EFFECT OF PLANTING TIME AND CORMS TREATMENT WITH GIBBERELLIC ACID ON GROWTH, FLOWERING, AND VASE LIFE OF *FREESIA HYBRIDA* ‘CORONA’

Short communication

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ABSTRACT

Freesia hybrida is one of the most important cut flowers with a short vase life. The present study was conducted to explain the effect of the two planting dates December 1st and 15th and soaking corms before planting in gibberellic acid at concentrations of 0, 75, and 150 mg·L⁻¹ on the growth, flowering, and flowers quality of *Freesia hybrida* ‘Corona’. A larger diameter of the inflorescence stem and floret head, fresh weight of inflorescence, and longer vase life were obtained when planted on December 1st. Soaking the corms in a GA₃ solution of 150 mg·L⁻¹ before planting significantly extended the vase life compared to the control. Finally, it can be concluded that the planting of corms soaked in a solution of 150 mg·L⁻¹ GA₃ on December 1st in unheated greenhouses can improve the growth, development, and quality of flowers of *Freesia hybrida* ‘Corona’.

Key words: cut flowers, corm yield, flower quality, days to sprouting, water uptake

INTRODUCTION

Freesia hybrida (Iridaceae) is a commonly produced ornamental plant that bears fragrant flowers with a short vase life (Zencirkiran 2002). It is used as cut flower and as a pot plant outside or indoor (Younis et al. 2012). The agro-climatic diversity in northern Iraq (Mediterranean) is suitable for growing freesia commercially in either open fields or under greenhouse; however, the number of commercially viable species for cut flowers is extremely limited in the local market. The date of planting is an important factor to regulate the growth and quality of freesia. However, the precise timing of flowering is predictable only under controlled conditions. Most of the studies under a natural condition in Iraq reported that the corm sprouts in early–late autumn (15/9 to 15/11) and the flowering in the greenhouse is expected about 14–17 weeks later, while in the field, it is expected after 17–23 weeks (AL-Sawaf &

Alwan 2010; Jasim 2009). In north Iraq, the temperature rises quickly in the spring. This abrupt increase in temperature decreases the inflorescence stem length and quality of the spikes. Locally produced flowers have short spikes of low quality and low yield (AL-Sawaf & Alwan 2010). Furthermore, the quality of flowers is affected negatively by rains at the end of winter and spring. There is no study on the possibility to change the sprouting date to the early winter, which is caused by troubles in import procedures. In the result, farmers are forced to plant imported bulbs at a later date in order to avoid losing the planting season and minimizing financial losses. On the other hand, freesia is prone to fungal diseases when planted in the autumn, and this result is referred by Le Nard (2002) who proposes to avoid tulip bulb infection with fusarium by delaying planting dates, which can be as late as December.

Growth regulators have many commercial applications in ornamental plants. Gibberellins are well-known and often used growth regulators.

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According to Żurawik and Placek (2013), treatment of freesia (*Freesia* Eckl. ex Klatt) corms with gibberellic acid at various concentrations (10, 20, 40, 80, 160 mg·dm⁻³) interrupts the dormancy of corms, accelerates plant flowering, and increases the length of the stem inflorescence. Gibberellic acid stimulates shoot elongation (Hanks 1984; Al-Ma'athedi et al. 2018), plant height, and a total number of leaves in freesia (Żurawik and Placek 2013) and in gladiolus (Padmalatha et al. 2014); it also stimulates the growth of shoots and leaves of *Tulipa* (Kumar et al. 2013), and *Freesia* × *hybrida* (Cocozza Talia 1985). Żurawik and Placek (2013) reported the influence of gibberellic acid on an increase in weight of corms of freesia. GA₃ delays the senescence of gladiolus flowers by reducing the senescence-promoting effect of ethylene (Faraji et al. 2011). Our study was aimed at finding the optimal planting time for *Freesia hybrida* 'Corona' corms in the early winter period and assessing the soaking of the corms before planting in GA₃ solutions in order to obtain cut flowers with a high market value.

MATERIALS AND METHODS

The pot experiment was carried out under unheated greenhouse conditions at the Landscape and Horticulture Department, Agriculture Forestry College, Mosul University, Iraq, during December 2017 to June 2018. *Freesia hybrida* 'Corona' corms with 5–6 g weight and 5–6 cm in circumference were grown individually in pots of 15 cm diameter, filled with a peat moss substrate "K ProLine TS 1 Fine Propagation (kla-10410)", produced by Klasmann-Deilmann (Germany). NPK water-soluble fertilizer PRO•SOL™ (20-20-20), all-purpose fertilizer produced by PRO-SOL (USA), was added at 2 g per pot monthly.

