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Improving Vegetative and Flowering Characteristics of Kalanchoe by Using some Plant Growth Retardants

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ABSTRACT

The objective of this investigation was to study the effects of cycocel (CCC) and paclobutrazol (PBZ) on *Kalanchoe blossfeldiana*, L. to produce plants more compact, shorter, with a plurality of branches and inflorescences, flowering earlier, and to be more suitable as a pot plant. Different concentrations of CCC at 1000, 2000, and 3000 ppm and PBZ 50, 100, and 150 ppm were applied as foliar spray for once (after 45 days) or twice (after 45 and 60 days from planting). All treated plants were shorter with profuse branches specially the ones which have been treated with PBZ at 150 ppm twice (6.00 branches/ plant), and by the same treatment achieved the maximum number of inflorescences as it recorded 5.00 inflorescences/ plant. Sprayed plants with PBZ at 150 ppm twice gave the minimum number (125.33) of days to flowering. The total chlorophyll and carbohydrates content were increased in all sprayed plants, as it was 0.679 mg/ g FW for chlorophyll (PBZ 100 ppm twice) and 207.07 mg/ g DW for carbohydrates (PBZ 150 ppm twice). For compressed Kalanchoe plants with dark green leaves, abundant branches, abundant blooms and early blooms, paclobutrazol may be recommended at 150 ppm twice.

Keywords: Cycocel, Paclobutrazol, branches, compressed Kalanchoe , foliar spray.

INTRODUCTION

Kalanchoe is a genus of about 125 species of tropical, succulent flowering plants in the family *Crassulaceae*, mainly native to Madagascar and tropical Africa. Most are shrubs or perennial herbaceous plants, but a few are annual or biennial. The largest, *Kalanchoe beharensis* from Madagascar, can reach 6 m tall, but most species are less than 1 m tall. Plant height in many varieties of the Kalanchoe is an obstacle in the diversity of their decorative purpose, so it must be scaled in some way (Currey and Erwin, 2012).

The application of spraying in most PGRs resources leads to an effective response, and the effectiveness of chemicals and different concentrations can vary between and within genus, species and varieties. . For example, Warner and Erwin (2003) reported variation among several hibiscus (*Hibiscus* spp.) to different PGRs at varying concentrations when applied as sprays. Also, Gibson and Whipker (2001), Krug *et al.* (2007), and Boldt (2008) reported variation among cultivars of angelonia (*Angelonia angustifolia*), ornamental cabbage and kale (*Brassica oleracea*), and tulip (*Tulipa gesneriana*) in response to different PGRs. Alem *et al.* (2015) showed that PGR spray mixture of daminozide and chlormequat at 1000 $mg \cdot L^{-1}$ each and drench, 0.25 $mg \cdot L^{-1}$ paclobutrazol) applications (spray or drench) reduced poinsettia (*Euphorbia pulcherrima*) height to 39 cm, below the final target level of 43.5 cm Currey *et al.* (2016) studied the effect of growth inhibitor spraying on New Guinea impatiens on plant height and time to the flower after 7 weeks of planting. They found that ancymidol, chlormequat chloride, and daminozide had low to no impact on stem elongation. But, flurprimidol, paclobutrazol, and uniconazole suppressed height at flowering of all three cultivars. Plant height with concentrations flurprimidol, paclobutrazol, or uniconazole up to 27 to 30, 20 to 30, or 4 to 5 $mg \cdot L^{-1}$, respectively, depending on the cultivar. Five to 20 $mg \cdot L^{-1}$ flurprimidol or paclobutrazol, or < 2.5 $mg \cdot L^{-1}$ uniconazole may be used to control stem elongation of seed-propagated New Guinea impatiens for production in flats. Plant growth retardants are used to control plant height and enhance flowering. Their main mode of action is to reduce stem growth (i.e. shorten internodes). Generally, they do not interfere with flower development, however low or high doses can affect flower size (Gilbertz, 1992).

Ahmad *et al.* (2007) found that cycocel (CCC) was ascertained for improving the production of compact dwarf carnation var. Red Sim. cycocel (CCC) at 500 and 1000 $mg \cdot L^{-1}$ were sprayed for the purpose. Plants were compact and dwarf with increased number of shoots and maximum number of flowers, when treated with higher level of cycocel (1000 $mg \cdot L^{-1}$) but leaf count and flower size were negatively affected. Dwarfness, number of branches and reduction in leaf area were directly correlated with the concentration of chemicals Antonio *et al.* (2000) on *Nerium oleander*, L. Plants treated with 800 mg CCC were significantly shorter than the control plants. Plants treated with the other doses of CCC did not alter plant height to any statistically significant extent compared to the control .This is especially true for the products that are effective at extremely low concentrations (e.g. Paclobutrazol, and Cycocel). The effectiveness of plant growth retardants varies from cultivar to cultivar (Devadanam *et al.* 2007).

Hawkins *et al.* (2015) found that spray paclobutrazol on plants was effective in reducing the growth of Dissotis (*D. rotundifolia*) but was not effective on *Tibouchina fothergillae* ×pilosa. However, delayed or reduced flowering in both plants. Likewise, Rezazadeh *et al.* (2016) on red firespike (*Odontonema strictum*) potted plant showed that drench

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applications of paclobutrazol and flurprimidol resulted in plants 65% or 46% to 62% shorter than control, respectively. Paclobutrazol and flurprimidol drench also decreased overall plant growth by 81% to 88% and 74% to 84%, respectively, compared with the control plants. PGRs did not affect the number of inflorescences; however, paclobutrazol and flurprimidol delayed flowering 23 to 31 days.

