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Effect of some growth regulators on flowering, corms and cormlets productivity of different gladiolus cultivars

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ABSTRACT

The present experiment was performed throughout two successive seasons (2015-2016 and 2016-2017) at the nursery of Horticulture Research Institute, ARC, Giza, Egypt for studying the effect of different types and levels of some growth regulators and their interactions on growth, flowering, corms and cormlets production and some chemical constituents of different gladiolus cvs. The three gladiolus cultivars used were Fortua Red, Wine and Roses and Peter Pears, the different growth regulators were Atonik at 1000 and 2000 ppm, 4-CAP at 125 and 250 ppm and CCC at 1000 and 2000 ppm. The results showed that the different gladiolus cultivars were different in their growth parameters and response to the different growth regulators used in the current study in both seasons. Peter Pears cv. occupied the first rank in this concern as it gave the utmost high values of various plant characters as plant height, number of leaves /plant, the significantly highest value of dry weight of cut spike, the heaviest fresh weight of the newly formed corms, the highest corm circumference, the highest values of cormlets yield (number of cormlets/pot) as well as the highest chlorophyll (a) content in leaves.

Concerning the beneficial effect of applying the different growth regulator treatments, results revealed that Atonik at both levels (1000 and 2000 ppm) caused a clear increment on plant height and produced the earliest flowering. Meanwhile, applying Atonik at 2000 ppm raised spike stem, rachis length, number of florets/spike, the heaviest corm fresh weight and proved its superiority in raising cormlets yield. CCC treatment at 2000 ppm caused also marked influences in improving some plant traits as it produced the significantly highest records of dry weight of cut spike, proved its mastery in elevating spike stem diameter, gave the largest corm diameter, produced the highest total carbohydrates content in the newly formed corms in both seasons, and proved its mastery in elevating chlorophylls a and b in leaves. Moreover, CCC at either 1000 or 2000 ppm succeeded in producing high carotenoids content in leaves in both seasons. Meanwhile, the least effect of the growth regulators used was a result of applying 4-CAP at 125 ppm which only raised number of leaves/plant and produced the heaviest fresh weight of cormlets.

From the aforementioned results it could be recommended to use Peter Pears cv. in plantation with supplying plants with Atonik at 2000 ppm for improving most of plant traits.

***Keywords*: Gladiolus cvs., Atonik, 4-Chlorophenoxyacetic acid, chlorocholine chloride**

Introduction

Gladiolus is the largest genus in the family Iridaceae, cultivated in most of the tropical and subtropical countries of the world and used for cut flowers and sometimes for landscape design. The plant is not only an important ornamental one, but also an economical crop. It is the main exportable ornamental plants in Egypt. The flowers are available throughout the year, (John and Peter 2008).

Plant hormones are structurally unrelated collection of small molecules derived from various essential metabolic pathways. These compounds are important regulators of plant growth and mediate responses to both biotic and abiotic stresses, Aaron, *et al*., 2009. The plant hormone is naturally produced in the plant, along with the presence of synthetic hormones that will be used in this study. Synthetic growth regulating chemicals have been reported to be very effective in growth, flowering and corm production in gladiolus (Baskaran and Misra, 2007; Suresh Kumar *et al*., 2008).

Atonik (Asahi) is an aromatic nitro-phenolic compound, composed of sodium ortho-nitophenolic, para-nitrophenolic and sodium nitro-guaiacol, as active ingredients which accelerate the

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plasma flowing of the cell by increasing the endogenous auxin level (Datta *et al.,* 1986). The principal ingredients of this biostimulator are natural active compounds found in the plant world: 5-nitroguaiacolatc as well as ortho- and para-nitrophenols in the form of potassium salts (Król 2009). The growth stimulator Asahi was proven to positively affect the yield and quality of chamomile raw material, Cezary 2015. Its positive effect on yield is now well demonstrated (Djanaguiraman *et al*., 2009; Bynum *et al.,* 2007; Michalski *et al.,* 2008; Sawicka and Mikos-Bielak, 2008). Plants treated with nitrophenolates have greater inhibition of IAA oxidase, which ensures a higher activity of naturally synthesized auxins (Stutte and Clark, 1990). The phosphorylated form of para-nitrophenolate increase IAA activity when used as a substrate for phosphatases *via* increased high-affinity binding sites of IAA (Davies, 1987) and could be as effective as ATP (Koizumi *et al.,* 1990). According to Stutte *et al.* (1987), plants exposed to nitrophenolates uptake more nutrients from the medium. Kocira *et al*. (2018) the application of Atonik was found to improve the efficiency of the photosynthetic apparatus and chlorophyll content in the leaves of *Dracocephalum moldavica* plants. Furthermore, phenolic acids are natural compound of several plants which can influence cell morphology, physiology and metabolism.

4-Chlorophenoxyacetic acid (4-CAP) or 2-(4-chlorophenoxy) acetic acid is a synthetic pesticide similar to chemicals in a group of plant auxins. Baliyan *et al*., 2013 and Rahman *et al.,* 2015 concluded that the application of 4-CPA indicated a positive and significant effect on the fruit set and yields of tomato.

Chlorocholine chloride is used as a plant growth regulator, and most important inhibitor of gibberellin biosynthesis (Wilhelm and Lutz, 2010). CCC is an anti-gibberellin growth regulator based on its inhibition of the conversion from geranylgeranyl pyrophosphate (GGPP) to ent-kaurene, an early step in gibberellic acid (GA) biosynthesis (Wang *et al.,* 2009). Wang and Xiao (2009) found that foliar spraying of CCC could noticeably decrease GA and abscisic acid (ABA) contents in potato leaves, which in turn increased chlorophyll contents and stimulated photosynthetic rate (Sharma *et al*., 1998). Zheng *et al*., 2012 showed that chlorocholine chloride (CCC) increased the biomass of leaves and stems and suggested that CCC treatment is an effective method to promote carbohydrate accumulation in lily bulbs.