The daytime temperature in the greenhouse in December was 16–21 °C, in January 14–18 °C, in February 17–19 °C, in March 19–25 °C, in April 24–30 °C, and in May 30–36 °C. The average midnight temperatures for the months were 9.80, 3.95, 5.65, 9.05, 9.60, and 26.60 °C, respectively (Fig. 1).

Factors and experimental design

The experiment was arranged as a two factorial with randomized complete block design (RCBD) with

three replications. Each experimental treatment consisted of 5 corms (5 pots), in each replication ($n = 15$). The corms of freesia were soaked in a solution of GA₃ at 0, 75, and 150 mg·L⁻¹ for 60 min. before planting (the first factor). After the treatment, corms were left to dry for 2 hours and then planted. The second factor was represented by two dates of planting, 1st and 15th December.

Plant growth, flowering, and corm yield parameters

Three growth parameters were recorded: number of days to sprout, number of leaves (measured when the first floret colored), and plant height (measured from the soil surface to the top of floret head). Flowering parameters (taken at the beginning of flowering) included a number of days from planting to flowering (to the appearance of inflorescence stem), number of days to the first floret coloring, inflorescence stem length, inflorescence stem diameter, floret head diameter, florets number per inflorescence, and fresh weight of inflorescences. After the appearance of leaves yellowing, corms and cormels were removed, and corms were cleaned after drying. Corm yield parameters included the mother corm diameter, fresh weight of the mother corm, fresh weight of the cormels, and their number per mother corm.

Water uptake and vase life measurement

The water uptake and vase life were measured in the laboratory, at a temperature of 27 ± 2 °C and humidity of $65 \pm 5\%$. The inflorescence stems were excised in the morning at the stage of opening and coloring of the first buds (Zencirkiran 2002), transferred to the laboratory, recut to 30 cm, and placed in separate vases containing 300 ml distilled water that was changed every 3 days.

Solution uptake was measured every 3 days, and vase life was taken from the time of the first floret opening to the time when more than 50% of the florets were visibly senescing and petals wilted.

Statistical analysis

All plants were utilized for measuring all parameters, and then the results were analyzed statistically using the analysis of variance (ANOVA) procedure with SAS software (9.0) in the randomized complete block design. The values of the means were compared by Duncan's multiple range test at the significant level $p \leq 0.05$.

RESULTS AND DISCUSSION

Number of days to sprouting, flowering, and first floret coloration

All plants under experiment sprouted. The planting time had a significant effect on the time of sprouting (Table 1). The results showed a significant difference between corms planted on December 15th that needed only 20.9 days and on December 1st that needed 31 days. A temperature of 18–22 °C is required for good germination, which in December is about 16–21 °C during daytime (Fig. 1), while 10 °C is adequate for slow growth, and 12–15 °C is suitable for faster growth (Mansour 1968).

The later planting shortened the time to flower by 17 days but did not affect the time of the first florets' coloration. High temperatures delayed the process of flower initiation in freesia after planting in the temperature range of 9–15 °C (Berghoef et al. 1986). Also, the number of days to flower decreased with increasing greenhouse temperature, but the response varied somewhat among the cultivars; for example, Aurora cultivar flowered earlier at 15 °C than at 20 °C (Wulster et al. 1989). To delay flowering until May, Anderson (2006) planted corms from December 1st to December 20th.

These results are in concurrence to that of Aftab et al. (2007), which reported a decrease in the time to flower from 145–146 days to 134–137 days when delayed planting date from 15th October to 30th October.

The GA₃ application did not affect the time of sprouting (Table 1). GA₃ corm-soaking did not influence the number of days to sprout but shortened the time to flower and delayed significantly flower coloration when was applied in higher concentrations. The sprouting time is connected with day and night temperature. Application of GA₃ speeds flowering in gladiolus (Baskaran et al. 2017; Baskaran & Abirami 2016). Speeding of freesia flowering with GA₃ treatment was significant only at the later corm planting. Application of GA₃ delayed also the first floret coloring. The results of Cocozza Talia (1985) showed that GA₃ treatment in freesia induces advanced flowering without changing the qualitative characteristics of the flowers. The improving effect of GA₃ on flowering characteristics may be due to their stimulatory effect on cell division, elongation, and differentiation. Earlier flowering of plants treated by GA₃ might be due to their vital role in the production and regulation of floral stimulus (Taha 2012).