Plant growth retardants actually inhibit the production of gibberellic acid within plants, causes slowing down the cell division and elongation in meristematic tissues of shoot and regulate the plant height without formative effects and change the morphology and physiology of the plant (Varma, 2004). Applying plant growth retardants at the incorrect rate or time can result in stunted plants, delayed flowering, or market unsuitability (Abadi, 2010). Used it properly, plants will be more compact, and will be rich in chlorophyll content causes dark green foliage (Kim *et al*. 2010).

Foliar sprays have the advantage of being a relatively easy application method, inexpensive to apply with respect to labor, often use less total chemical, and are appropriate for nearly every PGR. As such, foliar sprays are the most common method employed for PGR application (Gent and McAvoy, 2000).

The objective of this investigation was to study the effects of cycocel and paclobutrazol to produce Kalanchoe plants more compact, shorter, with a plurality of branches and inflorescences, flowering earlier, and are more suitable as a pot plant.

MATERIALS AND METHODS

Two outdoor pot experients were conducted at Mansoura Research Station, Horticulture Research Institute, Agriculture Research Center, during two successive seasons (2014/2015 and 2015/2016).

I) Plant materials:

Uniform terminal cuttings (7-9 cm) length were planted in 8cm plastic pots filled with a mixture of clay and sand (3:1 V:V) on October 1st in both seasons. Then transplants were re-cultured in 18cm plastic pots filled with the same culture media. The regenerated plants were fertilized with a fixed dose from NPK 19:19:19 + micro elements as drench to the soil.

II) Plant growth retardants treatments:

Plants were sprayed after 45 days of planting (spraying once) and after 45 days and 60 days (spraying twice) with Chlormequat (CCC) at 1000, 2000 or 3000 ppm, Paclobutrazol (PBZ) at 50, 100 or150 ppm and distilled water, respectively.

III) Data recorded:

Data were recorded on vegetative growth, flowering parameters and chemical components after 90 days from planting.

i. Vegetative growth:

1. Plant height (cm) measured from the edge of the pot to the uppermost top plant.
2. Number of branches / plant.

ii. Flowering parameters

3. Number of inflorescence / plant
4. Inflorescence diameter (cm).
5. Time (days) from planting till the opening of the first florets on the first inflorescence blooming.

iii. Chemical components:

6. Chlorophyll content (mg/g FW) measured in the 3rd leaf from the plant top according to Jeffrey and Humphrey (1975).
7. Total carbohydrates content (mg/g DW) measured in whole plant according to Dubois *et al.* (1956).

IV. Anatomical study:

The cross-sections of the stem were taken from the middle of the third internodes under the stem apex, after one month from foliar spraying with PBZ at 150ppm after 45 days and 60 days (spraying twice) and control treatments for electron microscopy examination, as described by Karnovski (1965). Put the specimens were coated with gold-palladium membranes and observed in a Jeol JSM-6510 L.V SEM, The microscope was operated at 30 KV at EM Unit, Mansoura University, Egypt.

V) The Experiment design and statistical analysis:

The experiments were factorial in a completely randomized block design. Each treatment had six replicates, each of which contains three plants. The first factor was the plant growth retardants type (CCC and PBZ), plus the control treatment (sprayed with distilled water). The second factor was the application times of both growth retardants (once or twice),

The data were subjected to statistical analysis of variance of the factorial experiment design according to Snedecor and Cochran (1989). The means were compared using least significant difference test (LSD) at $P \leq 0.05$.

RESULTS AND DISCUSSION

I. Vegetative growth:

1. Plant height (cm):

Data in Table (1) showed that treating plants with both growth retardants significantly decreased plant height when compared with the untreated plants. It was worth notice that the shortest plants obtained when plants were sprayed with CCC and PBZ in both seasons. PBZ applications gave the shortest plants, especially at 150 ppm concentration which recorded 10.83 and 11.18 cm in the first and the second season, respectively. Treated plants with CCC at 3000 ppm gave the best results when compared with other concentrations of CCC, as it were 11.28 and 11.86 cm in the first and second season, respectively. In both seasons there was no significant difference between PBZ and CCC treatments. While the untreated plants were 14.83 and 15.16 cm in the first and second season, respectively.

Data in the same Table showed that plants which treated with growth retardants for twice decreased plant height (11.32 and 11.73 cm) more than plants treated for once (12.12 and 12.62 cm in the first and second season, respectively).

Table 1. Effect of different concentrations of cycocel (CCC) and paclobutrazol (PBZ) and foliar spray times on plant height (cm) of *Kalanchoe blossfeldiana* at 2014-2015 and 2015-2016 seasons.

Growth retardants		Foliar spray times (B)					
	Once	Twice	Mean (A)	Once	Twice	Mean (A)
ppm (A)	2014-2015			2015-2016		
Control	14.83	14.83	14.83	15.16	15.16	15.16
1000	12.20	11.47	11.83	11.93	11.20	11.56
CCC 2000	11.77	11.20	11.48	12.57	11.83	12.20
3000	11.60	10.97	11.28	12.60	11.13	11.86
50	11.13	10.60	10.87	11.67	11.07	11.37
PBZ 100	11.67	10.17	10.92	12.73	11.10	11.91
150	11.63	10.03	10.83	11.70	10.67	11.18
Mean(B)	12.12	11.32		12.62	11.73	
LSD at 0.05	A 0.77	B 0.47	AB1.12	A 0.59	B 0.38	AB 0.87

Studying the interaction, data in Table (1) showed that spraying Kalanchoe with PBZ at 150 ppm for twice gave the shortest plants (10.03 and 10.67 cm in the first and second season, respectively). Sprayed plants with CCC at 3000 ppm for twice (10.97 and 11.13 cm) gave the lowest value in plant height in CCC applications. It was obvious that treated plants with the both growth retardants, in all concentrations, and the both frequencies had a significant difference when compared with the untreated plants.

