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Response of *Freesia refracta* (Jacq), Plant to Corms Cold Storage, Gibberellic Acid and their Interactions in North Delta, Egypt

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ABSTRACT

Freesia refracta belongs to the ornamental flowering bulbs (Fam. Iridaceae). It is used as flowering pot plants and cut flowers. The effect of corm storage temperature and duration, and the optimum levels of growth regulators especially gibberellic acid on freesia have not been previously studied under North Delta conditions. So, this work was conducted at Sakha Horticultural Research Station, Kafr El-Sheikh Governorate, Egypt, (situated at 31-57°/ N latitude and 30 -57° longitude and an elevation of about 6 m above sea level) during two successive seasons of 2012/2013 and 2013/2014 to study the effect of corms storage treatments and gibberellic acid foliar spray on plants and their interaction on some morphological and physiological traits**,** aiming to plant it in a large scale, since it became seldom planted in Egypt. Results indicated that plant height; fresh and dry weights of leaves were significantly increased as a result of corm cold storage treatments. Moreover, all cold storage treatments tended to induce a steady and significant increase in flowering precocity, spike length, as well as fresh and dry weights of spike, rachis length, number of florets per spike, vase life, cormels number and fresh and dry weights of the daughter corm by prolonging cold storage period in both seasons as compared to the control plants. The percentages of nitrogen, phosphorus, potassium and total carbohydrates in the leaves increased as a result of these treatments. Also, all cold storage treatments tended to induce a steady and significant increase in photosynthetic pigments such as chlorophyll (a), chlorophyll (b) and carotenoids as well as most of the studied characteristics which were significantly increased due to application of gibberellic acid. Referring to the interaction between the two factors, data showed the superiority of storing corms for 6 weeks at 5°C coupled with spraying plants whith gibberellic acid at 200 ppm, 30 days after planting corms, three times at 3 weeks interval. In brief, for obtaining plants of *Freesia refracta* with good morphological and physiological traits, it is recommended to store corms for 6 weeks at 5°C coupled with gibberellic acid foliar spray at 200 ppm, 30 days after planting corms, three times at three weeks interval under similar conditions of this investigation.

Key words: *Freesia refracta, corm storage, growth regulators, gibberellic acid*

Introduction

Freesia refracta, (Jacq), (Fam Iridaceae) is commonly known as freesia. In botanical terminology it is referred to as a cormous plant. In Netherlands, it occupies a considerable rank among cut flowers, besides roses, carnation and chrysanthemum. It could be easily transported since they are light in weight. It was vividly colored and has a somewhat fragrant Inflorescence. It belongs to the geophyte plants group, so it needs a cold period to ensure vegetative growth and development of flowering.

Among several naturally occurring environmental factors, temperature plays a predominant role in controlling proper growth and flowering in ornamental geophytes, it is the major environmental factor that influences the flowering process from flower initiation to development in plants (Roh and Hong 2007). Prolonged cold increases sensitivity to auxins, which induces shoot growth. The induction of growth triggers the remobilization of all reserve metabolites in bulbs, increases respiration and water flux and the onset of gibberellin biosynthesis. Accumulation of gibberellins leads to an enhanced expression of invertase genes, which provides the hexoses necessary for shoot elongation and leads to proper stalk elongation and flowering. Auxins probably affect the onset of gibberellin synthesis (Khodorova and Boitel-Conti, 2013).

Numerous studies have shown the effects of cold storage temperature on the physiological pattern and morphological traits, as Sochacki and Chojnowska (2005) and Asghri (2014) on *Tulipa gesneriona*, EL-Bably and Mahmoud (2009) on *Tritonia crocata*, Padmalatha *et al.*,(2013), Bhujbal *et al*., (2014) and Khan *et al*., (2013) on gladiolus, and Patcharaphorn and Rumrungsri (2013) on *Eucomis autumnalis.*

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Growth regulators are used to mediate internal hormones, as depending on the time of application and concentration they stimulate or inhibit flowering (Viemont and Crabbe 2000). Gibberellic acid is known for its role in the elongation of axial organs (stems, petioles and inflorescences), flower development (Hsu *et al*., 2008). Rani and Singh (2013) reported that gibberellic acid at 150 ppm stimulated most of the vegetative growth, flowering and bulbous characteristics in tuberose. Gibberellic acid treatments are known to play important role in promoting diverse processes throughout the development of plant, induced early flowering, and increasing height of plant, number of leaves, chlorophyll content, yield and quality in different flowering crops (Tyagi and Singh 2006; Abdel-Wahid and Sweify 2009; Janowska and Andrzejak (2010, 2013); Emami *et al*., 2011; Sure *et al*., 2012 ; Kumar *et al*., 2013). In case of bulbous ornamental plants, gibberellins stimulate the of the plant height, length of flower stalk, flower size, duration of flowering, induce early flowering, increase number of roots, corm size, encourage more cormel production and also lengthening the life of the spike to a significant extent (Singh and Jitendra, 2008). Gibberellic acid is involved in several plant development processes and promote number of desirable effects including stem elongation, uniform and early flowering, and increase flower number (Ertan and Ayan, 2005; Al-Khassawneh *et al*., 2006; Pogroszewska *et al*., 2007). In gladiolus application of chemicals plant growth regulators was found to improve the growth and flowering of cut spike (Raju *et al*., 2008). Shakarami *et al*. (2013) mentioned that the effect of gibberellic acid treatment was useful for the dormancy breaking in gladiolus corm. It determines important physiological changes such as cell division and expansion, and promotes flowering (Vieira *et al*., 2010). It is known to stimulate physiological responses in plants and alter the source-sink metabolism through their effect on photosynthesis and sink formation (Iqbal *et al*., 2011). Sajjad *et al*. (2014 and 2015) found that the foliar application of plant growth regulators improved the economically important characteristics of gladiolus flower. Aier *et al*., (2015) reported that gibberellic acid at 200 ppm recorded the significantly highest plant number of leaves the minimum days taken for the first floret to show color as well as increased length of spike, rachis length, number of florets per spike and fresh and dry weight of spike.

Concerning the interaction between the two factors, Bhujbal *et al*. (2014) concluded that gladiolus corm dormancy will be broken by the use of growth regulators and cold storage treatments. Previous studies indicate that cold storage and gibberellic acid in our production system can help the growers to improve the growth and flowering traits of freesia which will ultimately lead to score more prices in the domestic and international markets. However, under north Delta climatic conditions, quality flower production is severely affected by lack or flowering distorted one, small flower stalk, and short vase life. Hence, this study was performed to evaluate the potential of cold storage and gibberellic acid effect to obtain good morphological and physiological traits of *Freesia refracta* in North Delta (Egypt).

Materials and Methods

Corms of *Freesia refracta* of 3-5 g weight were selected in both seasons.

Four types of corm storage treatments were chosen in both seasons as follows:

1. Control [storage at room (room) temperature of 27^{o}C ± 3] from lifting corms till planting .This group had zero days of storing at 5^{o}C
2. Storage at 5^{o}C for 2, 4 and 6 weeks and relative humidity of 80%.
3. Gibberellic acid (GA_3) spray at, (G_0) 100 ppm (G_1) and 200 ppm (G_2).

The procedure:

The corms were lifted from the soil in mid of May, and after examining and cleaning, they were then stored as previously mentioned. The corms were planted at a spacing of 10 cm x 5 cm at a depth of 3-5 cm depth of soil surface on October 21th of each season. The plants were fertilized with kirstallon (19:19:19) at 5g/ l. Fertilizers were dispensed in three equal portions, the first was sprayed one month after planting, and the second applied a month later, while the third was applied after cutting spikes. Gibberellic acid was applied after one month of planting three times at three weeks interval.

