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RESPONSE OF FREESIA (*FREESIA REFRECTA* L.) PLANT TO DIFFERENT GROWTH MEDIA, CALCIUM CHLORIDE AND GIBBERELLIC ACID

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ABSTRACT

A pot experiment has been conducted in a plastic house at the Department of Protected Cultivation, Technical Institute of Zakho, Duhok Polytechnic University during the fall season of 2021–2022 to investigate the effects of three growth media (peat moss, loam + peat moss (1:1) and clay + peat moss (1:1)), foliar spraying of calcium chloride ($CaCl_2$) at three concentrations (0, 500 and 1000 mg. L^{-1}) and Gibberellic acid (GA_3) at three concentrations (0, 200 and 400 mg. L^{-1}) on vegetative growth, flowering and corm yield of freesia (*Freesia refrecta* L.) plant. The experiment was laid out in a Randomized Complete Block Design (RCBD) of three factors with three replicates. The obtained results displayed that the peat moss medium surpassed other media in giving the highest vegetative growth traits (plant height, leaf area, and number of leaves per plant) as well as enhancing flowering traits (number of florets/spike, and vase life of cut flower) and corm yield traits (number of produced corm/plant, and corm volume). The same significant impact was exhibited by $CaCl_2$ at concentrations of 500 and 1000 mg. L^{-1}. Whereas GA_3 at concentrations of 200 and 400 mg. L^{-1} improved most studied traits except number of florets per plant and vase life of cut flowers. The maximum vegetative, flowering, and corm harvest traits were obtained from grown plants in peat moss medium and by spraying them with increased concentrations of $CaCl_2$ and GA_3. Therefore, the peat moss medium in combination with increased concentrations of GA_3 and $CaCl_2$ is recommended for the improvement of freesia production quality and vase life.

***KEYWORDS**:* growth media, calcium chloride ($CaCl_2$), gibberellic acid (GA_3), freesia plant

INTRODUCTION

Freesia (*Freesia hybrida*) is a prominent annual bulb plant and a popular cut flower and is a member of the Iridaceae family. It is native to South Africa and the genus Freesia includes about 11 species (Manning *et al*., 2010). Freesia approaches a height range of between 30-45 cm and is grouped under winter bulbs cultivated in Iraq with a temperature between 13-20 ºC considered optimal for its outgrowth (AL-Khafaji and Chalabi, 2016). More than 200 cultivars are cultivated as cut flowers. Freesia flowers have become one of the most remarkable picked flowers in the world due to their distinguished and impressive aromatic ascent, their longevity, and their various bright colors (Khalaf and Mohammad Saeed, 2020).

Growth medium is one of the most important factors influencing the growth of ornamental plants, and many of these ornamental plants spend their entire life cycle in growing pots and require media that meets their various needs. Hence, it is necessary to prepare an appropriate growth medium that consists of substantial components for this goal (Mohamed, 2018). The physical and chemical characteristics of the utilized

growth media govern the plant's growth since these characteristics directly influence water and nutrient obtainability for plant growth and root breaking via medium as well as affect porosity for root aeration and drainage (Ali *et al*., 2011; Asour *et al*., 2020). The most intensively utilised organic substrate for the creation of growth medium for potted ornaments is peat moss (Shahid *et al.*, 2017). The favorability of peat moss or peat moss plus other mixes in raising numerous ornamental pot plants having perfect vegetative and flowering traits has been proven in several research papers (Farhad Naz *et al.*, 2013; Abdul-Hafeez *et al*., 2015; Mousa *et al.*, 2015). Lee (2016) displayed that the growth substrate comprised of peat moss and another one comprised of a mix of perlite and peat moss (1:1) significantly enhanced the vegetative and

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flowering traits of freesia plants as compared to perlite substrate. Khalaf and Mohammad (2021) revealed that the best foliage, flowering, and corm harvest attributes were obtainable from the growing medium containing of (2 soil: 1 peat moss: 1 perlite).

The utilization of plant growth regulators has led to a unique revolution in the floriculture industry. Gibberellins (GAs) are important plant growth regulators that are effective in affecting various biological processes and plant growth, from foliage growth to blooming, and can also promote the development of flowers. Moreover, other developmental aspects like dormancy, sex expression, senescence of leaf and fruit, performance, and development of seeds in fruits are dominated by gibberellins (Plackett and Wilson, 2016; Satish and Manju, 2018). Gibberellic acid (GA_3) retards senescence of flowers by suppressing the senescence-stimulating impact of ethylene (Faraji *et al*., 2011). Many studies have unveiled a significant improvement in the performance of ornamental plants under the efficacy of gibberellic acid. El-Bably (2016) found that storing corms at 5 ºC for 5 weeks pre-planting plus foliar application of GA_3 at 200 ppm after 30 days of planting led to production of premium vegetative, flowering and corm yield components of freesia compared to control. Adil *et al.* (2021) showed that soaking the freesia corms in GA_3 prepared a solution of 150 mg. L^{-1} prior to planting gave the maximum foliage components and the thickest inflorescence stem, the largest floret head, the heaviest inflorescence, and the best vase life relative to control.