Fig. 1. The average temperatures in the greenhouse during the experiment

Table 1. The effect of planting date and GA₃ treatment on plant growth parameters of *Freesia hybrida* 'Corona'

Treatment		No. of days to sprout	No. of days to flower	No. of days to first floret coloration	Plant height (cm)	No. of leaves
Planting date	1 st Dec.	31.0±3.7 A	117.7±4.4 A	127.3±3.3 A	43.7±6.1 A	8.8±0.5 A
	15 th Dec.	20.9±2.5 B	100.3±2.0 B	109.4±2.1 B	45.0±2.4 A	7.2±0.4 B
GA ₃ (mg·L ⁻¹)	0	26.6±5.8 A	111.1±11.9 A	119.4±9.8 A	42.0±3.5 B	8.0±0.9 A
	75	26.5±5.5 A	109.0±9.9 AB	117.8±10.8 A	43.5±4.1 AB	8.0±0.8 A
	150	24.7±7.6 A	106.8±7.5 B	117.9±9.8 A	47.5±4.7 A	8.0±1.1 A
Planting date × GA ₃						
1 st Dec.	0	31.0±4.7 a	121.3±5.3 a	127.9±4.6 a	40.0±4.3 b	8.8±0.3 a
	75	31.3±1.4 a	118.1±1.1 ab	127.5±2.3 a	42.3±4.5 ab	8.6±0.6 a
	150	30.6±5.7 a	113.6±1.6 b	126.4±3.9 a	48.6±7.2 a	8.9±0.6 a
15 th Dec.	0	22.2±2.0 b	100.8±3.6 c	110.9±1.6 b	44.0±1.0 ab	7.2±0.1 b
	75	21.6±1.9 b	100.0±1.1 c	108.0±1.7 b	44.7±4.3 ab	7.3±0.5 b
	150	18.9±2.9 b	99.9±0.8 c	109.3±2.5 b	46.3±1.0 ab	7.1±0.7 b

Means that have same letters in each column are nonsignificant statistically at $p = 0.05$ (DMR test); values are means ± standard deviation; capital letters refer to main effects, while lower case letters refer to interactions

Plant height and number of leaves

The time of planting did not influence plant height contrary to the GA₃ (Table 1). Plants, which corms were soaked in the GA₃ solution 150 mg·L⁻¹, were 13.1% longer over the non-soaked control. The promotion of plant height with GA₃ in freesia was earlier reported by Żurawik and Placek (2013). This treatment was more effective (higher by 21.5%) at earlier planting. The main function of GA₃ is cell elongation and division, and it is known to be involved in various processes of plant development. In various plants, exogenous gibberellin promotes shoot elongation and plant height. This was confirmed in gladiolus (Padmalatha et al. 2014; Chopde et al. 2015; Baskaran et al. 2017; Baskaran & Abirami 2016), *Iris* (Al-Khassawneh et al. 2006), and *Tuberose* (Asil et al. 2011).

Contrary to plant height, the leaf number was regulated by the time of planting but not by GA₃ application (Table 1). This finding confirmed the results of Thompson et al. (2011) as they reported the higher number of leaves in *Watsonia* (Iridaceae) in plants growing under long-day and higher temperatures. Thus, it is desirable to grow freesia at 12–15 °C for obtaining 6–8 leaves prior to flowering,

which is required for breaking dormancy of the corms and optimal quality and yield of freesia flowers (Dole 2003).

Quality of flowers

The result showed that later corm planting and soaking in GA₃ affected inflorescence lengthening (Table 2). Stem diameter was larger in plants in which corms were planted earlier and GA₃ did not affect this trait. These results are inconsistent with the results of Aftab et al. (2007), who reported that the freesia inflorescence length decreased with the planting delayed from 15th to 30th October. GA₃ increases inflorescence stem length through cell enlargement and cell division (Hartmann et al. 1990; Daykin et al. 1997; Kumar et al. 2013), which might have elongate the stalk length. Several workers have already reported an increase in the length of the stalk in *Iris* (Al-Khassawneh et al. 2006), in *Tuberose* (Asil et al. 2011; Shanker et al. 2011), and in *Gladiolus* (Baskaran et al. 2017; Baskaran & Abirami 2016; Sajjad et al. 2014) due to GA₃ treatment. Larger stem and floret head diameter and fresh weight of inflorescence were correlated with leaf number that provides more metabolites that can strengthen the plant.