Different research studies have proved that the application of growth regulators help to produce good quality cut flowers and additional yield of gladiolus corms. Thus, the present experiment was undertaken to find out the best plant growth regulator and the best level for obtaining the best flowers as well as corm yield of the imported gladiolus cultivars, in order to decrease the cost of importing gladiolus cultivars from abroad annually.

Material and Methods

This trial was performed throughout two successive seasons (2015-2016) and (2016-2017) at the nursery of Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. The aim of this study to find out the effect of three growth regulators at two levels of each, *viz*, Atonik (1000 and 2000 ppm), 4-Chlorophenoxyacetic acid (125 and 250 ppm), Chlorocholine chloride "CCC" (1000 and 2000 ppm) on growth, flowering, corm and cormlet production of three *Gladiolus grandiflorus* cvs.

Materials

Plastic pots of 30 cm diameter filled with a mixture of sand/clay (1:1, v/v), (one corm/pot). The physical and chemical properties of the used sand/clay medium are presented in Table (a).

Table (a): The physical and chemical analysis of growing medium (sand /clay 1:1).

Soil texture %				Cations meq/l			Anions meq/l			
Coarse sand	Fine sand	Silt	Clay	Ca++	Mg++	Na+	K+	HCO-3	Cl-	SO4--
5.27%	25.9%	20.23%	48.60%	5.27	2.60	8.76	2.20	2.57	6.17	5.87
S.P.	EC (ds/m)	pH	Elements (ppm)	N	P	K	Fe	Zn	Mn	Cu
30.5	3.17	7.80		100.7	18.9	274	4.99	5.92	8.81	3.71

Procedures:

On December 1st, gladiolus cv. Fortuna Red corms of 6-8 cm circumferences, 6.5-7 g; gladiolus cv. Peter Pears corms of 8-10 cm, 11-11.5 g and gladiolus cv. Wine and Roses corms 10-12 cm and 11.5-12 g were planted in 30 cm plastic pots (one corm each) filled with about 5-6 kg of sand/clay mixture (1:1, v/v) and left to grow at open field condition in both seasons. The layout of the experiment was factorial experiment in a randomized complete block design, (RCBD) with three replicates. The main factor represented gladiolus cultivar, whereas the second factor was the growth regulator treatments. The corms were soaked overnight (12 hrs) and then planted in the pots.

Regular agricultural practices were carried out whenever needed, such as watering, weeding and fertilization with the mixture of NPK (1:2:1) for 4 times (one month from planting, at the mid of vegetative growth stage, at flowering time and immediately after picking flowers, at the rate of 2g / pot).

The experiment contained 21 treatments (3 gladiolus cvs. × 7 treatments), replicated three times and every experimental unit was represented by 6 bulbs, and every treatment contained 18 corms. The following data were recorded:

- Plant height and number of leaves/plant.
- Number of days from planting to flowering.
- Spike stem length and diameter, fresh and dry weight of stem spike, rachis length and number of florets/spike.
- Corm circumference and fresh weight.
- Cormlets yield (number of cormlets/plot) and cormlets fresh weight.

Chemical constituents:

In fresh leaves samples, photosynthetic pigments (chlorophyll (a), chlorophyll (b) and carotenoids were determined according Lichtenthaler and Wellburn (1985). Total carbohydrates of new corms were determined according to A.O.A.C. (1995).

Statistical analysis

Data were statistically analysed using MSTAT (1985), whereas Duncan's Multiple Range Test (Waller and Duncan, 1969) was used for elucidating the differences between means of different treatment at 0.05 levels.

Results and Discussion

Effect of some growth regulators on vegetative growth of the three gladiolus cultivars

Marked influences on vegetative growth parameters of either plant height or number of leaves/plant of the three cultivars were detected in the two seasons. The utmost high values of plant height and number of leaves/plant were obtained due to using Peter Pears cv. in plantation in the two seasons, whereas Fortua Red cv. gave the least scores for both parameters in the two seasons.

Concerning the effect of growth regulators on both parameters, it is evident from data in Table (1) that an increment with significant effect was observed on plant height due to supplying plants with Atonik at both levels (1000 and 2000 ppm) compared to the control or other treatments, in the two seasons. In this connection many authors showed also an increase effect of Atonik on plant height. Other many authors registered such effect on others plants. This was mentioned by Gruszczyk and Berbeć (2004) on feverfew (*Chrysathemum parthenium* L.) and Kiełtyka (2010) on motherwort (*Leonurus cardiaca* L.) and Sitinjak (2015) on Rosa sp. In contrast, treating plants with CCC at 1000 ppm led to a decrease in plant height compared with that scored from the control or other treatments, with significant effect in most cases in the two seasons.