Irrigation and agricultural practices were done whenever plants needed as local growers did. Factorial experiment in randomized complete block design was used, and the12 treatments were replicated three times and distributed within each block. Duncan's multiple range tests were used for the comparison between means of treatments according to Snedecor and Cochran (1980). The following data were recorded:

Vegetative and flowering parameters:

Plant height, number of leaves per plant, fresh and dry weights of leaves/plant, flowering date (as number of days from planting to the first flower bud open), spike length, fresh and dry weights of spike, rachis length, number of florets/spike, vase life (three similar spikes from each replicate were chosen at the stage of the first floret opening and put in a vase containing distilled water), number of produced corms/plant (corms yield), fresh and dry weights of the principal corm. Data on vegetative growth and flowering were recorded at flowering time, i.e. February, while those of corms were estimated after the end of flowering duration when the plants began to wilt, i.e. in April.

Chemical analyses:

Percentages of N, P and K of dried leaves and new corms were determined at the end of the experiment according to the following methods: Nitrogen was determined by micro-kjeldahle apparatus (Blake, 1965). Phosphorus was colorimetrically determined using ascorbic acid method (John, 1970). Potassium was determined using the flame photometer (Dewis and Freitas, 1970). Total carbohydrates % in the leaves and new corms were determined using colorimetric method described by Herbert *et al*. (1971). Determinations of chlorophyll (a), (b) and carotenoids were carried out according to Wettstein, (1957). The physical and chemical analysis of the used soil before the planting is shown in Table (A) and performed according to Jackson, (1967).

Table a: Physical and chemical analysis of the used soil mixture (average of both seasons).

Physical properties	(%)	Chemical analyses:	
Clay	55.5	pH	8.0
Silt	13.4	EC dsm^{-1} (Soil paste extract)	2.3
Fine sand	12.5	Organic matter	1.7
Coarse sand	18.6	Available-N mg^{-1} (1M KCL extract)	31
Soil texture	Clayey	Available-P mg^{-1} (0.5N $NaHCO_3$ extract)	6.1
		Available-K mg^{-1} (Ammonium acetate extract)	240

Table b: Mean of some meteorological data for Kafr El –Sheikh area during 2012, 2013 and 2014 seasons according to Sakha meteorological data of Agricultural Research Station

Month	T (°C)			RH (%)			Ws	Pan Evap. (mm/ day).	Rain (mm)
	Max.	Min.	Mean	Max.	Min.	Mean	(m/sec)		
2012									
Oct.	29.92	19.64	20.64	85.24	55.31	70.27	0.69	2.72	3.28
Nov.	25.32	15.47	20.40	89.53	61.80	75.67	0.66	1.87	28.20
Dec.	21.35	10.52	15.94	84.77	60.83	72.80	0.73	4.15	81.90
	Max.	Min.	Mean	Max.	Min.	Mean	m/sec		
2013									
Jan.	19.22	7.62	13.42	91.06	65.35	78.21	0.52	1.99	78.74
Feb.	20.68	8.88	14.78	89.89	64.04	76.97	0.73	2.89	0.00
Mar.	24.56	12.45	18.51	79.48	50.84	65.16	1.03	4.46	0.00
April.	26.04	15.87	20.96	74.20	43.90	59.05	1.11	5.30	8.40
May	31.43	21.85	26.64	75.03	45.78	60.41	1.20	6.35	0.00
June	32.44	23.97	28.21	74.63	51.27	62.95	1.34	6.61	0.00
July	32.32	24.31	28.32	79.57	54.70	67.14	1.28	6.11	0.00
August.	33.79	24.72	29.29	83.63	60.52	72.08	1.04	5.13	0.00
Sep.	32.50	22.93	27.72	81.00	56.60	68.80	1.01	3.82	0.00
Oct.	27.79	19.42	23.61	76.23	57.36	66.80	1.26	2.87	0.00
Nov.	25.39	15.14	20.27	87.00	64.43	75.72	0.80	2.28	0.00
Dec.	19.64	8.51	14.06	92.07	67.61	79.84	0.61	4.15	81.9
2014									
Jan.	20.34	7.55	13.95	93.69	70.55	80.55	0.54	1.60	20.7
Feb.	20.64	8.19	14.42	91.90	67.15	79.53	0.79	2.52	16.5
Mar.	22.94	11.71	17.33	86.10	56.80	71.45	0.96	3.14	26.2
April.	27.50	15.53	21.52	81.80	49.80	65.8	1.07	4.91	20.2
May	30.47	19.57	25.02	77.20	48.60	62.90	1.14	5.87	0.00
June	32.65	20.6	26.63	86.23	52.30	69.27	0.95	6.56	0.00
July	33.15	23.64	28.40	83.19	55.11	69.15	1.13	7.73	0.00
August	34.10	21.80	27.95	92.40	53.50	72.95	1.15	8.14	0.00
Sep.	32.49	20.76	26.63	87.57	52.20	69.89	1.03	6.65	0.00
Oct.	29.75	18.75	24.25	80.92	53.39	67.16	0.95	4.51	0.00
Nov.	24.30	13.79	19.05	87.80	60.50	74.15	0.78	2.77	24.6
Dec.	22.27	9.72	16.00	88.60	63.50	76.05	0.53	1.72	5.7

Wind speed (w_s).

Results and Discussion

Effect on some vegetative growth traits:

Plant height:

Data presented in Table (1) indicated that all cold storage treatments resulted in significantly taller plants than control plants in both seasons. The highest record resulted from the treatment of storage for 6 weeks as it gave 14.98 and 17.39 cm against 10.28 and 11.56 cm for the control plants in the first and second seasons, respectively.

These results may be due to the increase in gibberellin content and activity in the corms during cold storage treatments especially by prolonging the period of storage (Alpi *et al*., 1976). Similar results were observed by Suh *et al*., (2000) on *Ornithogalum* and EL-Bably and Mahmoud (2009) on *Tritonia*.

Concerning gibberellic acid treatments, data in the same Table indicated that the high level of gibberellic acid (200 ppm) significantly increased the plant height in comparison to control treatment. The recorded values were 13.62 and 15.38 cm, while the untreated plants (G_0) recorded 12.22 and 14.32 cm in the two seasons, respectively.

These results are logic since gibberellic acid increased height of plants due to the growth promoting effect an stimulating and accelerating cell division, increasing cell elongation ,cell enlargement or both as mentioned by Taiz and Zeiger (1998) on gladiolus. Similar results were obtained by Al-Khassawreh *et al.,* (2006) on black iris, Bhalla and Kumar (2008) on gladiolus, Asil *et al*., (2011) on *Polianthes tuberosa*, Kumar *et al.,* (2013) on tulip and Aier *et al*., (2015) on gladiolus cv. Red Candyman.

Regarding the interaction between storage treatments and gibberellic acid throughout the two experimental seasons, data presented in Table (1) indicated that the tallest plants resulted from planting corms which were stored for 6 weeks and spraying with gibberellic acid at the rate of 200 ppm, as it gave, 16.09 and 17.80 cm in the first and second seasons, respectively. However, the plants untreated with gibberellic acid and stored at room temperature gave the least values of 10.05 and 11.11 cm in both seasons, respectively.

Table 1: Effect of corm storage treatments, gibberellic acid foliar spray and their interaction on some vegetative growth traits of *Freesia refracta* during 2012/2013 and 2013/2014 season.