Table 2. The effect of planting date and GA₃ treatment on flowering parameters of *Freesia hybrida* 'Corona'

Treatment		Inflo- rescence stem length (cm)	Inflorescence stem diameter (mm)	Floret head diameter (cm)	No. of florets per inflo- rescence	Fresh weight of inflo- rescence (g)	Water uptake (ml)	Vase life (days)
Planting date	1 st Dec.	34.7±6.9 B	3.6±0.2 A	4.6±0.3 A	6.8±0.5 A	7.9±1.0 A	6.3±0.7 A	6.8±1.5 A
	15 th Dec.	38.9±2.6 A	3.0±0.2 B	4.1±0.2 B	6.9±0.4 A	6.0±0.2 B	6.6±2.4 A	5.3±1.6 B
GA ₃ (mg·L ⁻¹)	0	32.9±5.2 B	3.3±0.5 A	4.1±0.1 B	6.5±0.3 B	6.5±0.9 B	5.1±1.2 B	5.0±2.0 B
	75	36.2±5.2 B	3.3±0.3 A	4.4±0.2 A	6.7±0.2 AB	6.7±0.8 B	6.8±1.6 A	6.0±1.6 AB
	150	41.4±1.7 A	3.4±0.4 A	4.6±0.4 A	7.2±0.5 A	7.7±1.6 A	7.6±1.4 A	7.2±0.7 A
Planting date × GA ₃								
1 st Dec.	0	28.6±4.2 c	3.6±0.4 a	4.2±0.1 bc	6.4±0.5 b	7.3±0.4 b	6.1±0.6 b	6.0±2.0 ab
	75	33.3±5.2 bc	3.6±0.1 a	4.6±0.2 ab	6.6±0.1 ab	7.4±0.3 b	6.3±0.5 b	7.0±2.0 a
	150	42.3±0.8 a	3.7±0.2 a	5.0±0.1 a	7.4±0.4 a	8.9±1.2 a	6.6±1.2 ab	7.3±0.5 a
15 th Dec.	0	37.2±1.5 ab	2.9±0.3 b	4.0±0.1 c	6.5±0.2 b	5.7±0.3 c	4.1±0.8 b	4.0±1.7 b
	75	39.2±3.7 ab	3.0±0.3 b	4.2±0.2 bc	6.8±0.3 ab	6.0±0.2 c	7.2±2.3 ab	5.0±0.0 ab
	150	40.5±2.0 a	3.0±0.2 b	4.2±0.3 bc	6.9±0.6 ab	6.3±0.5 c	8.6±0.9 a	7.0±1.0 a

Means that have same letters in each column are nonsignificant statistically at $p = 0.05$ (DMR test); values are means ± standard deviation; capital letters refer to main effects, while lower case letters refer to interactions

Floret's head diameter was influenced by both studied factors. Different planting dates and various concentrations of GA₃ and interaction of these factors had a significant effect on floret head diameter. The diameter of the flower head and fresh weight of inflorescence were greater in plants treated with GA₃ (Table 2). The opposite results were obtained by Żurawik and Placek (2013), working with Easy Pot Freesias, and confirmed results of Kumar and Misra (2012) on tulip.

The number of florets per inflorescence did not depend on the time of corms planting but was higher in plants that corms were soaked in 150 mg·L⁻¹ GA₃ (Table 2). The least number of florets, 6.5 per spike, was noticed in control plants. According to Żurawik and Placek (2013), treating Easy Pot Freesia with gibberellic acid increases the number of flowers depended on the concentration of the gibberellic acid. The obtained results are in line with those of Pogroszewska et al. (2007) on *Allium*, Kumar and Misra (2012) on tulip, Baskaran et al. (2017) and Baskaran and Abirami (2016) on *Gladiolus*.

Vase life

There were no significant differences in water uptake due to GA₃ application to corms (Table 2). The amount of water uptake increased by increasing GA₃ concentration. The interaction of planting date × GA₃ was significant. The best option was planting the corms on December 15th coupled with GA₃ at 150 mg·L⁻¹, which caused a maximum solution uptake of 8.6 ml.

It is worth noting that the maximum vase life was 6.8 days that was recorded for the corms planted on December 1st, compared to 5.3 days for the flowers obtained from corms planted on December 15th. The results in Table 2 show that treatment of GA₃ significantly extended the vase life of freesia cut flowers compared to control. The longest vase life, 7.3 days, was obtained by planting corms on December 1st and using 150 mg·L⁻¹ GA₃; while, the vase life of flowers from untreated corms was only 5 days. This result is in line with Ramzan et al. (2014) and Kumar et al. (2013) who found longer vase life of tulip obtained on plants treated with 400 mg·L⁻¹ gibberellic acids compared with the control plants.