Referring to the decreasing effect of CCC on plant height, many authors reported such effect on various plants, as mentioned by Currey and Lopoz (2010) on *Lilium longiflorum,* Taha (2012) on *Iris* and Zheng *et al.* (2012) on *Lilium* plants, Bąbelewski and Pancerz (2014) on *Torenia fournieri*, *Fuchsia* hybrida, *Calibrachoa* × hybrida, *Lobelia erinus* and *Petunia*. Number of leaves/plant increased when supplying plants with 4-CAP at 125 ppm in the two seasons, compared to the other treatments used in both seasons. Concerning the interaction, the superiority of Atonik at 2000 ppm was evident in elevating plant height supplying of Wine and Roses cultivar compared to the other treatments, used in the two seasons. In this respect Sitinjak (2015) found that using Atonik led to increasing number of leaves of *Rosa* sp., the same was found by El-Khateeb (2018) on *Spathiphyllum wallisii* L. plants. Meanwhile, the opposite was right for treating Fortua Red cv. with CCC at 1000 ppm, where the least scores were registered in the two seasons. In this connection Sable *et al* (2015) on gladiolus recorded minimum number of leaves/plant by using CCC. On the other side, the interaction between the different gladiolus cvs. and growth regulators indicated the superiority of treating Peter Pears cv. with either 4-CAP at 250 ppm in the first season or treating the same cultivar with CCC at 2000 ppm in the second one in producing the highest number of leaves/plant. Meanwhile, the least values were obtained by as a result of Fortua Red untreated with growth regulators in the first seasons or the same cv. treated with CCC at 1000 ppm in the second one.

Table 1: Effect of some growth regulators on the plant height (cm), number of leaves/pot, number of days from planting to flowering and spike stem length (cm) of three gladiolus cultivars in the two seasons (2015-2016) and (2016-2017).

Graduals cultivars (A)	Treatment (B)	Plant height (cm)		Number of leaves /pot		Number of days from planting to flowering		Spike stem length (cm)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Fortua Red	Control	87.5	87.8	5.6	5.7	76.0	75.2	63.6	66.2
	Atonik1000 ppm	89.4	90.5	5.8	6.0	72.0	73.5	67.9	70.5
	Atonik 2000 ppm	91.9	92.3	5.6	5.8	72.3	71.4	70.6	71.6
	4- CAP 125 ppm	92.6	94.7	5.9	6.4	77.0	79.0	66.5	69.8
	4- CAP 250 ppm	89.8	91.1	5.7	5.9	79.2	80.1	65.2	66.1
	CCC 1000 ppm	82.7	82.9	6.0	5.6	84.1	84.3	59.3 l	64.5
	CCC 2000 ppm	85.8	86.4	6.4	5.7	80.4	82.6	62.5	65.3
	Mean	**88.5**	**89.4**	**5.9**	**5.9**	**77.3**	**78.0**	**65.1**	**67.7**
Wine and Roses	Control	93.3	94.1	6.0	6.0	80.1	81.0	71.2	71.5
	Atonik1000 ppm	99.7	101.2	6.2	6.3	72.2	75.4	77.7	80.2
	Atonik 2000 ppm	108.8	109.6	6.7	6.4	72.0	72.0	80.4	82.7
	4- CAP 125 ppm	96.6	98.3	7.0	6.8	79.4	80.0	73.1	79.2
	4- CAP 250 ppm	93.5	94.7	6.5	6.2	80.0	81.0	73.7	78.4
	CCC 1000 ppm	88.3	88.9	6.3	7.0	80.2	82.6	62.4	68.2
	CCC 2000 ppm	90.6	91.2	6.4	6.5	80.3	81.4	69.6	70.4
	Mean	**95.9**	**96.9**	**6.4**	**6.5**	**77.7**	**79.1**	**72.6**	**75.8**
Peter Pears	Control	101.2	101.0	6.6	6.9	90. 2	89.1	70.1	66.5
	Atonik1000 ppm	105.8	106.4	7.5	7.5	88.5	89.2	73.0	73.9
	Atonik 2000 ppm	103.1	103.8	7.8	7.8	86 .0	84.0	76.1	75.4
	4- CAP 125 ppm	97.3	98.5	7.5	7.5	90 .0	91.3	71.4	72.5
	4- CAP 250 ppm	105.4	107.5	8.0	7.5	90 .1	92.0	70.7	70.1
	CCC 1000 ppm	92.4	93.7	7.8	7.5	92.5	94.4	64.3	66.0
	CCC 2000 ppm	94.7	96.5	7.5	8.0	91.2	92.6	68.7	67.6
	Mean	**99.9**	**101.1**	**7.5**	**7.9**	**89.8**	**90.4**	**70.6**	**70.3**
Control		**93.9**	**94.3**	**6.1**	**6.2**	**82.1**	**81.8**	**68.3**	**68.1**
Atonik1000 ppm		**98.8**	**99.4**	**6.5**	**6.6**	**77.6**	**79.4**	**72.9**	**74.9**
Atonik 2000 ppm		**101.2**	**101.9**	**6.7**	**6.7**	**76.8**	**75.8**	**75.7**	**76.6**
4- CAP 125 ppm		**95.3**	**97.2**	**6.8**	**6.9**	**82.1**	**83.4**	**70.3**	**73.8**
4- CAP 250 ppm		**96.2**	**97.8**	**6.7**	**6.5**	**83.1**	**84.4**	**69.9**	**71.5**
CCC 1000 ppm		**87.8**	**88.5**	**6.7**	**6.7**	**85.6**	**87.1**	**62.0**	**66.2**
CCC 2000 ppm		**90.3**	**91.4**	**6.8**	**6.7**	**84.0**	**85.5**	**66.9**	**67.8**
L.S.D. Gladules (A)		**2.102**	**1.805**	**0.247**	**0.192**	**1.288**	**1.244**	**1.240**	**1.205**
L.S.D. Treatments (B)		**3.210**	**2.757**	**0.377**	**0.292**	**1.967**	**1.900**	**1.894**	**1.841**
L.S.D. AX B		**5.560**	**4.770**	**0.505**	**0.353**	**3.407**	**3.291**	**3.280**	**3.188**

Effect of some growth regulators on flowering traits of the three gladiolus cultivars