The dwarfing effect may be attributed to the retardants a reduction in the rate of cell division in the meristem area of the stem tips and the sub-apical meristem.

These results and interpretation were in agreement with those of Warner & Erwin (2003) on *Hibiscus* spp., and Majeed (2017) on African marigold (*Tagetes erecta* L.) cv. "Pusa Basanti".

2. Number of branches per plant:

Data recorded in Table (2) showed that number of branches was increased by using the growth retardants (CCC or PBZ) irrespective of their level when compared with the untreated plants. It was quite clear that using PBZ at 150 ppm more effective in the second season (5.83 branches per plant) when compared with CCC which was more effective in the first season (5.50 branches per plant). In both seasons there was no significant difference between CCC and PBZ in almost applications.

Data recorded in the same Table showed that treated plants with growth retardants for twice (4.67 and 4.71 branches/ plant in the first and second season, respectively) increased number of branches/ plant when compared with the plants which treated for once (4.24 and 4.38 branches/plant in the first and second season, respectively), but this wasn't a significant difference.

Table 2. Effect of different concentrations of cycocel and paclobutrazol and foliar spray times on number of branches of *Kalanchoe blossfeldiana* at 2014-2015 and 2015-2016 seasons.

Growth retardants ppm (A)		Foliar spray times (B)					
		Once	Twice	Mean (A)	Once	Twice	Mean (A)
		2014-2015			2015-2016		
Control		2.67	2.67	2.67	2.33	2.33	2.33
CCC	1000	4.33	4.67	4.50	4.67	5.00	4.83
	2000	4.33	5.00	4.67	4.00	4.67	4.33
	3000	5.33	5.67	5.50	5.00	5.33	5.17
PBZ	50	4.00	4.33	4.17	4.33	4.67	4.50
	100	4.33	5.00	4.67	4.67	5.00	4.83
	150	4.67	5.33	5.00	5.67	6.00	5.83
Mean(B)		4.24	4.67		4.38	4.71	
LSD at 0.05		A 0.96	B 0.43	AB 1.20	A 0.98	B 0.47	AB 1.25

Concerning the interaction data in Table (2) indicated that both growth retardants in all concentrations and the both frequency applications significantly increased the number of branches per plant when compared with control treatment. It was quite clear that sprayed plants with CCC at 3000 ppm for twice gave the best result in the first season (5.67 branches/ plant), while treated plants in the same season with CCC at the same concentration for once or PBZ at 150 ppm for twice came in the second order in this respect, as it was 5.33 branches/ plant. In the second season it was clear that using PBZ at 150 ppm for twice gave the maximum number of branches/ plant (6.00 branches/ plant) when compared with all of other treatments in both seasons.

CCC and PBZ retard the hormonal activity of apical meristem of plant and break the apical dormancy allowing plants to be more branching.

These results and interpretation were in agreement with those of Talukdar and Paswan (1996) on chrysanthemum cv. Prof. Harris, and Ahmad *et al*. (2007) on *Dianthus caryophyllus* var. Red Sim.

II. Flowering parameters:

3. Number of inflorescences/ plant:

Data in Table (3) showed that number of inflorescences was increased by using CCC and PBZ compared with the control. It was worth notice that treated plants with CCC at 3000 ppm in the first season gave more than double of inflorescences number comparing with untreated plants, as it was 4.83 inflorescences/ plant. In the second season the maximum number of inflorescences/ plant was obtained when used PBZ at 150 ppm (4.67 inflorescences/ plant), and it was more than triple when compared with control.

In addition Table (3) showed that using each of both growth retardants for twice (3.95 and 3.81 inflorescences/ plant) was more effective in increasing the number of inflorescences/ plant than once (3.53 and 3.43 inflorescences/ plant) in the first and second season, respectively, but it wasn't a significant difference.

Table 3. Effect of different concentrations of cycocel and paclobutrazol and foliar spray times on number of inflorescences of *Kalanchoe blossfeldiana* at 2014-2015 and 2015-2016 seasons.

Growth retardants ppm (A)		Foliar spray times (B)					
		Once	Twice	Mean (A)	Once	Twice	Mean (A)
		2014-2015			2015-2016		
Control		1.67	1.67	1.67	1.33	1.33	1.33
CCC	1000	3.67	4.00	3.83	3.67	4.00	3.83
	2000	3.67	4.00	3.83	3.33	3.67	3.50
	3000	4.67	5.00	4.83	4.00	4.33	4.17
PBZ	50	3.33	4.00	3.67	3.33	3.67	3.50
	100	3.67	4.33	4.00	4.00	4.67	4.33
	150	4.00	4.67	4.33	4.33	5.00	4.67
Mean(B)		3.53	3.95		3.43	3.81	
LSD at 0.05		A 0.51	B 0.35	AB 0.80	A 0.74	B 0.40	AB1.00

Studying the interaction data in Table (3) indicated that treated Kalanchoe with CCC at 3000 for twice in the first season or PBZ at 150 ppm for twice in the second season gave the maximum number of inflorescences (5.00 inflorescences/ plant). While in the first season using CCC at 3000 ppm for once or PBZ 150 ppm for twice came in the second order of this respect as it was 4.67 inflorescences/ plant. In the second season using PBZ at 150 for once or CCC at 3000 for twice came in the second order of this respect, as it was 4.33 inflorescences/ plant. Using higher concentration of each growth retardants was more effective in this measurement comparing to lower concentrations and the control.