Calcium is an important macronutrient for the production of ornamental plants. Calcium, in the right concentration, can improve the vegetative traits, flower and corm production of ornamental plants like gladiolus and freesia (Sharma *et al.*, 2013). Calcium actively contributes to the maintenance and plays a significant role in numerous cell functions depending on its existence in the membrane and in the cell wall. Calcium integrates the cell wall through giving stability, leading to making the cell wall more rigid (Sardoei, 2014). The effectiveness of calcium on the performance of ornamental plants has been confirmed in various researches. Giri *et al.* (2018) confirmed that providing hybrid lilium with calcium chloride at 440 mg. L^{-1} effectively increased blooming and bulb attributes of the plant as compared to control. Al-Atrakchii and Allawi (2020) showed that dosing gladiolus plants with 500 and 1000 mg. l^{-1} of $CaCl_2$ importantly ameliorated vegetative growth and vase life of gladiolus.

The aim of this study is to evaluate the effect of various growth media and different concentrations of $Cacl_2$ and GA_3 on vegetative growth, flowering, corm yield, and cut flower vase life of (*Freesia refrecta* L.) plant to determine the optimum growth medium and best concentrations of GA_3 and $CaCl_2$ for growth and production of Freesia plant.

MATERIALS AND METHODS

This study was carried out in a plastic house at the department of protect cultivation department, Technical Institute of Zakho, Duhok Polytechnic University, during the period from 15th October 2021 to 15th October 2022. The pot filled with mix media was created by using clay, loam, and peat moss. Cultural practices like weeding, irrigation, and monitoring were done after planting. The corms of *Freesia refrecta* were using as plant material. They were planted in three growth media, including (peat moss, loam + peat moss (1:1) and clay + peat moss (1:1)) on October 20th and placed in the plastic house. Foliar application of calcium chloride ($CaCl_2$) at three concentrations (0, 500 and 1000 mg. L^{-1}) and gibberellic acid (GA_3) at three concentrations (0, 200 and 400 mg. L^{-1}). The spray of $CaCl_2$ and GA_3 replicates three times throughout the experiment. The first spray of calcium chloride was done on January 5th, with three-week intervals between each spray. The first spray of gibberellic acid was performed on January 12th, with three-week intervals between each spray. The experiment was laid out in a Randomized Complete Block Design (RCBD) of three factors with three replicates, and each replicate consisted of 3 pots with a size of 25 cm^3 (3 corms .Pot^{-1}). The studied measurements included plant height (cm), leaf number .plant^{-1}, leaf area (cm^2), date to flowering (days), number of florets .spike flower-1, vase life of cut flower (days), and number of corms produced per plant, corm volume (cm3), and percentage of calcium in dried leaves. The data has been analyzed by using the computer through the SAS program, and mean comparison was done by Duncan's Multiple Ranges Test under the 5% (SAS, 2010).

RESULTS AND DISCUSSION

1. Plant Height (cm)

The data in Table (1) showed that the plant height of freesia displayed statistically significant variations in terms of the effects of growth media, $CaCl_2$ and GA3, and their combined concentrations. Plants grown in peat moss medium were significantly taller (51.12 cm), while those grown in clay + peat moss medium were significantly shorter (45.15 cm). In the case of $CaCl_2$ treatment, the premium average plant heights (48.90 cm and 48.29 cm) were produced from 500 and 1000 mg. L^{-1}, surpassing control treatment (45.43 cm). The same remarkable effect was observed from the two concentrations of GA_3 (200 and 400 mg. L^{-1}) that created the best plant heights of fressia plants as compared with control. Regarding the triple interaction, plants were grown in peat moss medium and sprayed with $CaCl_2$ at 500 mg. L^{-1} along with receiving GA_3 at 200 and 400 mg. L^{-1} possessed the best plant height values (54.18 and 53.77 cm) respectively, over the least average value (39.09 cm) that was recorded for untreated plants with $CaCl_2$ and GA_3 grown in medium consisting of (loam + peat moss 1:1).

Table (1).:- Effect of growth media, CaC_2 and GA_3 concentrations on plant height (cm) of Freesia (*Freesia hybrida* L.) plant.