Data exhibited in Table (2) indicated that Fortua Red was the earliest gladiolus cultivar to flower in the two seasons, whereas, the latest one was Peter Pears as it required the longest period from planting to flowering. Referring to the effect of growth regulators, it is evident that the earliest flowering was as result of treating corms with Atonik at either 1000 ppm or 2000 ppm in the first season and those which treated with Atonik at 2000 ppm in the second one. These results were with the findings of Bynum *et al.* (2007) who conceded that cotton responded to foliar applications of Chaperone by early flowering. The interactions, on the other side, indicated the prevalence of applying Atonik at 1000 ppm to Fortua Red in the first season and applying Atonik at 2000 ppm to the same cultivar in the second one, in producing the earliest flowering. The latest flowreing was gained due to treating Peter Pears with CCC at 1000 ppm in the two seasons. The delaying effect of CCC was recorded by various investigators on different plants, as mentioned by Patel *et al*. (2010) on gladliolus, Zheng *et al*. (2012) on *Lilium* and Taha (2012) who stated that CCC treatment significantly delayed the flowering date of Iris.

The different gladiolus cultivars were significantly differed in spike stem length in the two seasons. The tallest one was from Wine and Roses cv., whereas the shortest was Fortua Red. On the other hand, the significantly highest spike stem was obtained by the application of Atonik at 2000 ppm, followed in the second rank by using 4-CAP at 125 ppm in the two seasons. Meanwhile, the shortest one was recorded as a result of treating plants with CCC at 2000 ppm in both seasons. Regarding the interaction, treating Wine and Roses with Atonik at 2000 ppm proved its mastery in inducing the longest spike stem in the two seasons. The lowest record was obtained by Fortua Red untreated with growth regulators in both seasons.

Negligible and insignificant effects were observed in rachis length of the three different gladiolus cultivars used in the two seasons. On the other hand, treating plants with Atonik at 2000 ppm proved its mastery in increasing length, in the two seasons. The opposite was the right when using CCC at 1000 ppm, which caused a clear decrement in rachis length compared with the untreated control plants in both seasons. Concerning the interaction, it is evident from data that the clear increment of rachis length was due to applying Atonik at 2000 ppm on Wine and Roses in the two seasons. The lowest records were gained when supplying Wine and Roses plants with CCC at 2000 ppm in the first season, or those of Peter Pears with CCC at 1000 ppm in the season one.

Slight effects on number of florets/spike were noticed in the two seasons, between the different gladiolus cultivars. The different growth regulators also showed slight effects on the same trait in the two seasons. However, the best one was a result of treating plants with Atonik at 2000 ppm in the two seasons. In this respect, an increase in the number of florets/spike was also noted by Widiastoety (1987) who mentioned that Atonik at 500 or 1000 ppm used as spray on *Pitcairnia angustifolia* (Bromeliaceae) significantly increased the number of buds produced. Referring to the interaction, the highest scores were obtained as a result of treating Wine and Roses with Atonik at 2000 ppm in both seasons. The lowest ones resulted when treating Peter Pears with CCC at 1000 ppm in the two seasons.

Negligible differences in fresh weight of cut spike were observed between the different gladiolus cultivar in the two seasons, as indicated in Table (2). On the other side, supplying plants with the highest CCC level (2000 ppm) gave the utmost high values on fresh weight of cut spike in the two seasons, followed in the second degree by those of plants supplied with CCC at 1000 ppm in the second season. The promotive effect of CCC on gladiolus stem was also recorded by Patel *et al*. (2010) and Zheng *et al*. (2012) showed that CCC increased the biomass of stem as it produce more photoassimilates available for transportation and utilization. The interactions indicated the superiority of treating Fortua Red with CCC at 2000 ppm in raising fresh weight of cut spike in both seasons. The lowest records in this regard were obtained by of Peter Pears untreated with growth regulators in the first seasons and that of Fortua Red untreated also with growth regulators in the second one.

Table 2: Effect of some growth regulators on the rachis length (cm), number of florets/spike, fresh weight of spike (g) and dry weight of spike (g) of three gladiolus cultivars in the two seasons (2015-2016) and (2016-2017).