4. Inflorescence diameter

Data in Table (4) reflected that treated plants with the both growth retardants significantly decreased the inflorescences' diameter in all treatments with one exception (CCC at 1000 ppm in the first season). Treated plants with PBZ at 100 ppm in the first season and 150 ppm in the second season gave the lowest values in this respect. It was worth notice that the difference between treated plants with CCC and the untreated plants acceptable, as it were 9.32 and 9.55 cm in the first and second season, respectively.

In addition Table (4) showed that duplicating the applications frequency insignificantly decreased the inflorescences' diameter. Sprayed kalanchoe once recorded

7.77 and 8.57 cm, while twice recorded 7.62 and 8.05 cm in the first and second season, respectively.

Concerning the interaction effect data indicated that sprayed plants with PBZ at all concentrations significantly decreased the inflorescence diameter when compared with untreated and the majority of treated plants with CCC. Sprayed plants in the first season with PBZ at 100 ppm for twice gave the lowest value in this respect, as it was 6.03 cm, while the lowest value in the second season (6.13 cm) was detected when PBZ at 150 ppm for twice sprayed on plants. It was clear that treated plants in the first season with CCC at 3000 ppm once or twice significantly decreased the inflorescence diameter when compared to the rest of the CCC applications and untreated plants, as it were 7.50 and 7.10 cm for once and twice, respectively. It was obvious that no significant difference noticed in the second season between control treatment and treated plants with CCC for once at 1000 or 2000 ppm.

Table 4. Effect of different concentrations of cycocel and paclobutrazol and foliar spray times on inflorescence diameter (cm) of *Kalanchoe blossfeldiana* at 2014-2015 and 2015-2016 seasons.

Growth retardants ppm (A)		Foliar spray times (B)					
		Once	Twice	Mean (A)	Once	Twice	Mean (A)
		2014-2015			2015-2016		
Control		9.80	9.80	9.80	10.23	10.23	10.23
CCC	1000	9.40	9.23	9.32	9.83	9.27	9.55
	2000	8.80	8.77	8.78	9.80	9.00	9.40
	3000	7.50	7.10	7.30	9.07	8.33	8.70
PBZ	50	6.50	6.27	6.38	7.13	7.03	7.08
	100	6.23	6.03	6.13	7.00	6.33	6.67
	150	6.17	6.13	6.15	6.90	6.13	6.52
Mean(B)		7.77	7.62		8.57	8.05	
LSD at 0.05		A 0.91	B 0.28	AB 1.01	A 0.39	B 0.30	AB 0.65

The reduction of the inflorescence diameter was the output of using the growth retardants as aforementioned by Gilbertz (1992) on chrysanthemum plants.

5. Time (days) to flowering:

It was clear that treating plants with both growth retardants significantly reduced number of days to flowering when compared with the untreated ones (Table 5). Sprayed plants with PBZ at 150 ppm in the second season gave the earliest interval to flowering (126.00 days to flower in the first season), while this treated one with CCC at 3000 ppm came in the second order in this respect, as it was 129.50 days to flowering in the same season. In the second season CCC at 3000 ppm and PBZ at 150 ppm treatments gave the lowest number of days to flowering. It is worth notice that there was a significant difference between the high and low concentrations of the both growth retardants in its effects of this respect.

Results recorded in the same Table showed that treated plants with the both growth retardants for twice encouraged significantly flowering earlier (133.00 and 130.81 days) compared with spraying plants for once (136.33 and 133.67 days) in the first and second season, respectively.

Concerning the interaction data in Table (5) show that treated plants with PBZ at 150 ppm for twice flowered after 125.33 days in the first season. These values were the significantly minimum days to flowering compared with all of the other treatments, while the result of CCC treatment at 3000 ppm for twice in the second season gave the minimum days to flower, as it recorded 125.67 days. Treated plants in the same season with PBZ at 150 ppm for twice came in the second order in this respect, as it was 126.00 days to flowering.

The effect of plant growth retardants reduces the number of short days required for flowering. Similar results were also reported by Naidu *et al*. (2014) on marigold plants.

Table 5. Effect of different concentrations of cycocel and paclobutrazol and foliar spray times on time to flowering (days) of *Kalanchoe blossfeldiana* at 2014-2015 and 2015-2016 seasons.

Growth retardants ppm (A)		Foliar spray times (B)					
		Once	Twice	Mean (A)	Once	Twice	Mean (A)
		2014-2015			2015-2016		
Control		148.67	148.67	148.67	145.00	145.00	145.00
CCC	1000	139.67	133.33	136.50	136.00	131.00	133.50
	2000	131.33	129.33	130.33	129.67	127.33	128.50
	3000	130.33	128.67	129.50	127.00	125.67	126.33
PBZ	50	140.67	130.00	135.33	137.00	131.00	134.00
	100	137.00	135.67	136.33	134.33	129.67	132.00
	150	126.67	125.33	126.00	126.67	126.00	126.33
Mean(B)		136.33	133.00		133.67	130.81	
LSD at 0.05		A 1.66	B 0.72	AB 2.04	A 0.93	B 0.85	AB 1.78

The chemical components:

It is a well-known fact that the real picture about plant metabolism and health may be given by the chemical components.