Growth media	$CaCl_2$ Conc. (mg. L^{-1})	GA_3 concentrations (mg. L^{-1})			Growth media mean	$CaCl_2$ Conc. Mean
		0	200	400		
Peat moss	0	46.05 a-g	50.33 a-e	48.33 a-f	51.12 a	
	500	50.22 a-e	54.18 a	53.77 a		
	1000	51.79 a-d	53.06 ab	52.39 a-c		
Loam + peat moss (1:1)	0	39.09 g	46.84 a-g	46.85 a-g	46.34 b	
	500	46.87 a-g	48.33 a-f	44.32 c-g		
	1000	47.72 a-g	47.11 a-g	49.89 a-e		
Clay + peat moss (1:1)	0	42.28 e-g	42.36 e-g	46.71 a-g	45.15 b	45.43 b
	500	40.24 fg	52.74 a-c	49.39 a-e		48.90 a
	1000	44.81 c-g	44.24 c-g	43.56 d-g		48.29 a
GA_3 Conc. Mean		45.45 b	48.80 a	48.36 a		

Means with same letter for each factor and interaction are not significantly different at 5% level based on Duncan's Multiple Range test.

2. Leaves number.Plant^{-1}

According to the data in Table (2), the growth media and foliar feeding of $CaCl_2$ and GA_3 significantly ameliorated the number of leaves of freesia plants. Plants grown in peat moss medium produced the most leaves (8.81), while plants grown in loam + peat moss medium produced the least number of leaves (8.38). Similarly, the sole concentration of $CaCl_2$ at 1000 mg. L^{-1} created the largest number of (9.18 leaves. Plant^{-1}), exceeding the other concentrations. Respective to the individual impact of GA_3, spraying plants with 200 mg. L^{-1} significantly enhanced the number of leaves per plant, producing an average mean value of (8.81) that was greater than that found in control (8.36). The impact of all factors together also significantly affected the number of leaves per plant that was evident at the complex concentration; growth medium (Loam + peat moss) + $CaCl_2$ at 1000 mg. L^{-1} + GA_3 at 200 mg .L^{-1}. The highest average value (10.57) and the minimum number of leaves (7.35) were for plants grown in peat moss and sprayed with 500 mg. L^{-1} of $CaCl_2$ without GA_3.

3. Leaf area (cm^2)

The results in Table (3) demonstrated that the leaf area of freesia plants displayed variant values related to the influence of growth medium and foliar spraying of $CaCl_2$ and GA_3 and their combination. The peat moss medium and medium consisting of loam + peat moss was significantly better than the medium consist of clay + peat moss in ameliorating the leaf area (11.47 and 11.12 cm^2), respectively. On the other hand, $CaCl_2$ at a concentration of 500 mg .L^{-1} led to obtaining the best mean value (12.71 cm^2) over control (8.88 cm^2). Concerning the effect of GA_3, 200 mg. L^{-1} of GA_3 gave a significant value of leaf area (11.28 cm^2)

superior to other concentrations. Regarding the triple interactions of factors, the greatest value (18.01 cm^2) was recorded for plants grown in peat moss medium and received 500 mg. L^{-1} of $CaCl_2$ without any concentration of GA_3 when encountered with the least average value (4.60 cm^2) which was estimated for plants grown in the loam + peat moss medium without being treated with $CaCl_2$ or GA_3.

Table (2).:- Effect of growth media, $CaCl_2$ and GA_3 concentrations on leaves number .$plant^{-1}$ of Freesia (*Freesia hybrida* L.) plant.

Growth media	$CaCl_2$ Conc. ($mg.L^{-1}$)	GA_3 concentrations ($mg. L^{-1}$)			Growth media mean	$CaCl_2$ Conc. Mean
		0	200	400		
Peat moss	0	8.54 c-h	8.40 c-h	8.55 c-h	8.81 a	
	500	7.35 h	8.70 c-h	8.11 d-h		
	1000	10.57 ab	9.45 b-d	9.64 bc		
Loam + peat moss (1:1)	0	8.40 c-h	8.12 d-h	7.81 f-h	8.53 ab	
	500	7.73 f-h	8.99 c-f	8.70 c-h		
	1000	7.73 f-h	10.86 a	8.45 c-h		
Clay + peat moss (1:1)	0	7.57 gh	7.45 h	8.53 c-h	8.38 b	8.15 b
	500	8.40 c-h	9.23 c-e	8.37 c-h		8.40 b
	1000	8.93 c-g	8.05 e-h	8.94 c-f		9.18 a
GA_3 Conc. mean		8.36 b	8.81 a	8.57 ab		

Table (3).:- Effect of growth media, $CaCl_2$ and GA_3 concentrations on leaf area (cm^2) of Freesia (*Freesia hybrida* L.) plant.