Treatments	Plant height (cm)				No. of leaves/plant				Fresh weight of leaves (g)				Dry weight of leaves (g)			
	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean
	First season (2012/2013)															
0 (Control)	10.05 g	10.09 g	10.71 f	10.28 D	6.7 cd	6.7 cd	6.8 cd	6.7 D	6.6 c	7.3 bc	7.0 b	6.9 D	2.0	2.1	2.3	2.1 C
2 weeks	11.13 e	12.08 d	13.42 c	12.21 C	6.8 cd	6.9 c	7.0 bc	6.9 C	7.4 bc	7.8 bc	7.9 bc	7.7 C	2.4	2.6	2.9	2.6 B
4 weeks	13.63 c	13.96 c	14.27b	13.94 B	7.0 bc	7.2 bc	7.5 b	7.2 B	7.8	7.9	8.8b	8.1 B	2.5	2.7	2.7	2.6 B
6 weeks	14.07 bc	14.80b	16.09a	14.98 A	7.8 ab	7.9 ab	8.0 a	7.9 A	8.4b	8.9b	9.4 a	8.9 A	2.7	2.9	3.1	2.9 A
Mean	12.22 C	12.73 B	13.62 A		7.0 B	7.1 AB	7.3 A		7.5 C	7.9 B	8.2 A		2.4 C	2.5 B	2.7 A	
	Second season (2013/2014)															
0 (control)	11.11 d	11.51 d	12.08 c	11.56 D	6.0 b	6.3 b	6.3 b	6.2 C	7.1 c	7.0 c	7.4 c	7.1 C	2.1 b	2.3 ab	2.5 ab	2.3 C
2 weeks	13.33 c	13.75 c	14.46 b	13.84 C	7.3 ab	7.0 ab	7.3 ab	7.2 B	8.6 b	8.4 b	8.7 b	8.5 B	2.3 ab	2.5 ab	2.7 a	2.5 B
4 weeks	15.84 b	17.01 a	17.21 a	16.68 B	7.6 a	7.7 a	7.9 a	7.7 AB	9.0 b	9.8 ab	9.0 b	9.2 B	2.5 ab	2.7 a	2.9 a	2.7 A
6 weeks	17.00 a	17.37a	17.80 a	17.39 A	7.9 a	8.0 a	8.3 a	8.0 A	9.7 ab	9.9 a	11.0 a	10.2 A	2.6 a	2.8 a	2.9 a	2.7 A
Mean	14.32 C	14.91 B	15.38 A		7.2 A	7.2 A	7.4 A		8.6 B	8.8 AB	8.9 A		2.3 C	2.5 B	2.7 A	

Means within a column having the same letters are not significantly different according to Duncan's multiple range test.

Number of leaves per plant:

Data presented in Table (1) indicated that the treatment of storing corms for 6 weeks gave records of 7.9 and 8.0 leaves/plant against 6.7 and 6.2 leaves/plant for control plants in both seasons, respectively.

Regarding the treatments of gibberellic acid, it is evident from Table (1) that using gibberellic acid affected leaf number per plant with non–significant differences among the two GA_3 treatments. The treatment of 200 ppm gave 7.3 and 7.4 leaves/plant against 7.0 and 7.2 leaves/plant for the control treatment in both seasons, respectively. Increased number of leaves per plant was also obtained by, Rani and Singh (2013) on *Polianthes tuberosa*, Bhalla and Kumar (2008) and Aier *et al.,* (2015) on gladiolus.

As regards the interaction between the two studied factors, it is obvious from the results presented in Table (1) that the highest records resulted from planting corms which were stored for 6 weeks and their plants were not sprayed with GA_3 at 200 ppm, as it gave 8.0 and 8.3 leaves/plant, while the corms stored at room temperature and non treated with GA_3 gave the least values of 6.7 and 6.0 leaves/plant in both seasons, respectively.

Fresh weight of leaves/plant:

It is obvious from data presented in Table (1) that all cold storage treatments significantly increased the fresh weight of leaves over control plants. The significantly highest value was obtained from the treatment of storage for 6 weeks as it gave 8.9 and 10.2 g against 6.9 and 7.1 g for the control treatment in the first and second season, respectively.

The effect of cold storage treatments on fresh weight of leaves may be due to the stimulatory effect of cold storage on converting the complex stored metabolites in the corms to more soluble forms available for plant growth especially by prolonging the storage period. Similar results were obtained by El-Bably (2003) on *Antholyzia aethiopica* and El-Bably and Mahmoud (2009) on *Tritonia crocata.*

Regarding the effect of gibberellic acid treatments data presented in the same Table showed that using gibberellic acid at the rate of 200 ppm significantly increased the fresh weight of leaves over control plants. Applying GA_3 at 200 ppm recorded 8.2 and 8.9 g, while the control plants recorded 7.5 and 8.6 g in the two seasons, respectively.

Referring to the interaction between the two factors, data in the same table showed the superiority of storing corms for 6 weeks and spraying plants with GA_3 at 200 ppm, as it gave the heaviest leaves fresh weight over the other treatments in both seasons. This treatment gave 9.4 and 11.0 g while control treatment gave the least values of 6.6 and 7.1 g in two seasons, respectively.

Dry weight of leaves:

In regard to the effect of cold storage period, data presented in Table (1) indicated a similar trend of dry weight of freesia leaves as that of fresh weight of leaves to some extent and may be interpreted in the same way.

As for using gibberellic acid foliar spraying, data in the same Table showed that GA_3 at 200 ppm, significantly increased the dry weight of leaves over untreated plants, as they recorded 2.7 g, in each seasons, while the control plants gave 2.4 and 2.3 g for the two seasons respectively.

The influence of the interaction between storage and gibberellic acid treatments is shown in the same Table (1). It pointed out that the significantly highest dry weight resulted from using corms stored for 6 weeks and spraying plants with gibberellic acid at the level of 200 ppm as it gave 3.1 and 2.9 g, while control treatments gave the least values of 2.0 and 2.1 g in the two seasons, respectively.

Effect on some flowering traits:

Flowering date:

From the recorded data in Table (2), it can be concluded that the different cold storage treatments caused a steady and significant precocity in flowering by prolonging cold storage period compared with corms stored at room temperature throughout the two seasons. The earliest flowering resulted significantly form planting the corms stored for 6 weeks as it occurred after 102.3 and 104.5 days against 126.6 and 122.5 days for control plants in the two seasons, respectively. Armitage *et al*., (1996) planted *Oxalis adenophylla* and *Ipheion uniflorum* bulbs, which were stored at 5°C for 0, 6, 10, 14 or 18 weeks before planting, and found that time to flowering decreased for both species with increasing duration of cooling. The low temperature effectively stimulates the flower formation in meristem tissue by changing leaf bud to flower bud (Ruamrungsri, 2001). Also, cold storage had a significant effect on flowering acceleration of *Iris tingitana* (Atta-Alla and Zaghloul 2002).

Concerning gibberellic acid treatments data presented in Table (2) indicated that high levels of G_2 induced earlier flowering after 110.6 and 112.7 days comparing with 116.0 and 117.8 days of the control plants in both seasons, respectively.

Early flowering of treated plants by gibberellic acid might be due to its vital role in the production and regulation of floral stimulus (Taha, 2012). The previous results are in agreement with those attained by Asil *et al.,* (2011) on *Polianthes tuberosa* , Iqbql *et al.,* (2011) and Kumar *et al*., (2013), who found that gibberellic acid at 400 pm significantly caused earliest flowering of tulip (141.30 days) followed by 200 ppm (142.43 days) as compared to the control (148.93 days). Also Shakarami *et al*., (2013) demonstrated that gibberellic acid at 250 and 500 ppm can be an effective agent in tulip's flower precocity. Foliar application of gibberellic acid at 346.38 ppm caused early flowering in gladiolus, (Sajjad *et al*., 2014).

