخضري والزهرى والمحتوى الكيماوي لنبات البنتنس . وأوضحت النتائج أن جميع المعاملات أدت إلى نقص في النمو الخضري لنبات البنتنس وأن المعاملة ١٢٠ ملجم / لتر أدت إلى أكبر نقص معنوي في معظم صفات النمو الخضري المدروسة بينما كان تأثير جميع معاملات

الباكلوبيوترازول غير معنوي على الصفات الزهرية المدروسة أما بالنسبة للوزن الجاف للجذور ومحتوى النبات من الكلورفيل والكريوهيدرات الكلية اظهرت النتائج أن جميع المعاملات أدت إلى زيادة معنوية . اما بالنسبة لطريقة الإضافة اتضح ان الإضافة عن طريق التربة كان اكثر كفاءة من الرش على الأوراق في تقليل النمو الخضري وزيادة وزن الجذور ومحتوى النبات من الكلورفيل والكريوهيدرات.

الكلمات الكاشفة : نبات البنتنس - الباكلوبيوترازول - الإضافة للتربة - الإضافة بالرش على الأوراق