Growth media	$CaCl_2$ Conc. ($mg.L^{-1}$)	GA_3 concentrations ($mg. L^{-1}$)			Growth media mean	$CaCl_2$ Conc. Mean
		0	200	400		
Peat moss	0	8.02 hi	10.65 e-h	8.66 f-i	11.47 a	
	500	18.01 a	12.74 c-e	14.24 b-d		
	1000	8.85 f-i	10.43 e-h	11.66 d-f		
Loam + peat moss (1:1)	0	4.60 j	9.90 e-h	12.42 c-e	11.12 a	
	500	12.60c-e	11.24 e-g	15.53 ab		
	1000	14.98 bc	10.49 e-h	8.34 g-i		
Clay + peat moss (1:1)	0	5.00 j	10.82 e-h	9.82 e-h	9.53 b	8.88 c
	500	6.76 ij	12.17 c-e	11.05 e-h		12.71 a
	1000	10.54 e-h	9.84 e-h	9.78 e-h		10.55 b
GA_3 Conc. mean		9.93 b	10.92 a	11.28 a		

4. Flowering Date (Days)

The data in Table (4) revealed significant differences in the flowering date of freesia grown in growth media and foliar sprays of $CaCl_2$ and GA_3 and their combinations. The least number of days (137.58 days) required for flowering was for plants grown in peat moss medium in comparison with the other two media. The same effect was observed for individual concentrations of $CaCl_2$ with the maximum number of days (143.45 days) needed for control plants to flower versus the lesser number of days (137.02 and 137.09 days) for plants treated with 500 and 1000 mg. L^{-1} to start flowering. In term of GA_3 independent impact, plants untreated with GA_3 needed the biggest number of days (141.11 days) to flowering relative to those sprayed with 200 and 400 mg. L^{-1} requires (137.92 and 138.53) days to flower. Regarding the triple interaction, the greatest number of days (146.80 days) for flowering was for plants grown in clay + peat moss medium and sprayed with 200 mg. L^{-1} of GA_3 and 0 mg $.L^{-1}$. The least number of days (122.17 days) to flower was for plants grown in peat moss medium and sprayed with 1000 mg. L^{-1} of $CaCl_2$ and 400 mg. L^{-1} of GA_3.

Table (4).:- Effect of growth media, $CaCl_2$ and GA_3 concentrations on flowering date (day) of Freesia (*Freesia hybrida* L.) plant.

Growth media	$CaCl_2$ Conc. (mg. L^{-1})	GA_3 concentrations (mg. L^{-1})			Growth media mean	$CaCl_2$ Conc. mean
		0	200	400		
Peat moss	0	143.42 a-c	139.28 b-g	143.00 a-d	137.58 b	
	500	136.42 c-g	133.50 g	135.16 e-g		
	1000	140.17 a-g	134.11 g	133.17 g		
Loam + peat moss (1:1)	0	141.75 a-f	142.11 a-e	146.94 a	139.77 a	
	500	139.06 b-g	137.09 c-g	136.11 d-g		
	1000	142.16 a-e	136.26 d-g	136.44 c-g		
Clay + peat moss (1:1)	0	144.72 ab	146.80 a	143.00 a-d	140.21 a	143.45 a
	500	142.55 a-d	134.89 fg	138.44 b-g		137.02 b
	1000	139.75 b-g	137.28 c-g	134.50 g		137.09 b
GA_3 Conc. mean		141.11 a	137.92 b	138.53 b		

5. Number of Florets/ Spike

The results in Table (5) revealed that the growth media and application of $CaCl_2$ and GA_3 and their interactions significantly influenced the number of florets per spike. In terms of independent effects, plants grown in peat moss medium had the highest mean number of florets per spike (9.52) when compared to other media. The single concentrations are 500 and 1000 mg. L^{-1} of $CaCl_2$ gave the most prominent number of florets per spike (9.33 and 9.19), respectively, against the lowest number for control (8.48). In contrast, the foliar addition of GA_3 had no significant increase in number of florets relative to control. Regarding the biggest number of florets per spike (10.00), it was for plants grown in peat moss medium and sprayed with 500 and 1000 mg. L^{-1} of $CaCl_2$ without GA_3 whereas the lowest number of florets (7.33) was determined for plants grown in clay + peat moss without sprayed of $CaCl_2$ and GA_3

Table (5).:- Effect of growth media, calcium chloride ($CaCl_2$) and GA_3 concentrations on number of florets\spike of Freesia (*Freesia hybrida* L.) plant.