The interaction between cold storage and gibberellic acid treatments indicated that corms which were stored for 6 weeks and plants sprayed with GA_3 at the level of 200 ppm gave significantly the earliest flowering (after 100.0 and 98.3 days), whereas the corms stored at room temperature and not treated with gibberellic acid had a delayed flowering, as they recorded 130.7 and 125.0 days in two seasons, respectively. The previous results are in agreement with those of Bhujbal *et al*., (2014) on gladiolus.

Spike length:

A marked increase in spike length was recorded due to different cold storage treatments (Table, 2). The highest increment was obtained from the treatment of storage for 6 weeks as it gave 14.2 and 14.0 cm against 10.1 and 9.1 cm for the control plants in the two seasons, respectively. In this respect Patcharaphorn and Ruamrungsri (2013) found that storing *Eucomis* at 5°C increased stalk length.

Table 2: Effect of corms storage treatments, gibberellic acid foliar spray and their interaction on some flowering traits of *Freesia refracta* plant during 2012/2013 and 2013/2014 season.

Treatments	Flowering date (days)				Spike length (cm)				Fresh weight of spike (g)				Dry weight of spike (g)			
	G0	G1	G2	Mean	G0	G1	G2	Mean	G0	G1	G2	Mean	G0	G1	G2	Mean
	First season (2005/2006)															
0 (Control)	130.7 c	127.3 c	122.0 b	126.6 D	9.1 d	9.8 d	11.6 c	10.1 D	4.1 c	4.4 c	4.9 c	4.4 D	0.83 d	1.07 d	1.22 cd	1.04D
2 weeks	118.3 b	113.3 ab	113.0 ab	114.8 C	11.0 c	10.9 cd	11.0	10.9 C	5.9 b	6.3 ab	6.7 ab	6.3 C	0.93 d	1.31 c	1.60 bc	1.28 C
4 weeks	111.3 ab	109.7 ab	107.7 ab	109.5 B	13.3 b	13.5 b	14.3 a	13.7 B	6.9 ab	6.9 ab	7.4 a	7.0 B	1.39 bc	1.70 bc	1.88 b	1.65 B
6 weeks	103.7 a	103.3 a	100.0 a	102.3 A	14.0 a	14.2 a	14.4 a	14.2 A	7.2 a	7.9 a	7.9 a	7.6 A	1.96 b	1.98 b	2.30 a	2.08 A
Mean	116.0 C	113.4 B	110.6 A		11.8 C	12.1 B	12.8 A		6.0 C	6.3 B	6.7 A		0.90 C	1.50 B	1.70 A	
	Second season (2006/2007)															
0 (Control)	125.0 c	122.3 c	120.3 bc	122.5 D	8.2 d	8.3 d	11.0	9.0 C	5.5 b	5.3 b	5.8 ab	5.5 C	0.80 c	0.88 bc	0.95 b	0.88 D
2 weeks	121.0 c	118.3 b	118.0 b	119.1 C	9.0 c	9.4 c	9.6 c	9.3 C	5.9 ab	6.5 ab	6.1 ab	6.1 B	0.87 bc	0.91 b	1.01 b	0.93 C
4 weeks	116.6 b	114.3 b	114.3 b	115.0 B	11.0 b	11.5 b	12.6 b	11.7 B	6.2 ab	6.3 ab	6.9 ab	6.4 B	1.61 ab	1.78 ab	1.81 ab	1.13 B
6 weeks	108.6 ab	106.6 ab	98.3 a	104.5 A	13.6 ab	13.8 a	14.6 a	14.0 A	7.1 a	7.4 a	7.9 a	7.4 A	1.90 a	1.95 a	1.99 a	1.31 A
Mean	117.8 C	115.3 B	112.7 A		10.4 C	10.7 B	11.9 A		6.1 B	6.3 B	6.6 A		0.87 C	0.95 B	1.37 A	

Means within a column having the same letters are not significantly different according to Duncan's multiple range test.

Regarding the effect of gibberellic acid treatments, it is clear from the data, that (G_2) significantly increased spike length in comparison to control treatments as it recorded 12.8 and 11.9 cm, while (G_0) gave 11.8 and 10.4 cm, respectively in both seasons.

These results are in agreement with those attained by, Kumar *et al*., (2013) who found that maximum stem length of tulip was obtained by using of giberellic acid at 400 ppm, as it gave 31.96 cm and 200 ppm as it gave 26.36 cm over control plants (22.86 cm). Increased flower stem length was also obtained by Dantuluri and Misra (2002), Dhiman *et al*., (2002) on lily, Ertan and Ayan (2005), Shakarami *et al.,* 2013) on tulip, Pogroszewska *et al.,* 2007) on Allium, Asil *et al.,* (2011) on *Polianthes tuberosa* .

Referring to the interaction between gibberellic acid treatments and storage ones, it is clear from Table (2) that the longest spikes resulted from using corms which were stored for 6 weeks and their plants were sprayed with GA_3 at 200 ppm, as it gave 14.4 and 14.6 cm in both seasons, respectively. However, corms which were stored at room temperature and untreated with GA_3 gave the shortest spikes of 9.1 and 8.3 cm, respectively in the two seasons.

Fresh weight of spike:

Data presented in Table (2) pointed out that fresh weight of spike was gradually and significantly increased by prolonging cold storage period in both seasons. The significantly heaviest fresh weight of spikes resulted from the treatment of storage for 6 weeks as it gave 7.9 and 7.4 g against 4.4 and 5.5 g for the control plants in both seasons, respectively.

The obtained results are similar to those reported by Atta-Alla and Zaghloul (2002) on *Iris* and EL-Bably and Mahmoud (2009) on *Tritonia crocata*.

Regarding gibberellic acid treatments data presented in Table (2) indicated that (G_2) gave significantly higher records when compared to (G_0) as the recorded values were 6.7 and 6.6 g against 6.0 and 6.1 g, respectively in both seasons. These results are in agreement with those obtained by Ramzan *et al*., (2014) on tulip and Aier *et al.,* (2015) on gladiolus.

As for the interaction between gibberellic acid treatments and storage ones in Table (2) the superiority was for planting the corms stored for 6 weeks coupled with spraying plants with GA_3 at the rate of 200 ppm, as it gave the heaviest weight of 7.9 g in each seasons. The corms which were stored at room temperature and none treated with gibberellic acid gave the least fresh weight of 4.1 and 5.5 g, respectively in both seasons.

Dry weight of spike:

From the presentation in Table (2), data showed that there was a gradual and significant increase in spike dry weight by increasing the storage period up to 6 weeks as compared to the control. The treatment of storage for 6 weeks recorded the heaviest dry weights (1.8 and 1.31g against 1.1 and 0.88 g, respectively for control in both seasons).

These results are parallel those obtained by Atta-Alla and Zaghloul (2002) on Iris, El-Bably (2003) on *Antholyza aethiopica* and EL-Bably and Mahmoud (2009) on *Tritonia crocata*.

Concerning gibberellic acid treatments data presented in Table (2) showed that (G_2) increased spike dry weight over (G_0) as recorded values of 1.70 and 1.37 g, while the control, recorded 0.90 and 0.87 g for both seasons, respectively.