III. Chemical components:

6. The total chlorophyll mg/ g FW):

Data in Table (6) indicated that treated plants with the both growth retardants significantly increased the total chlorophyll content when compared with the control treatment. It was clear that treated plants with PBZ gave the highest result in this respect. Treated plants with PBZ at 150 ppm gave the best result in the first season, as it was 0.549 mg/ g FW. While PBZ at 100 ppm in the second season gave the best result as it was 0.650 mg/ g FW. However CCC at 3000 ppm significantly increased the total chlorophyll when compared with control treatment, as it were 0.473 and 0.556 mg/ g FW in the first and second season, respectively.

Table 6. Effect of different concentrations of cycocel and paclobutrazol and foliar spray times on total chlorophyll (mg/g FW) of *Kalanchoe blossfeldiana* at 2014-2015 and 2015-2016 seasons.

Growth retardants ppm (A)		Foliar spray times (B)					
		Once	Twice	Mean (A)	Once	Twice	Mean (A)
		2014-2015			2015-2016		
Control		0.330	0.330	0.330	0.308	0.308	0.308
CCC	1000	0.397	0.427	0.412	0.408	0.427	0.417
	2000	0.399	0.429	0.414	0.437	0.480	0.458
	3000	0.465	0.482	0.473	0.537	0.576	0.556
PBZ	50	0.428	0.433	0.430	0.593	0.613	0.603
	100	0.456	0.512	0.484	0.621	0.679	0.650
	150	0.525	0.572	0.549	0.610	0.673	0.641
Mean(B)		0.428	0.455		0.502	0.536	
LSD at 0.05		A 0.012	B 0.006	AB 0.016	A 0.013	B 0.007	AB0.017

Results recorded at the same Table showed a significant difference between treated plants for once (0.428 and 0.502 mg/ g FW) or twice (0.455 and 0.536 mg/ g FW) in the first and second season, respectively.

Studying the interaction data in Table (6) indicate that treated plants with CCC or PBZ at all concentrations and applications' times gave significant effects when compared with control treatment. PBZ applications were more effective in increasing the total chlorophyll content in treated plants. The best result of total chlorophyll content in the first season occurred when plants treated with PBZ at 150 ppm for twice (0.572 mg/ g FW), while the best result in the second season and ever was 0.679 mg/ g FW when used PBZ at 100 ppm for twice. Used PBZ at 150 ppm for twice in the second season gave the second record in this respect, as it was 0.673 mg/ g

FW. High concentration of CCC which sprayed twice was more effective when compared with the lowest ones and the untreated plants, as it was 0.482 and 0.576 mg/ g FW in the first and second season, respectively.

These results in agreement with Borowski *et al.* (1998) on sweet pepper cv. Kujawinka, and Antonio *et al.* (2000) on *Nerium oleander* L.

7. The total carbohydrates (mg/ g DW):

Data in Table (7) showed that treating plants with both growth retardants significantly increased the total carbohydrates when compared with the untreated plants. It was worth notice that the maximum total carbohydrates obtained resulted when plants were treated with CCC and PBZ in both seasons. PBZ at 150 ppm gave the highest value of total carbohydrates which recorded 168.24and 204.56 mg/ g DW in the first and second season, respectively. Treated plants with CCC at 3000 ppm was more effective when compared with the lowest ones and the untreated plants, as it was 145.19 and 161.44 mg/ g DW in the first and second season, respectively. In both seasons there was significant difference between PBZ and CCC, while the untreated plants were 109.36 and 111.38 mg/ g DW in the first and second season, respectively.

Table 7. Effect of different concentrations of cycocel and paclobutrazol and foliar spray times on total carbohydrates (mg/g DW) of *Kalanchoe blossfeldiana* at 2014-2015 and 2015-2016 seasons.

Growth retardants ppm (A)		Foliar spray times (B)					
		Once	Twice	Mean (A)	Once	Twice	Mean (A)
		2014-2015			2015-2016		
Control		109.36	109.36	109.36	111.33	111.38	111.35
CCC	1000	126.65	136.22	131.43	144.50	149.52	147.01
	2000	137.36	145.68	141.52	156.27	161.30	158.78
	3000	141.22	149.17	145.19	160.52	162.37	161.44
PBZ	50	131.09	137.54	134.31	159.06	163.75	161.41
	100	140.12	143.55	141.83	165.07	170.35	167.71
	150	165.42	171.07	168.24	202.05	207.07	204.56
Mean(B)		135.89	141.80		156.97	160.82	
LSD at 0.05		A 2.66	B 1.72	AB 3.98	A 2.89	B 1.90	AB 4.36

Results recorded at the same Table showed that duplicated the applications frequency significantly increased the total carbohydrates. It was clear that results in the second season (157.00 mg/ g DW for once and 160.87 mg/ g DW for twice) higher than the others in the first season (135.89 mg/ g DW for once and 141.80 mg/ g DW for twice).

Studying the interaction data in Table (7) showed that spraying Kalanchoe with CCC and PBZ at all studied applications and concentrations significantly increased the content of total carbohydrates when compared with the untreated plants. It was obvious that treated plants with PBZ at 150 ppm for twice gave the best result in this respect, as it recorded 171.07 and 207.07 mg/ g DW in the first and second season, respectively. Treated plants with PBZ at 150 ppm for once came in the second record of increasing the content of total carbohydrates of kalanchoe plants, as it was 165.42 and 202.05 mg/ g DW in the first and second season, respectively. It was clear that using high concentrations of CCC was more effective in increasing the content of total carbohydrates, while CCC at 3000 ppm for twice recorded 149.17 and 162.37 mg/ g DW in the first and second season, respectively.