Growth media	$CaCl_2$ Conc. (mg.L^{-1})	GA_3 concentrations (mg. L^{-1})			Growth media mean	$CaCl_2$ Conc. mean
		0	200	400		
Peat moss	0	9.33 ab	9.67 ab	9.67 ab	9.52 a	
	500	10.00 a	9.00 a-c	9.33 ab		
	1000	10.00 a	9.67 ab	9.00 a-c		
Loam + peat moss (1:1)	0	8.00 bc	7.33 c	8.33 a-c	8.70 b	
	500	9.33 ab	9.33 ab	8.67 a-c		
	1000	9.33 ab	8.33 a-c	9.67 ab		
Clay + peat moss (1:1)	0	7.33 c	8.67 a-c	8.00 bc	8.78 b	8.48 b
	500	9.00 a-c	10.00 a	9.33 ab		9.33 a
	1000	8.33 a-c	9.00 a-c	9.33 ab		9.19 a
GA_3 Conc. mean		8.96 a	9.00 a	9.04 a		

6. Vase Life (Day).

The results of Table (6) indicated that the peat moss medium was significantly superior to other media and give the highest value for vase life (18.19 days). Similarly, the individual concentrations of 500 and 1000 mg. L^{-1} of $CaCl_2$ resulted in significantly higher mean values of vase life (18.63 and 18.60 days, respectively) than that of control (15.50 days), while spraying of GA_3 had no significant effect on the vase life. Relating the triple interactions of factors, the greatest average value (19.86 days) of vase life was for plants cultivated in peat moss medium and sprayed with 1000 mg. L^{-1} of $CaCl_2$ without sprayed with GA_3 succeeded by those grown in clay + peat moss medium and sprayed with 1000 mg. L^{-1} of $CaCl_2$ and 400 mg. L^{-1} of GA_3 having an average value of (19.66) days as compared to the least average (14.19 days) was for plants cultivated in clay + peat medium and without spray of $CaCl_2$ or GA_3.

7. Number of produced corms .Plant^{-1}

The data analysis in Table (7) showed that the growth media positively influenced the number of produced corms per plant, with the maximum mean value (14.41 corm. plant^{-1}) determined for peat moss grown plants and the lowest mean value (10.59 corm. plant^{-1}) was for plants grown in clay + peat moss. In contrast, no significant effect was observed from foliar spraying of $CaCl_2$ relative to control. The plants were sprayed with GA_3 at 200 mg. L^{-1} produced the significant highest number of corms (13.56 corm. plant^{-1}) followed by those received 400 mg. L^{-1} (12.96 corm .plant^{-1}) in comparison with control (11.63 corm .plant^{-1}). As for triple interactions, the maximum number of corms (18.33 corm. plant-1) was for plants grown in peat moss medium and treated with $CaCl_2$ at 1000 mg. L^{-1} and GA_3 at 200 mg .L^{-1} they were grown in the same medium (peat moss) and received the same concentration of GA_3 at 200 mg. L^{-1} but without $CaCl_2$ in comparison with the lowest number of corms (8.67 corms. plant^{-1}) which was for plants grown in loam + peat moss medium and treated with 500 mg. L^{-1} of $CaCl_2$ with without spray of GA_3.

Table (6).:- Effect of growth media, $CaCl_2$ and GA_3 concentrations on the flowers vase life (day) of Freesia (*Freesia hybrida* L.) plant.

Growth media	$CaCl_2$ Conc. (mg.L^{-1})	GA_3 concentrations (mg. L^{-1})			Growth media mean	$CaCl_2$ Conc. mean
		0	200	400		
Peat moss	0	16.71 b-i	15.54 f-i	15.83 d-i	18.19 a	
	500	19.07 a-c	19.30 ab	18.84 a-c		
	1000	19.72 a	18.87 a-c	19.86 a		
Loam + peat moss (1:1)	0	15.38 g-i	16.42 c-i	15.54 f-i	17.23 b	
	500	18.27 a-f	17.08 a-h	19.00 a-c		
	1000	19.11a-c	15.70 e-i	18.55 a-d		
Clay + peat moss (1:1)	0	14.19 i	15.36 g-i	14.51hi	17.31 b	15.50 b
	500	18.44 a-e	18.97 a-c	18.70 a-c		18.63 a
	1000	17.91 a-g	18.04 a-g	19.66 a		18.60 a
GA_3 Conc. mean		17.64 a	17.25 a	17.83 a		

Table (7). :-Effect of growth media, $CaCl_2$ and GA_3 concentrations on number of produced corms. plant^{-1} (corms yield) of Freesia (*Freesia hybrida* L.) plant.