Graduals cultivars (A)	Treatment (B)	Rachis length (cm)		Number of florets/spike		Fresh weight of spike (g)		Dry weight of spike (g)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Fortua Red	Control	33.4	35.2	9.8	10.0	22.5	22.0	3.0	3.1
	Atonik1000 ppm	36.2	40.2	10.7	11.0	20.9	22.2	2.9	3.2
	Atonik 2000 ppm	35.8	36.7	11.6	11.9	26.5	27.8	3.4	3.5
	4- CAP 125 ppm	36.3	38.4	10.3	10.5	25.4	27.1	3.1	3.2
	4- CAP 250 ppm	35.5	37.4	10.1	10.0	21.7	23.4	2.8	2.9
	CCC 1000 ppm	30.4	32.1	9.4	9.3	30.5	33.1	3.0	3.3
	CCC 2000 ppm	35.8	36.9	9.8	9.5	33.3	34.5	3.6	3.7
	Mean	**34.6**	**36.7**	**10.2**	**10.3**	**25.8**	**27.2**	**3.1**	**3.3**
Wine and Roses	Control	33.5	36.2	9. 7	10.2	22.0	23.7	2.7	2.6
	Atonik1000 ppm	37.6	40.1	11.0	11.4	25.1	24.3	2.7	2.8
	Atonik 2000 ppm	40.3	42.0	12.6	13.1a	22.7	26.3	3.3	3.5
	4- CAP 125 ppm	35.1	37.2	10.6	11.0	23.1	24.3	2.8	2.8
	4- CAP 250 ppm	37.3	38.9	10.7	11.3	24.8	25.7	2.3	2.5
	CCC 1000 ppm	34.5	36.4	9.2	9.5	28.1	31.0	3.4	3.3
	CCC 2000 ppm	30.2	33.3	9.6	10.1	30.2	33.9	4.0	4.2
	Mean	**35.5**	**37.8**	**10.5**	**10.9**	**25.1**	**27.0**	**3.0**	**3.1**
Peter Pears	Control	35.3	37.1	9.4	9.9	21.4	22.6	3.4	3.5
	Atonik1000 ppm	37.0	39.5	11.1	11.7	22.8	24.0	3.3	3.6
	Atonik 2000 ppm	39.2	42.8	11.8	12.5	25.4	27.7	3.9	4.2
	4- CAP 125 ppm	36.5	39.6	11.3	11.7	24.4	26.3	3.5	3.9
	4- CAP 250 ppm	32.6	35.6	10.4	10.8	26.5	24.2	3.3	3.5
	CCC 1000 ppm	30.0	33.2	8.5	9.1	29.5	28.2	3.7	3.9
	CCC 2000 ppm	32.8	34.9	9.0	9.5	29.8	30.0	3.9	4.0
	Mean	**34.7**	**37.5**	**10.2**	**10.7**	**25.7**	**26.1**	**3.6**	**3.8**
Control		**34.1**	**36.2**	**9.6**	**10.0**	**21.9**	**22.8**	**3.0**	**3.1**
Atonik1000 ppm		**36.9**	**39.9**	**10.9**	**11.4**	**22.9**	**23.5**	**2.9**	**3.2**
Atonik 2000 ppm		**38.4**	**40.7**	**12.0**	**12.5**	**24.9**	**27.3**	**3.5**	**3.7**
4- CAP 125 ppm		**35.9**	**38.4**	**10.8**	**11.1**	**25.0**	**25.9**	**3.1**	**3.3**
4- CAP 250 ppm		**35.1**	**37.3**	**10.4**	**10.7**	**24.3**	**24.4**	**2.8**	**3.0**
CCC 1000 ppm		**31.6**	**33.9**	**9.0**	**9.3**	**29.4**	**30.8**	**3.4**	**3.5**
CCC 2000 ppm		**32.9**	**35.0**	**9.5**	**9.7**	**31.1**	**32.8**	**3.8**	**4.0**
L.S.D. Gladules (A)		**N.S.**	**N.S.**	**N.S.**	**0.407**	**N.S.**	**0.896**	**0.465**	**0.146**
L.S.D. Treatments (B)		**1.957**	**1.559**	**0.621**	**0.567**	**1.725**	**1.369**	**0.717**	**0.223**
L.S.D. AX B		**3.389**	**2.699**	**1.077**	**0.983**	**2.988**	**2.371**	**1.231**	**0.387**

In both seasons, the significantly highest value of dry weight of cut spike was obtained by the cv. of Peter Pears, followed in the second rank by that of Fortua Red in the two seasons. On the other side, the significantly highest records were a result of CCC application at 2000 ppm in the two seasons. The lowest scores were obtained when using 4-CAP at 250 ppm in both seasons. Referring to the interaction, data outlined in Table (2) indicated the great influence of treating plants of Wine and Roses with CCC at 2000 ppm in raising dry weight of cut spike in the two seasons, in addition to plants of Peter Pears treated with Atonik at 2000 ppm in the second season. An opposite, response was observed on the same parameter when supplying plants of Wine and Roses with Atonik at 1000 ppm or of the same cv. untreated with growth regulators in the first season, as well as those of Wine and Roses plants treated with 4-CAP at 250 ppm in the second one. All of these treatments recorded the lowest means in this regard.

Spike stem diameter showed also significant differences and positive responses when using the different gladiolus cultivars and growth regulators treatments. In this connection, thickest spikes belonged to Fortua Red in both seasons, whereas, thinnest ones were those of Peter Pears in the two seasons. Meanwhile, supplying plants CCC at 2000 ppm proved its mastery in increasing spike stem diameter compared to the other growth regulators, in both seasons. Concerning the interaction, data in

Table (3) indicated the superiority of treating Fortua Red with CCC at 2000 ppm in increasing spike stem diameter compared with that gained from the other treatments, in the two seasons.

Table 3: Effect of some growth regulators on the spike stem diameter (cm), fresh weight of corm (g) and circumference of corm (cm) of three gladiolus cultivars in the two seasons (2015-2016) and (2016-2017).