In this respect, on tulip Ramzan *et al*., (2014) found that using gibberellic acid at 100 mg^{-1} exihibted more dry weight of stalk flower. Also, Aier *et al*., (2015) on gladiolus attained similar results.

As for the interaction between corm storage and gibberellic acid treatments, it was obvious from data presented in Table (2) that the corms which were stored for 6 weeks and treated with GA_3 at 200 ppm, gave markedly the heaviest spike dry weight of 2.30 and 1.99 g, whereas the control plants gave the least weights of 0.83 and 0.80 g in both seasons, respectively.

Rachis length:

It is distinct from data presented in Table (3) that a similar trend as that in case of spike length was obtained for rachis length. Data showed that the significantly highest value in both seasons resulted from planting the corms after storage for 6 weeks, as it gave 7.7 and 7.8 cm against 5.3 and 5.7 cm, for control respectively in the two seasons.

The obtained findings are in agreement with those mentioned by many workers such as Soliman (2002) on tuberose who found that using cold storage at 5ºC increased rachis length as compared to room temperature.

Regarding the application of gibberellic acid regardless the other factor presented data in Table (3) indicated that the using (G_2) gave longer rachis than the control plants in both seasons. The recorded values were 7.0 and 6.9 cm, while untreated plants (G_0) recorded 6.2 and 6.0 cm in both seasons, respectively.

Gibberellic acid stimulates rapid stem, growth and induce mitotic division of some plants.

These results are in harmony with those of other researchers such as Aier *et al.,* (2015) on *Gladiolus*.

Concerning the interaction between gibberellic acid application and storage treatments data presented in Table (3) revealed that rachis length increased with increasing duration of storage up to 6 weeks for the corms sprayed with GA_3 at 200 ppm, in the two seasons. These treatments gave the highest record of 8.0 and 7.8 cm in the two seasons, respectively, while corms which were stored at room temperature and not treated plants with GA_3 gave the shortest rachis of 4.5 and 5.1 cm, respectively in both seasons.

Table 3: Effect of corm storage treatments, gibberellic acid foliar spraying and their interaction on rachis length, number of florets/spike, vase-life and fresh and dry weights of spike of *Freesia refracta* during 2012/2013 and 2013/2014 seasons.

Treatments	Rachis length (cm)				No. of florets/spike				Vase life (days)			
	G0	G1	G2	Mean	G0	G1	G2	Mean	G0	G1	G2	Mean
	First season (2012/2013)											
0 (Control)	4.5b	5.4b	6.0ab	5.3 D	5.0b	5.5b	5.7b	5.4 D	4.4b	5.0ab	5.1ab	4.8 C
2 weeks	6.0ab	6.4ab	6.7ab	6.3 C	6.7ab	7.0ab	7.3ab	7.0 C	5.1ab	5.5ab	5.5ab	5.3 B
4 weeks	6.7ab	6.9ab	7.4b	7.0 B	7.3ab	7.7a	7.8a	7.6 B	5.9ab	6.0a	6.0a	5.9 AB
6 weeks	7.4b	7.8ab	8.0a	7.7 A	8.0a	8.3a	8.4a	8.2 A	6.0a	6.1a	6.3a	6.1 A
Mean	6.2 C	6.6 B	7.0 A		6.7 B	7.1 AB	7.3 A		5.3 B	5.6 AB	5.7 A	
	Second season (2013/2014)											
0 (Control)	5.1c	5.6c	6.5bc	5.7 D	5.0c	6.3bc	6.4bc	5.9 D	4.3c	4.6c	4.6c	4.5 D
2 weeks	5.7c	6.0bc	6.3bc	6.0 C	7.0b	7.0b	7.2b	7.0 C	5.0bc	5.3bc	5.5b	5.2 C
4 weeks	6.6bc	6.8bc	7.3b	6.9 B	8.0ab	8.4a	8.6a	8.3 B	5.6b	5.9b	5.9b	5.8 B
6 weeks	6.9bc	7.4b	7.8a	7.3 A	8.9a	9.0a	9.0a	8.9 A	5.8b	6.6a	7.0a	6.4 A
Mean	6.0 B	6.4 AB	6.9 A		7.2 B	7.6 A	7.8 A		5.1 B	5.6 A	5.7 A	

Means within a column having the same letters are not significantly different according to Duncan's multiple range test.

Number of florets per spike:

Recorded data in Table (3) indicated that a gradual and significant increment in number of florets was observed due to prolonging cold storage duration up to 6 weeks. This treatment gave significantly the

highest records of 8.2 and 8.9 florets/spike against 5.4 and 5.9 florets/spike for control plants in both seasons, respectively.

The increase in floret number per spike with increasing cold storage period may be due to the promotive effect on growth traits which was reflected on flowering. Increasing the duration of cooling (3-18 weeks) promoted flowering and gave higher number of flower shoots per corm of *Liatris spicata* (Moe and Berland 1998). Similar results were obtained by Suh *et al*., (2000) on *Orinthoglum arabicum* and *O. dubium.*

As for the application of gibberellic acid it is evident from presented data in Table (3) that using gibberellic acid at 200 ppm pronouncedly affected floret number per spike, when compared with the control plants and resulted in a significant increment in number of florets during both seasons. The treatment of the highest level of GA_3 gave 7.3 and 7.8 florets/spike against 6.7 and 7.2 florets/spike for the untreated plants in the two seasons, respectively.

The obtained results are in conformity with those of Pogroszewska *et al*., (2007) on *Allium*, Rani and Singh (2013) on *Polianthes tuberosa* and Aier *et al.*, (2015) on *Gladiolus.*

Concerning the interaction between the two studied factors, it is evident from the results presented in Table (3) that the highest records of floret number resulted from planting corms which were stored for 6 weeks and their plants were treated with G_2 as it gave 8.4 and 9.0 florets/spike, while the control plants gave the least values of 5.0 florets/spike in each season.

Vase-life:

Regarding the presentation in Table (3) data showed a gradual and significant increase in vase-life resulted of prolonging cold storage from 2 up to 6 weeks. The longest vase-life was obtained from corms stored for 6 weeks as it gave 6.1 and 6.4 days, while the control plants gave the shortest vase-life of 4.8 and 4.5 days, respectively in both seasons.

The increase in vase-life by prolonging cold storage treatment may be due to the enhancement of vegetative growth traits under such conditions. In this concern, El-Bably (2003) concluded that chilling corms of *Antholyza aethiopica* at 5°C for 8 weeks exhibited remarkable significant effects on vase life.

As for the effect of gibberellic acid treatments on vase-life data presented in Table (3) recorded that the superiority was for the high rate over the control plants in both seasons. Using gibberellic acid at 200 ppm recorded the longest vase-life of 5.7 days in each season, while control plants recorded the shortest vase-life of 5.3 and 5.1 days in both seasons, respectively.

The obtained results are in parallel line with those of Kumr *et al.*, (2013) who found that the maximum vase life was obtained with 400 ppm gibberellic cid followed by 200 ppm over the control plants of tulip, likewise the results of Ramzan *et al*., (2014) on the same plant foliar application of plant growth regulators is helpful to improve the quality parameters of cut flowers (Sajid *et al*., 2009).

As for the interaction between storage treatments and GA_3 application it is obvious from data presented in Table (3) that the treatment of storing corms for 6 weeks and treated with gibberellic acid at the rate of 200 ppm, gave the longest vase-life of 6.3 and 7.0 days for both season, respectively, whereas the control plants gave the shortest vase-life of 4.4 and 4.3 days in the first and second seasons, respectively.