Growth media	$CaCl_2$ Conc. (mg.L^{-1})	GA_3 concentrations (mg. L^{-1})			Growth media mean	$CaCl_2$ Conc. mean
		0	200	400		
Peat moss	0	13.33 c-f	18.33 a	10.33 fg	14.41 a	
	500	15.33 a-d	16.00 a-c	10.00 fg		
	1000	14.67 b-e	13.33 c-f	18.33 a		
Loam + peat moss (1:1)	0	12.33 d-g	11.33 e-g	17.33 ab	13.15 b	
	500	8.67 g	14.67 b-e	16.33 a-c		
	1000	9.33 g	13.33 c-f	15.00 a-d		

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Clay + peat moss (1:1)	0	9.33 g	10.33 fg	10.00 fg	10.59 c	12.52 a
	500	12.33 d-g	14.67 b-e	9.67 g		13.07 a
	1000	9.33 g	10.00 fg	9.67 g		12.56 a
GA_3 Conc. mean		11.63 b	13.56 a	12.96 a		

8. Corms volume (cm3)

Results in Table (8) represented the average values of corm volume of freesia in response to growing in three growing media and foliar feeding of $CaCl_2$ and GA_3 at three concentrations alone and with their interaction. Plants grown in peat moss medium consisted of were characterized by their peak corm volume (6.79 cm3) but those grown in clay + peat moss medium possessed the smallest corm volume (5.34 cm^3). $CaCl_2$ at a concentration of 500 mg. L^{-1} also notably enhanced corm volume, producing an average value of (6.60 cm^3) as compared to control (5.47 cm^3). In the case of an independent impact of GA_3, the largest corms (6.44 cm^3) were for plants treated with 200 mg. L^{-1} of GA_3 relative to control (5.88 cm^3). The interaction among all factors produced an evident amelioration in the corm volume and that was observable in plants grown in peat moss medium and sprayed with 500 mg. L^{-1} of $CaCl_2$ plus 200 mg. L^{-1} GA_3 which owned the significant highest corm volume (8.17 cm^3) in comparison with the smallest corms (3.77 cm^3) was for plants grown in the clay + peat moss medium and provided with 1000 mg. L^{-1} of $CaCl_2$ without GA_3.

Table (8).:- Effect of growth media, calcium chloride ($CaCl_2$) and GA_3 concentrations on corm volume (cm^3) of Freesia (*Freesia hybrida* L.) plant.

Growth media	$CaCl_2$ Conc. (mg.L^{-1})	GA3 concentrations (mg. L^{-1})			Growth media mean	$CaCl_2$ Conc. mean
		0	200	400		
Peat moss	0	7.02 b-e	7.23 a-d	4.82	6.79 a	
	500	6.00 e-g	8.17 a	7.37 a-c		
	1000	8.00 a	6.23 d-g	6.27 d-g		
Loam + peat moss (1:1)	0	5.43 g-j	4.60 kl	5.77 f-g	6.13 b	
	500	6.47 c-f	6.37 d-g	6.97 b-e		
	1000	6.57 c-f	6.87 b-e	6.13 e-g		
Clay + peat moss (1:1)	0	4.93 h-k	5.00 h-k	4.40 kl	5.34 c	5.47 c
	500	4.73 i-k	7.73 ab	5.60 f-i		6.60 a
	1000	3.77 l	5.77 f-g	6.17 e-g		6.20 b
GA_3 Conc. mean		5.88 b	6.44 a	5.94 b		

9. Percentages of calcium (Ca) in dried leaves (%)

The results in Table (9) showed that growth media had a significant impact on the calcium content in dried leaves of freesia plants, with the highest calcium percentage (1.71%) recorded in leaves of plants grown in clay + peat moss medium compared to other media. Meanwhile, the increased concentrations of $CaCl_2$ 500 and 1000 mg. L^{-1} led to the creation of the best average percentage values of calcium (1.81 and 1.69 %), respectively. In contrast, no significant improvement in calcium percentage was displayed by foliar application of GA_3 relative to control. Regarding the triple interactions among all factors, the highest percentage of calcium (2.23 %) was in leaves for plants grown in clay + peat moss medium and sprayed with 500 mg. L^{-1} of $CaCl_2$ without GA_3 whereas the least percentage (1.25 %) of calcium was found in the dried leaves of plants grown in peat moss medium and treated with 400 mg.L^{-1} of GA_3 without $CaCl_2$.