From previous results it is clear that both growth retardants actually increased carbohydrates content at different values. Notably, the treated plant content is increased by total chlorophyll, which in turn increases photosynthesis. The carbohydrates convert by further metabolic processes into proteins, lipids, nucleic acids and other organic molecules. These carbohydrates increment could promote flowering, as agreed with Kim *et al.* (2010) on *Chrysanthemum morifolium*.

IV. Anatomical study:

In the paclobutrazol application the microscopic image (figure 1) of stem cross sections showed that the thickness of xylem was reduced (A) when compared to the control application (B) (figure 1). Xylem thickness may be attributed to the effect of this compound on the elongation of cells. Water and nutrient uptake in the plant would be affected as a result of this inhibition. These results and interpretation were in agreement with those Nazarudin *et al*. (2007) on *Syzygium campanulatum* and with that Aguirre and Blanco (1992) that paclobutrazol reduced the xylem thickness in *Prunus persica.* Wang and Gregg (1989) reported that restricted water and nutrient supply might occur which could be partially responsible for slow plant growth.

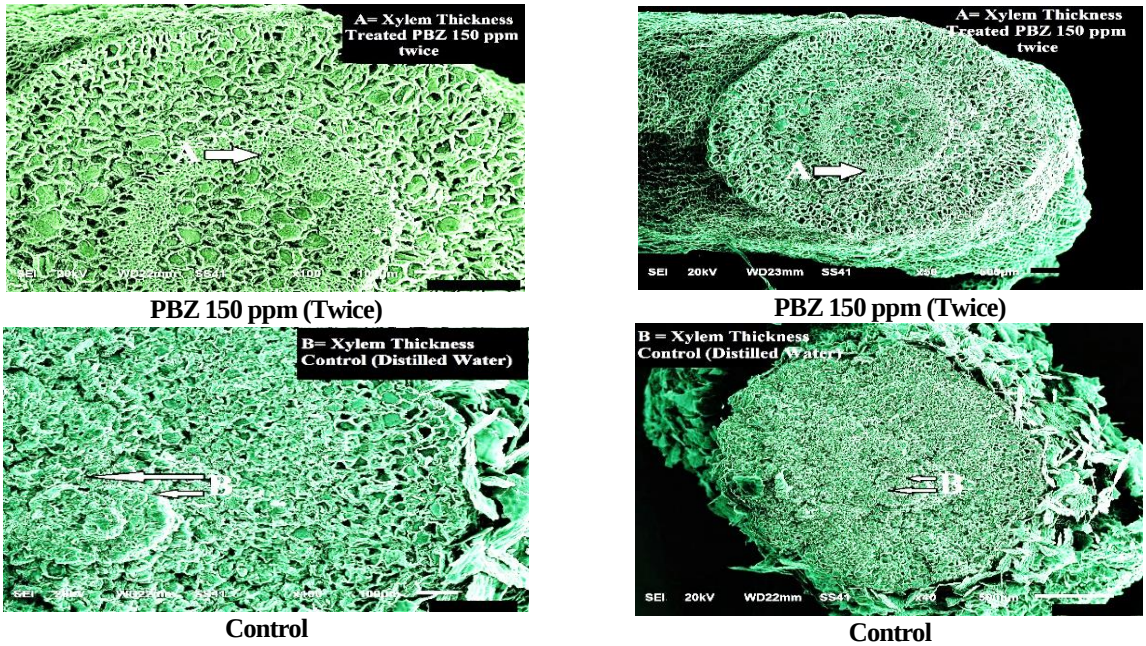

Fig. 1. Effect of spraying PBZ at 150 ppm after 45 and 60 days (spraying twice) on xylem thickness (A) comparing with xylem thickness (B) of the control treatment.

The micrograph images of sections from the stems of the control and paclobutrazol-treated Kalanchoe plants showed that treated stem (figure 2) is characterized by increased cortex thickness (CA), well-developed vascular bundles, and reduced internode length (DA). These results were in agreement with Davis and Curry (1991) who reported that shoot growth reduction in response to PBZ treatment occurs primarily due to a decrease in internode length, and the effective dose varies with species and cultivar.