This result could be due to the role of gibberellin in controlling the transferring of nutrients from the leaves toward the flowers (Ahmed et al. 2016).

Corm yield parameters

The planting dates did not affect the corm yield parameters except the fresh weight of cormels (Table 3). Delay of planting decreased the fresh weight of cormels by 30%. Soaking of cormels in GA₃, especially at 150 mg·L⁻¹, caused an increase in mother corm weight and diameter. Similar findings concerning the increase in bulb diameter were reported for gladiolus. The increase of weight of corms with the application of GA₃ can be attributed to its ability to increase the yield of photosynthetic products, which was reported in freesia by Żurawik and Placek (2013) and in gladiolus by Arora et al. (1992), Siraj and Al-Safar (2006), and Kumar and Misra (2012).

From the results of our investigation, it should be concluded that the choice of planting time of corms between 1st and 15th December could have significant consequences for freesia production. To the positives of earlier planting, anyone can account for more leaves, greater inflorescence and floret head diameter, greater fresh weight of inflorescence and cormels, and longer vase life. On the other hand,

plants need more time for sprouting and flowering and produced shorter inflorescences. Flowers are produced almost at the same time as from corms planted two weeks later but inflorescences are stronger what influenced positively vase life. It has been suggested that an appropriate planting date can lower production costs by reducing the production period from 14–17 weeks to 12–13 weeks (AL-Sawaf & Alwan 2010; Jasim 2009) and enable the production of flowers of higher quality and greater market value by offering products on the local market in early February and mid-March, when the supply of blooming flowers is low.

On the basis of the presented results, it can be concluded that soaking corms in 150 mg·L⁻¹ GA₃ had a positive effect on increasing the plant height, and it also caused the earliest stalking with a higher quality of flowers, increasing such parameters as the inflorescence stem length, floral head diameter, florets number per inflorescence, fresh weight of inflorescence, longer vase life, as well as greater corm diameter and weight. Therefore, we recommend the planting of *Freesia hybrida* 'Corona' corms soaked in 150 mg·L⁻¹ GA₃ on December 1st in unheated greenhouses.

Table 3. The effect of planting date and GA₃ treatment on corm yield parameters of *Freesia hybrida* 'Corona'

Treatment		Mother corm diameter (mm)	Fresh weight of mother corm (g)	Fresh weight of cormels (g)	No. of cormels per mother corm
Planting date	1 st Dec.	22.2±2.1 A	7.1±1.2 A	3.4±0.7 A	1.7±0.5 A
	15 th Dec.	22.5±2.9 A	7.5±0.8 A	2.4±0.6 B	1.8±0.9 A
GA ₃ (mg·L ⁻¹)	0	20.7±2.0 B	6.5±1.1 B	3.2±1.0 A	2.0±1.1 A
	75	22.5±2.9 AB	7.4±0.7 AB	3.0±1.0 A	2.0±0.4 A
	150	23.9±1.4 A	8.1±0.7 A	2.6±0.6 A	1.3±0.5 A
Planting date × GA ₃					
1 st Dec.	0	21.0±2.1 a	6.7±1.2 b	3.8±0.7 a	1.4±0.3 a
	75	21.5±1.1 a	7.2±1.0 ab	3.7±0.9 a	2.4±0.1 a
	150	24.2±1.8 a	8.6±0.7 a	2.9±0.5 a	1.4±0.4 a
15 th Dec.	0	20.3±2.4 a	6.4±1.2 b	2.7±1.0 a	2.6±1.3 a
	75	23.5±4.2 a	7.5±0.4 ab	2.2±0.1 a	1.6±0.3 a
	150	23.6±1.2 a	7.5±0.1 ab	2.4±0.7 a	1.2±0.6 a

Means that have same letters in each column are nonsignificant statistically at p = 0.05 (DMR test); values are means ± standard deviation; capital letters refer to main effects, while lower case letters refer to interactions

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Authorship contribution statement

E.E.A., A.T.A., and A.M.A. performed the measurements; A.F.A. and A.M.A. were involved in planning and supervised the work; and A.F.A. and A.M.A. processed the experimental data, performed the analysis, drafted the manuscript, and designed the tables and figures. A.F.A. performed the calculations. A.F.A. aided in interpreting the results and worked on the manuscript. All authors discussed the results and commented on the manuscript.

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