Table (9):- Effect of growth media, calcium chloride ($CaCl_2$) and GA_3 concentrations on percentage of calcium in dried leaves (%) of Freesia (*Freesia hybrida* L.) plant

Growth media	CaCl2 Conc. (mg.L-1)	GA3 concentrations (mg. L-1)			Growth media mean	CaCl2 Conc. mean
		0	200	400		
Peat moss	**0**	1.35 d-f	1.49 c-f	1.25 f	1.55 b	
	500	1.85 a-d	1.80 a-d	1.52 c-f		
	1000	1.42 c-f	1.73 a-f	1.53 c-f		
Loam + peat moss (1:1)	**0**	1.36 d-f	1.50 c-f	1.53 c-f	1.68 ab	
	500	1.93 a-c	1.69 b-f	1.67 b-f		
	1000	1.82 a-d	1.52 c-f	2.09 ab		
Clay + peat moss (1:1)	**0**	1.27 ef	1.51 c-f	1.68 b-f	1.71 a	1.44 b
	500	2.23 a	2.16 ab	1.47 c-f		1.81 a
	1000	1.78 a-f	1.77 a-f	1.52 c-f		1.69 a
GA3 Conc. mean		1.67 a	1.69 a	1.58 a		

It is evident from the previously mentioned results that the peat moss medium, either alone or in combination with GA_3 and $CaCl_2$ significantly improved vegetative traits (plant height, leaf area, and number of leaves per plant) as well as enhanced flowering (number of florets/spike, and vase life of cut flower) and corm yield traits (number of produced corm/plant, and corm volume) while decreasing the number of days to flowering (flower date). This positive impact of peat moss medium could be attributed to the effective role of peat moss on plant growth and productivity. Peat moss possesses significant functions for plants. It conserves water and nutrients and provides them constantly to plants. It also has air pockets or pores to give plant roots oxygen and permit proper drainage. Peat moss substrate is completely free of weeds and pathogens, has a low PH, and has a high capacity to hold air and water. It is also enriched with nourishing nutrients required for plant growth and development (Robertson, 1993). The same findings were confirmed by Lee (2016) on freesia and Hassan *et al.* (2016) on gladiolus, who displayed that the growth substrate comprised of peat moss significantly increased vegetative characteristics, flowering, and corm production of plants in comparison with other media.

The obtained findings also revealed a significant effect of calcium chloride ($CaCl_2$) as an individual concentration and in combination, especially the triple interaction that gave the maximum average values, with peat moss growing medium and gibberellic acid (GA_3) on growth, flowering, and harvest traits of freesia plants. The beneficial effect of calcium chloride on freesia plants could be attributed to the element calcium. Plants utilize calcium as a major macronutrient for plant performance since it undertakes various roles, such as making cross-bridges as necessary elements, organizing plant growth and development, and strengthening the cell wall (Hepler, 2005). The active contribution of calcium in keeping and modulating numerous cell functions is referred to its presence in the membrane and as a major constituent of the cell wall structure where it confers steadiness, driving a rigid cell wall (Sardoei, 2014). Furthermore, foliar addition of calcium is needed for amelioration of longevity. Ca reduces respiration rate (Anjum *et al.*, 2001) and also induces cell wall resistance (Gregory et al., 1988). Therefore, it enhances the vase life of cut flowers. In addition, calcium takes place in cross-binding negative charges, particularly on the carboxylic remnants of pectin, granting remarkable structural hardness to the cell wall (Hepler, 2010); more than 60% of calcium in plants is correlated with pectin (Lara *et al.*, 2004). Our results of $CaCl_2$ efficacy on freesia plants are consistent with that displayed by Reddy and Sarkar (2016) on gladiolus, who unveiled that the foliar spraying of calcium importantly increased corm and cormges attributes and extended the vase life of plants. Al-Atrakchii and Allawi (2020) reported that providing gladiolus plants with 500 and 1000 mg. l^{-1} of $CaCl_2$ significantly elevated vegetative growth and vase life.

The data analysis regarding the effect of gibberellic acid (GA_3) on freesia plants demonstrated that the foliar application of the growth regulator at singular concentrations caused a magnitude improvement in the vegetation and corm yield traits of freesia but did not significantly affect the number of florets per spike and vase life of cut flowers. However, its interaction with $CaCl_2$ and peat moss media resulted in the production of the highest ever vegetative growth, flowering and corm harvest traits. This could be attributed to the effectiveness of plant growth regulators in ameliorating the performance and quality of ornamental plants (Sajid *et al*., 2009). Gibberellins like GA_3 play a key role in hormonal and nutrient organization and blooming. GA_3 motivates the re-dispensation of photosynthesis (regulates sink–source relationships), particularly the conveyance of photosynthetic products from leaves to buds. It has a remarkable task in governing various significant processes of outgrowth, development, seed germination, stem elongation, leaf expansion, and flower development (Kawa and Saniewski, 1986). Furthermore, Gibberellic acid (GA_3) can delay the senescence of flowers by antagonizing the senescence-stimulating influence of ethylene (Faraji *et al.*, 2011). Many studies have unveiled a significant improvement in the performance of ornamental plants under the efficacy of gibberellic acid. Zurawik and Placek (2013) reported that treating freesia plants with 160 mg dm-3 of gibberellic acid (GA_3) significantly enhanced vegetation, flowering, and premium weight of offspring corms relative to control. Our findings are in agreement with that of El-Bably (2016) on freesia, who displayed that pre-planting plus foliar application of GA_3 at 200 ppm produced the premium vegetative, flowering, and corm yield characters compared to control. Adil *et al.* (2021) also soaked the corms of freesia in GA_3 prepared solution of 150 mg. L^{-1} prior to planting and recorded the best vegetative and blooming characteristics, including the thickest inflorescence stem, the largest floret head, the heaviest inflorescence, and the best vase life relative to control.