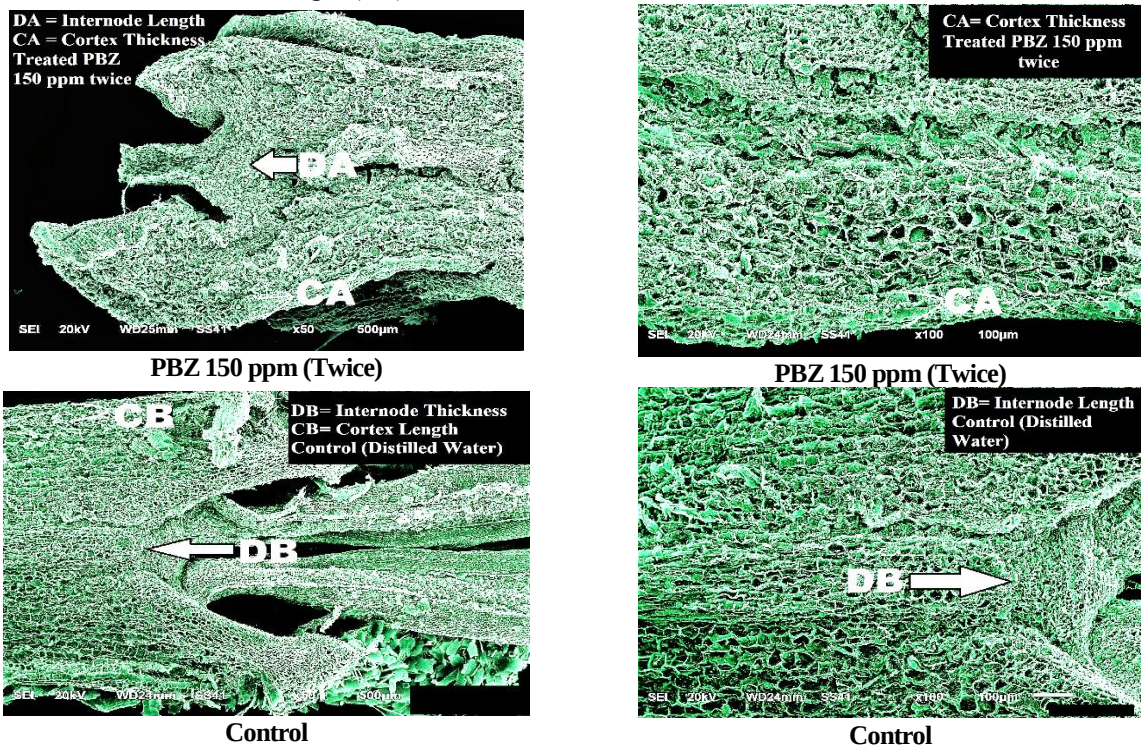

Fig. 2. Effect of spraying PBZ at 150 ppm after 45 and 60 days (spraying twice) on cortex thickness (CA), well-developed vascular bundles, and reduced internode length (DA) comparing with cortex thickness (CB) and internode length (DB) of the control treatment.

REFERENCES

Abadi, D.H., 2010. Yield and quality management of Rosa hybrid 'Poison' with plant growth regulators. American-Eurasian Journal of Agricultural and Environmental Science, 8 (6) 736-740.

Aguirre, R. & Blanco, A. 1992. Pattern of histological differentiation induce by paclobutrazol and GA3 in peach shoots. Acta Horticulture 315: 7–12.

Ahmad, I., Ziaf, K., Qasim, M. and Tariq, M., 2007. Comparative evaluation of different pinching approaches on vegetative and reproductive growth of carnation (*Dianthus caryophyllus*). Pak. J. Agri. Sci, 44 (4) 563-570.

Alem, P., Thomas, P.A. and van Iersel, M.W., 2015. Controlled water deficit as an alternative to plant growth retardants for regulation of poinsettia stem elongation. HortScience, 50 (4) 565-569.

Antonio, J., Leemhuis, F., Fernández Hernández, J.A., Ochoa Rego, J., Benaente-García, A.G. and Bañon Arias, S., 2000, March. Growth and leaf colour responses of oleander (*Nerium oleander* L.) to pinching and chlormequat chloride treatment. In V International Symposium on Protected Cultivation in Mild Winter Climates: Current Trends for Suistainable Technologies 559 (pp. 155-160.

Boldt, J.K., 2008. Cultural and environmental factors influence the performance of *Angelonia angustifolia* cultivars (Doctoral dissertation, University of Florida).

Borowski, E; Z. K. Blamowski and L. Kozlowska (1998): Growth and physiological reaction to cool in sweet peppers exposed to paclobutrazol. Annales Universitatis Mariae Curie-Skłodowska. Sectio EEE: Horticultura, 6, pp.129-136. Currey, C.J. and Erwin, J.E., 2012. Foliar applications of plant growth regulators affect stem elongation and branching of 11 kalanchoe species. HortTechnology, 22 (3) 338-344.

Currey, C.J. and Erwin, J.E., 2012. Foliar applications of plant growth regulators affect stem elongation and branching of 11 kalanchoe species. HortTechnology, 22 (3) 338-344.

Currey, C.J., Flax, N.J. and Walters, K.J., 2016. Foliar sprays of flurprimidol, paclobutrazol, and uniconazole suppress height of seed-propagated New Guinea Impatiens. HortTechnology, 26 (1) 20-25

Davis, T.D. and E.A. Curry. 1991. Chemical regulation of vegetative growth. Crit. Rev. Plant Sciences 10:151–188.

Devadanam, A., Shinde, B.N., Sable, P.B. and Vedpathak, S.G., 2007. Effect of foliar spray of plant growth regulators on flowering and vase life of tuberose (*Polianthes tuberosa* L.). Journal of Soils and Crops, 17 (1) 86-88.

Dubois, M., Gilles, K.A., Hamilton, J.K., Rebers, P.T. and Smith, F., 1956. Colorimetric method for determination of sugars and related substances. Analytical chemistry, 28 (3) 350-356.

Gent, M.P.N. and McAvoy, R.J., 2000. Plant growth retardants in ornamental horticulture. Plant growth regulators in agriculture and horticulture: Their role and commercial uses. Food Products Press, Binghamton, NY 89-146.

Gibson, J.L. and Whipker, B.E., 2001. Ornamental cabbage and kale cultivar comparison study: Growth characteristics and response to daminozide and uniconazole foliar sprays. HortTechnology, 11 (3) 376-380.

Gilbertz, D.A., 1992. Chrysanthemum response to timing of paclobutrazol and uniconazole sprays. HortScience, 27 (4) 322-323.