Graduals cultivars (A)	Treatment (B)	Spike stem diameter (cm)		Fresh weight of corm (g)		Circumference of corm (cm)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Fortua Red	Control	0.74	0.78	35.5	37.1	15.7	16.9
	Atonik1000 ppm	0.80	0.87	43.3	44.8	16.4	18.3
	Atonik 2000 ppm	0.83	0.91	44.3	46.5	15.6	16.8
	4- CAP 125 ppm	0.81	0.88	37.1	38.9	16.2	17.2
	4- CAP 250 ppm	0.78	0.85	36.9	38.1	16.8	18.4
	CCC 1000 ppm	0.82	0.87	38.8	40.3	16.5	17.9
	CCC 2000 ppm	0.90	0.99	45.0	47.2	19.1	21.1
	Mean	**0.81**	**0.88**	**40.0**	**41.9**	**16.6**	**18.1**
Wine and Roses	Control	0.68	0.75	45.6	46.7	16.4	17.2
	Atonik1000 ppm	0.79	0.84	44.5	46.1	18.9	20.2
	Atonik 2000 ppm	0.83	0.90	56.4	58.3	18.6	19.9
	4- CAP 125 ppm	0.78	0.83	47.9	48.4	16.7	18.0
	4- CAP 250 ppm	0.81	0.88	39.2	40.7	18.1	19.7
	CCC 1000 ppm	0.80	0.85	44.6	46.5	17.7	18.9
	CCC 2000 ppm	0.84	0.92	47.9	50.2	18.9	20.3
	Mean	**0.79**	**0.85**	**46.6**	**48.1**	**17.9**	**19.2**
Peter Pears	Control	0.68	0.71	48.9	50.0	18.0	19.3
	Atonik1000 ppm	0.69	0.74	50.7	52.1	18.5	20.1
	Atonik 2000 ppm	0.72	0.80	59.2	61.5	18.1	19.5
	4- CAP 125 ppm	0.71	0.77	49.1	52.3	17.8	18.4
	4- CAP 250 ppm	0.69	0.72	44.2	46.4	19.5	21.0
	CCC 1000 ppm	0.71	0.78	50.7	53.6	18.3	19.6
	CCC 2000 ppm	0.75	0.82	56.1	59.2	19.7	22.0
	Mean	**0.71**	**0.76**	**51.2**	**53.6**	**18.6**	**20.0**
Control		**0.70**	**0.75**	**43.3**	**44.6**	**16.7**	**17.8**
Atonik1000 ppm		**0.76**	**0.82**	**46.2**	**47.7**	**17.9**	**19.5**
Atonik 2000 ppm		**0.79**	**0.87**	**53.5**	**55.4**	**17.4**	**18.7**
4- CAP 125 ppm		**077**	**0.83**	**44.7**	**46.5**	**16.9**	**17.9**
4- CAP 250 ppm		**0.76**	**0.82**	**40.1**	**41.7**	**18.1**	**19.7**
CCC 1000 ppm		**0.77**	**0.83**	**44.7**	**46.7**	**17.5**	**18.8**
CCC 2000 ppm		**0.83**	**0.91**	**49.6**	**52.2**	**19.2**	**21.1**
L.S.D. Gladules (A)		**0.124**	**0.120**	**1.692**	**1.560**	**1.124**	**0.986**
L.S.D. Treatments (B)		**0.189**	**0.184**	**2.584**	**2.384**	**1.717**	**1.506**
L.S.D. AX B		**0.328**	**0.318**	**4.476**	**4.128**	**2.974**	**2.609**

Effect of some growth regulators on newly formed corms and cormlets of the three gladiolus cultivars

Considerable variations were observed on fresh weight of corms of the three gladiolus cultivars in the two seasons. The heaviest fresh weight of the produced corms belonged to Peter Pears in both seasons, followed in the second degree by those produced from Wine and Roses with significant difference in, both seasons. On the other side, the effect of growth regulators on corms showed the superiority of Atonik at 2000 ppm in producing the heaviest corm fresh weight in the two seasons. In contrast, the least scores were obtained by using plants 4-CAP at 250 ppm, in the two seasons. Concerning the interaction, it is evident from tabulated data that treating Wine and Roses with Atonik at 2000 ppm resulted in the heaviest fresh weight of the newly formed corms in the two seasons. On the contrary, the least records of the same trait were those of new corms produced from Fortua Red cv. untreated with growth regulators, in both seasons.

The significantly highest corm circumference was that of Peter Pears, in the two seasons, whereas the lowest one was obtained by Fortua Red in both seasons. On the other side, treating plants with CCC at 2000 ppm resulted in the largest corm circumference in the two seasons, followed without significant difference by plants received 4-CAP at 250 ppm in both seasons. In contrast, the lowest corm circumference was a result of untreated control plants in the two seasons. Concerning the interaction, it is evident from data outlined in Table (4) that the largest corm circumference was obtained as a result of treating Peter Pears with CCC at 2000 ppm, in the two seasons. The least scores of such trait was obtained as a result of untreated Fortua Red cv. in the two seasons.

Table 4: Effect of some growth regulators on the cormlets/plot (cormlets yield) and fresh weight of cormlet (g) of three gladiolus cultivars in the two seasons (2015-2016) and (2016-2017).

Graduals cultivars (A)	**Treatment (B)**	**Cormlets/plot**		**Fresh weight of cormlet (g)**	
		1st Season	**2nd Season**	**1st Season**	**2nd Season**
Fortua Red	Control	22.0	24.3	1.61	1.94
	Atonik1000 ppm	23.8	26.0	1.82	2.13
	Atonik 2000 ppm	32.9	35.4	1.35	1.64
	4- CAP 125 ppm	23.5	26.1	1.65	1.97
	4- CAP 250 ppm	22.4	23.9	1.58	1.91
	CCC 1000 ppm	38.8	39.7	0.92	1.29
	CCC 2000 ppm	44.7	46.4	1.00	1.36
	Mean	**29.7**	**31.7**	**1.42**	**1.75**
Wine and Roses	Control	25.5	26.8	1.79	1.99
	Atonik1000 ppm	40.6	42.6	1.10	1.24
	Atonik 2000 ppm	38.0	39.3	1.48	1.85
	4- CAP 125 ppm	23.3	25.4	2.06	2.34
	4- CAP 250 ppm	25.3	28.0	1.55	1.79
	CCC 1000 ppm	24.0	26.9	1.69	1.94
	CCC 2000 ppm	28.5	31.1	1.87	2.02
	Mean	**29.3**	**31.4**	**1.65**	**1.88**
Peter Pears	Control	39.5	40.7	1.24	1.51
	Atonik1000 ppm	37.2	39.1	1.36	1.57
	Atonik 2000 ppm	47.5	50.3	1.23	1.46
	4- CAP 125 ppm	27.5	29.8	1.93	2.16
	4- CAP 250 ppm	23.0	25.4	1.79	2.00
	CCC 1000 ppm	29.5	33.5	1.64	1.87
	CCC 2000 ppm	34.2	37.1	1.72	1.98
	Mean	**34.1**	**36.6**	**1.56**	**1.78**
Control		**29.0**	**30.6**	**1.55**	**1.81**
Atonik1000 ppm		**33.9**	**35.9**	**1.43**	**1.65**
Atonik 2000 ppm		**39.5**	**41.7**	**1.35**	**1.65**
4- CAP 125 ppm		**24.8**	**27.1**	**1.88**	**2.10**
4- CAP 250 ppm		**23.6**	**25.8**	**1.64**	**1.90**
CCC 1000 ppm		**30.8**	**33.4**	**1.42**	**1.70**
CCC 2000 ppm		**35.8**	**38.2**	**1.53**	**1.78**
L.S.D. Gladules (A)		**1.011**	**1.616**	**0.113**	**0.101**
L.S.D. Treatments (B)		**1.545**	**2.469**	**0.173**	**0.155**
L.S.D. AX B		**2.676**	**4.277**	**0.299**	**0.269**