The increase in floral traits may be due to the balance between the growth promoters and inhibitors which increases promoters on the account of inhibitors hence, enhance flowering.

Effect on corm production:

Number of cormels/ plant:

Data presented in Table (4) recorded that all cold storage periods significantly increased number of cormels per plant over control plants in both season. The highest records resulted from the treatment of storage for 6 weeks, as it gave 5.1 and 5.8, cormel while the treatment of storage at room temperature gave the least value of 3.8 and 4.5 cormels for both seasons, respectively. These results are in accordance with those of Suh *et al.*, (2000) on *Orinthogalum.*

Concerning the effect of gibberellic acid treatments on cormel production, data presented in Table (4) showed that (G_2) gave significantly the highest cormel yield in both seasons as it gave5.0 and 5.5, while the control plants recorded 3.9 and 4.3 for both seasons, respectively.

Gibberellic acid is known to increase plant height, number of leaves and leaf width that might have led to enhance the rate of photosynthesis. The present results are in agreement with the findings of Ertan and Ayan (2005) on *Tulipa genseriana*, Sudhakar and Kumar (2012) also reported that foliar application of gibberellic acid on gladiolus plants resulted in increased number of cormels. Kumar *el al.,* (2013) found maximum number of bulbs and daughter bulbs per plant were recorded with using giberellic acid at 400 ppm in tulip. Also were the results Siraj and Al-Safar (2006) on gladiolus and Shanker *et al.,* (2011) on tuberose.

As for the interaction between the two factors, it is evident from data presented in Table (4) that number of cormels per plant was significantly the highest for the treatment of storage for 6 weeks as it gave 6.1 and 6.6 cormels in the first and second seasons, respectively. Corms which were stored at room temperature and untreated plants with gibberellic acid gave the least values of 3.6 and 4.0, cormels in both seasons respectively.

Fresh weight of corm:

Table (4) revealed that all treatments significantly and gradually increased fresh weight of corm over the control plants in each seasons. The heaviest corms resulted from the longest cold storage period (6 weeks) as it gave 5.50 and 5.89 g, while the control plants gave 3.90 and 3.53 g in both seasons, respectively. In accordance with these results were those mentioned by Atta-Alla and Zaghloul (2002) on *Iris* and Kumar *et al*., (2008) on tulip.

Concerning the effect of giberellic acid treatments, it is evident from data that the high level of gibberellic acid significantly increased the fresh weight of corm over the control plants. Using GA_3 at the rate of 200 ppm recorded 5.14 and 4.85 g, while untreated plants gave 4.02 and 4.27 g in both seasons, respectively.

Table 4: Effect of corm storage treatments, gibberellic acid foliar spraying and their interaction on corms production of *Freesia refracta* during 2012/2013 and 2013/2014 seasons.

Treatments	Number of cormels				Fresh weigh of corm (g)				Fresh weigh of cormels (g)			
	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean
	First season (2012/2013)											
0 (Control)	3.6d	4.0c	4.0c	3.8 D	3.83c	3.46c	4.43b	3.90 D	3.44e	3.78e	3.87e	3.69 C
2 weeks	3.3d	4.0c	4.9bc	4.0 C	4.01bc	4.09bc	4.70b	4.26 C	4.55d	4.65d	5.02cd	4.74 B
4 weeks	4.3bc	5.0b	5.0b	4.7 B	3.56c	4.43b	5.45a	4.48 B	5.56cd	6.60c	7.08b	6.41 AB
6 weeks	4.4bc	5.0b	6.1a	5.1 A	4.70b	5.80a	6.00a	5.50 A	7.81ab	7.97ab	8.11a	7.96 A
Mean	3.9 C	4.5 B	5.0 A		4.02 C	4.44 B	5.14 A		5.34 C	5.75 B	6.02 A	
	Second season (2013/2014)											
0 (Control)	4.0b	4.6b	5.0abb	4.5 B	3.33d	3.46d	3.80d	3.53 D	3.88e	4.16 d	4.19 d	4.07 D
2 weeks	4.4b	5.0ab	5.1ab	4.8 B	3.40d	3.90d	4.56c	3.95 C	4.70cd	4.88 cd	4.97cd	4.85 C
4 weeks	4.3b	5.3ab	5.6ab	5.0 B	4.83c	4.88c	4.73c	4.81 B	5.11c	5.57c	6.67b	5.78 B
6 weeks	4.7b	6.3a	6.6a	5.8 A	5.55b	5.80b	6.33a	5.89 A	6.77b	6.98b	7.44a	7.06 A
Mean	4.3 C	5.3 B	5.5 A		4.27 C	45.1 B	4.85 A		5.11 C	5.39 B	5.81 A	

Means within a column having the same letters are not significantly different according to Duncan's multiple range test.

The increase in bulb weight and size may be attributed to cell enlargement caused by giberellic acid and also possible due to increased maximum carbohydrate which was transferred to bulb for storage (Shanker *et al*., 2011). These results are in line with those reported by Ertan and Ayan (2005) on *Tulipa genseriana*, Pogroszewska *et al*., (2007) on *Allium* and Sudhakar and Kumar (2012) on *Gladiolus grandiflorus*.

As for the interaction between the two studied factors, data presented in Table (4) revealed that corms which were stored for 6 weeks and treated with gibberellic acid at 200 ppm gave the heaviest weight of principal corm. The recorded values were 6.0 and 6.33 g in both seasons, respectively. On the other hand, the control plants gave the least values of 3.83 and 3.33 g in the two seasons, respectively. Atta-Alla and Zaghloul (2002) on *Iris* indicated that using giberellic acid at 100 ppm and storing bulbs at 8^{o}C for 3 weeks increased fresh weight of bulblets.

Fresh weight of cormels:

Data presented in Table (4) indicated that all used cold storage periods increased fresh weight of cormels over the control plants, the significantly heaviest fresh weights were obtained from the longest cold storage period of 6 weeks as it gave 7.96 and 7.06 g against 3.69 and 4.07 g for the control treatment in both seasons, respectively.

The increase in fresh weight of cormels may be due to the enhancement of plant growth which reflected on more accumulation of reserve materials in the corm as starch. In this concern Nabih and Saker (1992) stored *Iris* bulbs at 5ºC for 15, 25, 35 and 45 days besides room storage. They reported that soluble, non-soluble and total sugars were increased by cold storage for 25 and 45 days at 5ºC. Similar results were obtained by Inamoto *et al.*, (2000) on tulip.

Concerning spraying of gibberellic acid, data presented in Table (4) showed that fresh weight of cormels was the heaviest due to the treatment of GA_3 at the rate of 200 ppm, as it gave 6.02 and 5.81 against 5.34 and 5.11 g for the control treatment in both seasons, respectively.

As for the interaction between the two factors, it is evident from Table (4) that fresh weight of cormels was the heaviest due to the treatment of storing corms for 6 weeks and spraying plants with gibberellic acid at 200 ppm, as compared with the treatment of storage at room temperature and no gibberellic acid treatment which gave the least values (3.44 and 3.88) in both seasons. Similar results were obtained by Atta-Alla and Zaghloul (2002) on *Iris.*

Effect on chemical constituents:

Nitrogen percentage:

It is evident from data presented in Table (5) that all storage treatments significantly increased nitrogen percentage in the leaves over the control treatment during the two seasons in an ascending order from 2 to 6 weeks. The significantly highest values of nitrogen% were obtained from the treatment of storing for 6 weeks as it gave 1.35 and 1.46 against 1.02 and 1.12% for the control in the first and second seasons respectively.