Hawkins, S.M., Ruter, J.M. and Robacker, C.D., 2015. Spray and drench treatments of paclobutrazol influence growth of Dissotis and Tibouchina. HortScience, 50 (10) 1514-1517.

Jeffrey, S.T. and Humphrey, G.F., 1975. New spectrophotometric equations for determining chlorophylls a, b, c1 and c2 in higher plants, algae and natural phytoplankton. Biochemie und physiologie der pflanzen, 167 (2) 191-194.

Karnovsky, M.J., 1965. A formaldehyde -glutaraldehyde fixative of high osmolality for use in electron microscopy. J. Cell Biol. 27, 137-138.

Kim, Y.H., Khan, A.L., Hamayun, M., Kim, J.T., Lee, J.H., Hwang, I.C., Yoon, C.S. and Lee, I.J., 2010. Effects of prohexadione calcium on growth and gibberellins contents of *Chrysanthemum morifolium* R. cv Monalisa White. Scientia Horticulturae, 123 (3) 423-427.

Krug, B.A.,Whipker, B.E,. McCall, I. and Dole, J.M. 2007. Tulip cultivar variations with Flurprimidol J. Appl. Hort.96668

Majeed, C.T., 2017. Effect of different plant growth retardants on plant growth, flowering and yield of African marigold (*Tagetes erecta* L). cv. Pusa Basanti. IJCS, 5 (2) 201-204.

Naidu, J.H., Ashok, P., Sekhar, R.C. and Sasikala, K., 2014. Effect of plant growth retardants and spacings on vegetative growth and flower yield of African marigold (*Tagetes erecta* L) cv. Pusa Narangi Gainda. International Journal of Farm Sciences, 4 (2) 92-99.

Nazarudin, M.A., Fauzi, R.M. and Tsan, F.Y., 2007. Effects of paclobutrazol on the growth and anatomy of stems and leaves of Syzygium campanulatum. Journal of Tropical Forest Science, 86-91.

Rezazadeh, A., Harkess, R.L. and Bi, G., 2016. Effect of plant growth regulators on growth and flowering of potted red firespike. HortTechnology, 26 (1) 6-11.

Snedecor, G.W. and Cochran, W.G., 1989. Statistical methods, 8thEd. Ames: Iowa State Univ. Press Iowa.

Talukdar, M.C. and Paswan, L., 1996. Growth and flowering of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Prof. Harris as influenced by growth regulators. Horticultural Journal, 9 (2) 155-158.

Tyagi, A.K. and Kumar, V., 2006. Effect of gibberellic acid and vermicompost on vegetative growth and flowering in African marigold (*Tagetes erecta* L.). Journal of Ornamental Horticulture, 9 (2) 150-151.

Varma, L.R., 2004. Regulation of flowering in African marigold (*Tagetes erecta* L.) by the application of GA3 ethrel and MH. Journal of Ornamental Horticulture, 7 (3and4) 168-170.

Wang, Y. T. & Gregg, L. L. 1989. Uniconazole affects vegetative growth, flowering and stem anatomy of hibiscus. Journal of the American Society for Horticultural Science 114 (6): 927–932.

Warner, R.M. and Erwin, J.E., 2003. Effect of plant growth retardants on stem elongation of Hibiscus species. HortTechnology, 13 (2) 293-296.

تحسين الصفات الخضرية والزهرية لنبات الكلانشو بإستخدام بعض مؤخرات النمو

علي منصور حمزة[1] ، أميمة محمد عبد الكافي[1] ، ماجدة مصطفى السقا[2] و الأمير محى محى[2]*

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أجريت هذه التجربة لدراسة تأثير تركيزات مختلفة من الكلورمكويت (السيكوسيل) عند 1000 و 2000 أو 3000 جزء في المليون و الباكلوبترازول عند 50 و 100 أو 150 جزء في المليون على نبات الكلانشو لإنتاج نباتات أكثر إندماجاً وأقصر طولاً ، مع عدد وافر من الأفرع والنورات ، وتزهر في وقت مبكر ، وتكون أكثر ملاءمة كنبات أصص وقد تم تطبيق مؤخرات النمو على شكل رش ورقي لمرة واحدة (بعد 45 يومًا) أو مرتين (بعد 45 و 60 يومًا من الزراعة). كانت جميع النباتات المعاملة أقصر طولاً. كما كانت غزيرة التفريع خاصة تلك التي تم معاملتها بمركب الباكلوبترازول عند 150 جزء في المليون مرتين (6.00 فرع / نبات) ، وبنفس المعاملة حقق الحد الأقصى لعدد النورات حيث سجلت 5.00 نورات / النبات. أعطت النباتات التي تم رشها بالباكلوبترازول عند 150 جزء في المليون مرتين العدد الأدنى (125.33) من الأيام للتزهير. زاد المحتوى الكلي من الكلوروفيل والكربوهيدرات في جميع النباتات التي تم رشها ، حيث كان 0.679 ملجم / جرام وزن طازج للكلوروفيل (باكلوبترازول 100 جزء / مليون رشاً لمرتين) و 207.07 مجم / جرام وزن جاف للكربوهيدرات (باكلوبترازول 150 جزء / مليون رشاً مرتين). للحصول على نبات كلانشو متقزم ، مع أوراق خضراء داكنة ، أفروعاً وأزهاراً غزيرة ، وتبكير الإزهار، يوصى باستخدام مركب الباكلوبترازول بمعدل 150 جزء في المليون رشاً على الأوراق مرتين.