CONCLUSIONS

The production of Freesia plants has been increasing in recent years due to its attractive aesthetic appearance and the nice aromatic smell of its flowers. Therefore, efforts are being made to enhance the growth, productivity, and vase life of this plant using different effective factors such as calcium chloride, plant growth regulators, and organic growth media. Our pot study displayed that the utilization of a medium consisted of peat moss and foliar spraying of $CaCl_2$ at 500 and 1000 mg. L^{-1} and GA_3 at 200 and 400 mg. L^{-1} along with their interactions, exhibited superiority in giving the maximum vegetation, flowering, and corm harvest of freesia plants, especially the triple interaction that gave the highest values of such traits. Hence, the use of a medium like peat moss with good physical and chemical characteristics and efficient growth regulating matters like GA_3 added with an active substance like $CaCl_2$ is strongly recommended for optimum production of freesia, with more field studies to be conducted on freesia adding extra growth-regulating materials.

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بەرسڤدانا رووەکی فرێزیایێ ژبو بیاڤیت شینبونی ییت جورا وجور، کلوریدی کالیسیوم وترشێی جبرلێك

پوختە

ئەف ڤەکولێنا گولڎانا هاتیە ئەنجامدان دناڤا خانێی پلاستیکی دا ل بشکا چاندنا پاراستی ل پەیمانگەها زاخو یا تەکنیکی ، زانکویا پولی تەکنیکا دهوك د وەرزی پایێزی یێ سالا 2021-2022 ژبو دیفچوونا کارتێکرنا سێ بیاڤیت شێنبونی (پیت موس ، خیزی باغچا + پیت موس (1:1) و ئاخ + پیت موس (1:1) و رەشاندنا بەلگا ب سێ تیراتییێن ڤاری ژ 0) Cacl2، 500 و 1000 ملگم . لێتر-1) و ژ ترشێی جبرلێکی ب سێ تیراتییێن ڤاری (0، 200 و 400 ملم. لیتر-1) لسەر شێنکاتی وگولدان وبەرهەمی بیڤازین رووەکێ فرێزیا (Freesia refrecta L.). ئەف ڤەکولینە هاتە ئەنجامدان بکارئینانا دێزاینی (RCBD) بێکهاتبو ژ سێ فاکتەرا و هەر یەکەك سێ َبارە کربو. ئەنجامێت ڤەکولینێ دیاربون کو بیاڤی پیت موسی سەرکەفتنەکا بەرچاف نێشاندا بەراورد دگەل هەردوو بیاڤێن دی د ساخلەتین شێنکاتی دا (بلنداهیا رووکی، بانیا بەلگا ، ژمارا بەلگا لسەر رووکی) وهەروەسا د ساخلەتین گولدانی دا (ژمارا گولا د ئێشێی گولی دا ، و ژیێ گولی دناف ڤازادا) وساخلەتین بیڤازا (ژمارا بیڤازا لسەر رووەکی و قەباری بیڤازی). و هەروەسا هەردوو تیراتیین بکارئینای ژ (500 Cacl2 و1000 ملگم . لیتر-1) هەردوو تێراتێین ترشێی جبرلیك بونە ئەگەری بدەستڤەئینانا باشترین ساخلەتین دیارکری بەراورد دگەل رووەکین نە هاتێنە رەشاندن ژبلی ژمارا گولا د ئێشی دا وژیێ گولا دناف ڤازی دا. وبلندترین شێنکاتی وگولدان وبەرهەمی بیفازا بدەست ڤەهات دەمی بیفاز شێنبوین دناف بێاڤی پیت موسی دا و بزیدەکرنا تیراتیین Cacl2 وترشیی جبرلیکی، ژبەر ڤی چەندی یاباش ئەوە بیاڤی پیت موس وبکارئێنانا زیدەکرنا تێراتیێن Cacl2 وترشێی جبرلیکی بیتە بکارئینان ژبو بدەستڤەئینان بەرهەمەك وکوالیتیەکا باش یا شێنکاتی وگول و بڤازین رووەکی فرێزیایێ وزیدەکرنا ژیی گولا دناف ڤازدا.