Number of cormlets/plot (cormlets yield) of the different gladiolus cultivars significantly different in both seasons. The highest values belonged to Peter Pears followed by those of the other two cultivars, which were closely similar. Concerning the effect of growth regulators, data registered in Table (4) showed the superiority of treating plants with Atonik at 2000 ppm in raising cormlets yield, which occupied the first rank in both seasons, followed by CCC at 2000 ppm in both seasons. The increment in the yield of cormlets of gladiolus plant was also studied by Patel *et al* (2010), Sudhakar and Kumar (2012) and Pramod (2016). Concerning the interaction, the significantly highest record of cormlets yield was observed in Fortua Red treated with CCC at 2000 ppm in the two seasons. Meanwhile, the opposite was obtained from the same cv. untreated with growth regulators, which gave the lowest records in the two seasons.

The heaviest fresh weight of cormlets was obtained by using Wine and Roses, followed in the second rank by Peter Pears while Fortua Red scored the least values in the two seasons. The effect of growth regulators on the same character, revealed the superiority of treating plants, with 4-CAP at 125 ppm in producing the heaviest fresh weight of cormlets, followed in the second category by that obtained by using 4-CAP at 250 ppm, in both seasons. The least scores were registered as a result of using Atonik at either 1000 or 2000 ppm in both seasons, in addition to of that gained by treating plants CCC at 1000 ppm in the first season. With respect to the interaction, data in Table (4) showed the great influence of treating plants of Wine and Roses 4-CAP at 125 ppm in producing the heaviest fresh weight of cormlets in the two seasons. On the contrary, the lowest values of the same parameter were obtained as a result of treating Fortua Red by CCC at either 1000 or 2000 ppm in the first season and those of plants of the same cv. supplied with CCC at 1000 ppm in the second one.

Effect of some growth regulators on chemical constituents of the three gladiolus cultivars
Pigments content in leaves

The significantly highest chlorophyll (a) content in leaves was registered in Peter Pears in the two seasons as shown in Table (5). The leaves scores were gained resulting from Fortua Red in the two seasons. On the other side, supplying plants with CCC at 2000 ppm proved its mastery in elevating the same constituent in both seasons. Meanwhile, the interaction indicated the superiority of treating either Wine and Roses or Peter Pears with the highest level of CCC (2000 ppm) in increasing chlorophyll (a) content in leaves in the two seasons. The effect of CCC in this concern was described by Zheng *et al*. (2012) who found that CCC treatment substantially enhanced the sucrose contents in leaves probably due to the increase of chlorophyll contents on *Lilium* plants. Also, Taha (2012) on *Iris* plants found that CCC treatments significantly increased total chlorophyll content of the leaves. Youssef *et al* (2013) on *Tabernaemontana coronaria*, Osman (2014) on *Solidago canadensis* plant and Kasem and Abd El-Baset (2015) on *Lolium perenne* reported that CCC treatments significantly increased total chlorophyll content.

On the other side, slight differences, were noticed in chlorophyll (b) content in leaves of the different gladiolus cultivars in both seasons. Applying the different growth regulators treatments resulted in clear differences in chlorophyll (b) in leaves, where the utmost values were obtained when applying CCC at 2000 ppm in the two seasons. Concerning the interaction, treating Wine and Roses and Peter Pears with CCC at 2000 ppm revealed the superiority in increasing chlorophyll (b) content in the two seasons.

Concerning carotenoids content in leaves, it is evident from tabulated date that slight differences were observed between the different gladiolus cultivars in the two seasons as their means were closely similar. Using CCC at either 1000 or 2000 ppm proved their superiority in elevating careteniods content in leaves in both seasons. With respect to the interaction, it is clear from the registered values the superiority of supplying the three gladiolus cultivars with the highest level of CCC in the two seasons. The great influence of CCC in improving carotenoids of the plant was noticed by Osman (2014) who proved that application of CCC led to significantly increased carotenoids of *Solidago Canadensis*. Meanwhile Kasem and Abd El-Baset (2015) on *Lolium perenne* recorded the increase in the pigments content (total chlorophyll and carotenoids) than the control.