The promotive effect of cold storage treatments on nitrogen percentage in the leaves may be due the enhancement of vegetative growth and acceleration of sprouting which allowed more absorption of such element from the soil, and reflected on increasing it is content in the leaves. Similar results were obtained by Suh *et al*., (2000), Soliman (2002) on *Ornithogalum* and El-Bably (2003) on *Antholyza aethiopica*.

Concerning the gibberellic acid application data in the same Table indicated that the treatment of gibberellic acid at 200 ppm significantly increased nitrogen percentage in the leaves over the control as recorded 1.21 and 1.41 % against the control which gave 1.12 and 1.28% in the first and second seasons, respectively.

The obtained results are in conformity with those of Sajjad *et al.,* (2014) on Gladiolus.

As regards the interaction between the two studied factors, it is obvious from the results presented in Table (5) that the highest records of nitrogen% resulted from planting corms which were stored for 6 weeks followed with spraying plants with GA_3 at 200 ppm, as it gave 1.39 and 1.49% against 0.97 and 1.00% In the first and second seasons, respectively. In accordance with these results were those reported by Atta-Alla and Zaghloul (2002) on *Iris.*

Phosphorus percentage:

Data presented in Table (5) indicated that the highest record of phosphorus percentage in freesia leaves resulted in the first season from the treatment of storing for 6 weeks as it gave 0.48% and 0.50% against 0.11% and 0.27% for the control in both seasons, respectively. Similar results were observed by Soliman (2002) on *Orinthogalum.*

Concerning the application of GA_3, data clearly showed that the treatment of 200 ppm significantly increased the phosphorus percentage in the leaves in comparison to the control. The highest level recorded 0.30 and 0.43% for each season, respectively while the control recorded 0.21 and 0.35 % in the first and second seasons, respectively. Gibberellic acid effectively increased the P % of leaves in the present study. The obtained results are in conformity with those of Sajjad *et al*., (2014) on gladiolus.

Regarding the interaction between storage treatments and foliar gibberellic acid application throughout the two experimental seasons, data revealed that the highest phosphorus% resulted from the high gibberellic acid rate on plants stored for 6 weeks as it gave 0.53 and 0.52% in the first and second seasons, respectively while corms stored at room temperature gave the least value of 0.10 and 0.22% in the first and second seasons, respectively.

Potassium percentage:

Regarding cold storage effect, data presented in Table (5) indicate that all treatments significantly and gradually increased potassium percentage in the leaves over the control treatment in both seasons. The highest values were obtained from the longest cold storage period 6 weeks as it gave 1.88 and 1.03% while the control gave 0.77 and 0.93% in the first and second seasons, respectively. The increase in potassium percentage may be due to the aforementioned reasons in case of N and P %.

In accordance with these results were those reported by EL-Bably (2003) on *Antholyzia athiopeca* and EL-Bably and Mahmoud (2009) on *Tritonia crocata.*

As for as the effect of gibberellic acid treatments, it appears from data presented in Table (5) that the high rate significantly increased potassium percentage in the leaves in comparison to that of the control, as it recorded 1.41 and 1.02 % , while the control gave 1.10 and 0.93% in the two seasons, respectively. In this concerning Sajjad *et al.,* (2009) found similar conclusion on *Gladiolus*. Gibberellic acid effectively increased the K % of leaves in the present study.

Referring to the interaction between the two factors, data in the same Table showed that corms stored for 6 weeks coupled with GA_3 at 200 ppm, gave the highest values of potassium percentage in the leaves over the other treatments in the two seasons. This treatment gave 2.05 and 1.06%, while corms stored at room temperature and not treated with gibberellic acid gave the least values of 0.66 and 0.87% in two seasons, respectively.

Table 5: Effect of corm storage treatments, gibberellic acid foliar spraying and their interaction on some chemical constituents of *Freesia refracta* leaves during 2012/2013 and 2013/2014 seasons.

Treatments	N %				P %				K %				Total carbohydrates			
	G0	G1	G2	Mean	G0	G1	G2	Mean	G0	G1	G2	Mean	G0	G1	G2	Mean
	First season (2012/2013)															
0(Control)	0.97b	1.03b	1.06b	1.02 D	0.10e	0.11e	0.12e	0.11 D	0.66f	0.78e	0.88e	0.77 D	37.11 c	39.02 bc	39.91 bc	38.68 D
2 weeks	1.07b	1.08b	1.10b	1.08 C	0.13e	0.14e	0.15e	0.14 C	0.79e	1.02c	1.17c	0.99 C	40.00 bc	42.32 b	42.99 b	41.77 C
4 weeks	1.14b	1.17b	1.32a	1.21 B	0.20d	0.33c	0.42b	0.31 B	1.23c	1.39b	1.55ab	1.39 B	42.77 b	43.84 ab	44.24 a	43.61 B
6 weeks	1.30a	1.37a	1.39a	1.35 A	0.44b	0.49ab	0.53a	0.48 A	1.75ab	1.84ab	2.05a	1.88 A	44.01 a	44.13 a	44. 24 a	44.07 A
Mean	1.12 C	1.16 B	1.21 A	-	0.21 C	0.26 B	0.30 A	-	1.10 C	1.25 B	1.41 A	-	40.97 C	42.32 B	42.38 A	-
	Second season (2013/2014)															
0(Control)	1.00b	1.14b	1.24b	1.12 D	0.22c	0.26c	0.33bc	0.27 D	0.87b	0.91b	1.00a	0.93 D	34.10c	39.0b	39.40b	37.52 D
2 weeks	1.27b	1.39ab	1.42a	1.36 C	0.32bc	0.36b	0.38b	0.35 C	0.90b	0.95ab	0.97ab	0.94 C	36.77 bc	40.02 ab	40.13 ab	38.97 C
4 weeks	1.40ab	1.44a	1.49a	1.44 B	0.40b	0.44ab	0.49a	0.44 B	0.98ab	1.04a	1.05a	1.02 B	40.11 ab	42.55 a	42.57a	41.74 B
6 weeks	1.45a	1.46a	1.49a	1.46 A	0.49a	0.50a	0.52a	0.50 A	0.99a	1.06a	1.06a	1.03 A	40.76 ab	43.61	a43.69a	42.68 A
Mean	1.28 C	1.35 B	1.41 A	-	0.35 C	0.39 B	0.43 A	-	0.93 C	0.99 B	1.02A	-	37.93 C	41.29 B	41.44 A	-

Means within a column having the same letters are not significantly different according to Duncan's multiple range test.

Total carbohydrates:

From the presentation in Table (5) data revealed that all storage treatments significantly increased total carbohydrate% in the leaves over control in an ascending order, from the short to the long period, in the two seasons. The highest increment was obtained from the treatment of storage for 6 weeks, as it gave 44.07 and 42.68 mg/g D.W, against 38.68 and 37.52 mg/g D.W for the control in both seasons respectively.

The increase in total carbohydrates due to cold storage treatments may be due to their stimulatory effects on vegetative growth and earlier sprouting of corms which caused more photosynthetic activity of plant leaves and reflected on more accumulation of metabolites in them especially for the longest storage treatment of 6 weeks. A similar trend of results was found by Atta-Alla and Zaghloul (2002) on *Iris* and EL-Bably and Mahmoud (2009) on *Tritonia crocata*.

As for as the effect of gibberellic acid treatments, it appears from data presented in Table (5) that the high rate significantly increased total carbohydrates in the leaves in comparison to that of the control, as it recorded 42.38 and 41.44, while the control gave 40.97 and 37.93 in the two seasons, respectively. Sajjad *et al.,* (2009) found similar conclusion on gladiolus.