Total carbohydrates content:

In both seasons, the significantly highest record of total carbohydrates content in the newly formed corms was noticed in Wine and Roses followed without significant difference by those of Fortua Red in the two seasons as illustrated in Table (5). The least scores, belonged to Peter Pears. On the other side, supplying plants with CCC at 2000 ppm proved its mastery in producing the highest total carbohydrate content in the newly formed corms in both seasons. The interaction indicated the prevalence of Wine and Roses treated with CCC at 2000 ppm in recording the highest means of total carbohydrates in the two seasons. The opposite was right the untreated of Peter Pears plants in the two seasons, which scored the lowest means in this regard. In this connection Zheng *et al.* (2012) stated that the treatment with chlorocholine chloride (CCC) decreased GA but increased IAA contents in lily bulbs which might stimulate starch accumulation and formation of new scales and suggested that CCC treatment is an effective method to promote carbohydrate accumulation in lily bulbs. Medina *et al*. (2012) showed that starch content increased by chlorocholine chloride (CCC) applied to cassava plants and Youssef *et al* (2013) on *Tabernaemontana coronaria*.

Table 5: Effect of some growth regulators on the chlorophyll a, chlorophyll b, carotenoids (mg/g fw) and total carbohydrates (mg/g dw) in the bulbs of three gladiolus cultivars in the two seasons (2015-2016) and (2016-2017).

Graduals cultivars (A)	Treatment (B)	Chlorophyll a (mg/g fw)		Chlorophyll b (mg/g fw)		Carotenoids (mg/g fw)		Total carbohydrates (mg/g dw)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Fortua Red	Control	1.57	1.65	0.67	0.65	0.69	0.72	15.8	15.6
	Atonik1000 ppm	1.84	1.88	0.76	0.77	0.80	0.81	21.6	22.1
	Atonik 2000 ppm	1.85	1.92	0.79	0.80	0.83	0.85	23.7	24.6
	4- CAP 125 ppm	1.83	1.89	0.77	0.79	0.82	0.84	22.9	23.7
	4- CAP 250 ppm	1.80	1.84	0.75	0.76	0.80	0.83	21.7	21.9
	CCC 1000 ppm	1.92	1.97	0.83	0.85	0.86	0.89	23.0	25.2
	CCC 2000 ppm	2.07	2.13	0.91	0.92	0.93	0.94	25.3	26.3
	Mean	**1.84**	**1.89**	**0.78**	**0.79**	**0.82**	**0.84**	**22.0**	**22.9**
Wine and Roses	Control	1.67	1.75	0.69	0.70	0.70	0.70	16.3	17.1
	Atonik1000 ppm	2.07	2.10	0.78	0.78	0.83	0.84	22.5	23.7
	Atonik 2000 ppm	2.19	2.20	0.81	0.83	0.85	0.87	25.3	25.9
	4- CAP 125 ppm	2.13	2.17	0.78	0.79	0.83	0.85	22.4	22.8
	4- CAP 250 ppm	1.91	2.00	0.77	0.78	0.81	0.84	21.9	22.5
	CCC 1000 ppm	2.15	2.16	0.85	0.87	0.88	0.90	24.6	25.6
	CCC 2000 ppm	2.34	2.37	0.93	0.95	0.94	0.95	26.8	28.9
	Mean	**2.06**	**2.10**	**0.80**	**0.81**	**0.83**	**0.85**	**22.8**	**23.8**
Peter Pears	Control	1.69	1.72	0.69	0.68	0.72	0.74	14.6	14.8
	Atonik1000 ppm	2.13	2.19	0.80	0.81	0.85	0.86	20.3	21.6
	Atonik 2000 ppm	2.18	2.23	0.83	0.85	0.86	0.88	22.5	24.5
	4- CAP 125 ppm	2.11	2.16	0.82	0.84	0.85	0.87	19.4	20.7
	4- CAP 250 ppm	2.05	2.12	0.78	0.78	0.83	0.83	20.2	21.8
	CCC 1000 ppm	2.27	2.30	0.87	0.89	0.89	0.90	22.9	24.3
	CCC 2000 ppm	2.39	2.38	0.95	0.96	0.96	0.98	25.1	27.5
	Mean	**2.12**	**2.15**	**0.82**	**0.83**	**0.85**	**0.87**	**20.6**	**22.2**
Control		**1.64**	**1.71**	**0.68**	**0.68**	**0.70**	**0.72**	**15.6**	**15.8**
Atonik1000 ppm		**2.01**	**2.06**	**0.78**	**0.79**	**0.83**	**0.84**	**21.5**	**22.7**
Atonik 2000 ppm		**2.07**	**2.12**	**0.81**	**0.83**	**0.85**	**0.87**	**23.8**	**25.0**
4- CAP 125 ppm		**2.00**	**2.07**	**0.79**	**0.81**	**0.83**	**0.85**	**21.6**	**22.4**
4- CAP 250 ppm		**1.92**	**1.99**	**0.77**	**0.77**	**0.81**	**0.83**	**21.3**	**22.1**
CCC 1000 ppm		**2.11**	**2.14**	**0.85**	**0.87**	**0.88**	**0.90**	**23.5**	**25.0**
CCC 2000 ppm		**2.26**	**2.29**	**0.93**	**0.94**	**0.94**	**0.96**	**25.7**	**27.6**
L.S.D. Gladules (A)		**0.026**	**0.025**	**0.027**	**0.029**	**0.027**	**0.028**	**0.996**	**1.103**
L.S.D. Treatments (B)		**0.043**	**0.041**	**0.042**	**0.045**	**0.042**	**0.043**	**1.522**	**1.683**
L.S.D. AX B		**0.075**	**0.074**	**0.072**	**0.078**	**0.074**	**0.077**	**2.635**	**2.920**

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