Referring to the interaction between the two factors, data presented in the same Table showed that corms stored for 6weeks coupled with gibberellic acid application on plants at 200 ppm, gave the highest values over the other treatments in the two seasons. This treatment gave 44.24 and 43.69, while the corms which were stored at room temperature and corms untreated with gibberellic acid gave the least values of 37.11 and 34.10 in two seasons, respectively. In accordance with these results were those reported by Atta-Alla and Zaghloul (2002) on *Iris tingitana* and EL-Bably and Mahmoud (2009) on *Tritonia crocata*.

Pigments

Chlorophyll (a) content:

Table (6) point out that all storage treatments significantly increased chlorophyll (a) content over the control plants, the highest increment was obtained from the treatment of storage for 6 weeks, as it gave 0.85 and 1.36, against 0.63 and 0.78 mg/g f.w for the control in both seasons, respectively.

A similar trend of results was found by Atta-Alla and Zaghloul (2002) on *Iris* and EL-Bably (2003) on *Antholyza aethiopica.*

As for as the effect of gibberellic acid treatments, it is clear from the data that the high level (G_2) significantly increased chlorophyll (a) in comparison to the control as it recorded 0.76 and 1.28, while the control treatment of (G_0) gave 0.69 and 1.19 mg/g f.w., respectively in the two seasons.

A similar trend of results was found by Rani and Singh (2013), and Sajjad *et al*., (2014), who recorded that gibberellic acid at 1mM concentration was the most efficient treatment in increasing the chlorophyll a in gladiolus plants.

Referring to the interaction between foliar gibberellic acid treatments on plants and cold storage treatments, it is evident from Table (6) that the highest chlorophyll (a) resulted from planting corms which were stored for 6 weeks and spraying plants with the high level of gibberellic acid as it gave 0.91 and 2.08 mg/g f.w., respectively. Corms which were stored at room temperature and plants untreated with gibberellic acid gave the least value of 0.61 and 0.78 mg/g f.w. respectively, in both seasons.

This increase in chlorophyll content might have good impact on the growth and development of *Fressia refracta* plant.

Table 6: Effect of corm storage treatments, gibberellic acid foliar spraying and their interaction on pigments of *Freesia refracta* during 2012/2013 and 2013/2014 seasons.

Treatments	Chlorophyll (a) (mg/g f.w)				Chlorophyll (b) (mg/g f.w)				Carotenoids (mg/g f.w)			
	G0	G1	G2	Mean	G0	G1	G2	Mean	G0	G1	G2	Mean
	First season (2012/2013)											
0 (Control)	0.61c	0.63c	0.66bc	0.63 D	0. 16d	0. 16d	0.19d	0.17 D	0.38c	0.43b	0.43b	0.41 D
2 weeks	0.68b	0.68b	0.71ab	0.69 C	0.23cd	0.29c	0.29c	0.27 C	0.45b	0.46b	0.48b	0.46 C
4 weeks	0.70ab	0.73ab	0.77ab	0.73 B	0.33bc	0.39b	0.40b	0.37 B	0.47b	0.48b	0.50a	0.48 B
6 weeks	0.77ab	0.88a	0.91a	0.85 A	0.44a	0.44a	0.49a	0.45 A	0.51a	0.55a	0.61a	0.55 A
Mean	0.69 C	0.73 B	0.76 A		0.29 C	0.32 B	0.34 A		0.45 C	0.48 B	0.50 A	
	Second season (2013/2014)											
0 (Control)	0.78b	0.78b	0.78b	0.78 D	0.14c	0.17cd	0.17cd	0.16 D	0.45c	0.48c	0.53bc	0.48 D
2 weeks	0.93b	1.09ab	1.09ab	1.03 C	0.18cd	0.19cd	0.19cd	0.18 C	0.53bc	0.59b	0.70b	0.60 C
4 weeks	1.12ab	1.19ab	1.19ab	1.16 B	0.22c	0.28c	0.29c	0.26 B	0.67b	0.78a	0.81a	0.75 B
6 weeks	1.94ab	2.00a	2.08a	2.00 A	0.47b	0.55a	0.61a	0.54 A	0.79a	0.82a	0.83a	0.81 A
Mean	1.19 C	1.32 B	1.28 A		0.25 C	0.29 B	0.31 A		0.61 C	0.67 B	0.71 A	

Means within a column having the same letters are not significantly different according to Duncan's multiple range test.

Chlorophyll (b) content:

Data presented in Table (6) pointed out that all storage treatments significantly increased chlorophyll (b) over control treatment during both seasons in an ascending order from 2 to 6 weeks. The significantly highest value of chlorophyll (b) was obtained from the treatment of storage for 6 weeks as it gave 0.45 and 0.54, while the control treatment gave 0.17 and 0.16 mg/g f.w., in both seasons respectively.

Referring to using gibberellic acid, data in the same Table showed that the high rate (200 ppm) significantly increased chlorophyll (b) in comparison to the control as recorded 0.34 and 0.31mg/g f.w, while the control treatment gave 0.29 and 0.25 mg/g f.w., respectively in the two seasons. In this respect, Sajjad *et al*., (2014) recorded that gibberellic acid at 1mMwas the most efficient treatment for increasing chlorophyll b in Gladiolus, also on tulip Ramzan *et al*., (2014) found that using GA_3 at 100 m g/ l exhibited more leaf chlorophyll.

Concerning the interaction between the two studied factors, it is obvious from data presented in Table (6) that the highest chlorophyll (b) resulted from planting corms which were stored for 6 weeks and spraying plants with the highest level of gibberellic acid at 200 ppm, as it gave 0.49 and 0.61 mg/g f.w., respectively. The corms which were stored at room temperature and using no gibberellic acid treatment gave the least value of 0.16 and 0.14 mg/g f.w., respectively, in both seasons.

The results are in accordance with the findings of Janowska and Jerzy (2003) that gibberellic acid is able to prevent the degradation of photosynthetic pigment, i.e. the chlorophyll content in *Zantedeschia elliottiana*.

Carotenoids content:

As for cold storage effect Table (6) showed that all cold storage treatments significantly and gradually increased carotenoids over the control treatment in both seasons. The highest values were obtained from the longest cold storage period as it gave 0.55and 0.81 mg/g f.w., while the control gave 0.41 and 0.48 mg/g f.w in the first and second seasons, respectively. gibberellic acid at 1mM was the most efficient treatment for increasing carotenoids content (Sajjad *et al*., 2014).

Concerning the effect of gibberellic acid treatments, it appears from data presented in Table (6) that the highest rate significantly increased carotenoids in comparison to that for the control, as recorded 0.50 and 0.71 (mg/g f.w), while the control gave 0.45 and 0.61 mg/g f.w., in the two seasons, respectively. Sajjad *et al*., (2014) found similar conclusion.they found that gibberellic acid at 1mMwas the most efficient treatment for increasing the carotenoid contents in gladiolus leaves.

The application of gibberellic acid on *Beaucarnea recurvate* caused increasing carotenoids (Abdel-Wahid and Sweify 2009).

Referring to the interaction between the two studied factors, data in the same Table indicated that corms stored for 6weeks coupled with gibberellic acid application at 200 ppm as it gave the highest values of carotenoids mg/g f.w. over the other treatments in the two seasons. This treatment gave 0.61 and 0.83 mg/g f.w, while corms stored at room temperature and untreated with gibberellic acid gave the least values of 0.38 and 0.45 mg/g f.w., in both seasons, respectively.

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