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The Effect of Organic Fertilizer Application and Calcium Chloride Foliar Spray on Certain Growth Traits and Flowering Duration of Freesia Plant

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Abstract:

This study investigates the individual and interactive effects of organic fertilizers and foliar application of calcium chloride ($CaCl_2$) on the growth performance, physiological attributes, and postharvest behavior of Freesia spp. grown under semi-arid conditions. A randomized complete block design (RCBD) was used with three replications, including combinations of three levels of organic fertilizers and foliar calcium chloride. The results demonstrated that calcium chloride significantly enhanced leaf area, chlorophyll content, fresh corm weight, and flowering duration. The interaction between calcium chloride and humic acid proved particularly effective in improving dry matter accumulation, carbohydrate content, and water balance in leaves. Moreover, humic acid and seaweed extracts contributed to improved postharvest longevity through enhanced nutrient uptake, increased chlorophyll and sugar content, and delay in senescence processes. These findings suggest that integrating biostimulants with calcium chloride application is a viable strategy for improving both the physiological quality and commercial shelf life of ornamental freesia flowers.

Keywords: Organic fertilizers, Flowering duration, Freesia.

INTRODUCTION

Freesia (Freesia spp.), a popular ornamental plant known for its fragrant and colorful flowers, holds significant value in the cut flower industry due to its aesthetic appeal and long vase life. The success of freesia cultivation largely depends on optimizing agronomic practices that enhance its growth, flowering characteristics, and overall quality. Among the various cultivation strategies, nutrient management plays a central role in improving plant performance under both field and greenhouse conditions.

Organic fertilizers, derived from plant and animal residues, are increasingly being recognized for their potential to improve soil structure, increase microbial activity, and provide slow-release nutrients that support sustained plant growth. Recent studies have shown that organic inputs not only enhance biomass accumulation but also improve flowering parameters in ornamental species by stimulating root development and improving nutrient uptake efficiency (Mousavi et al., 2021; Ahmed et al., 2023). Moreover, organic fertilizers contribute to environmental sustainability by reducing dependence on synthetic agrochemicals and mitigating their associated ecological risks.

In parallel, the application of calcium chloride ($CaCl_2$) as a foliar spray has gained attention for its physiological benefits, particularly in strengthening cell wall integrity, enhancing membrane stability, and modulating stress responses in plants. Calcium is a secondary macronutrient essential for cell division and elongation, and its foliar application has been found effective in improving flowering duration and reducing bud abortion in various floricultural crops (Zhang et al., 2022; El-Sayed et al., 2020). The synergistic effect of calcium and organic matter may contribute to more vigorous growth and prolonged flowering, which are crucial attributes for the commercial success of freesia.

Despite the recognized importance of both organic fertilization and calcium supplementation, there remains limited empirical evidence on their combined impact on freesia cultivation. This study aims to evaluate the individual and interactive effects of organic fertilizer application and foliar spraying of calcium chloride on selected growth traits and flowering behavior of freesia. The findings are expected to contribute to the development of more sustainable and effective cultivation practices for ornamental horticulture.

MATERIALS AND METHODS

Site Description and Experimental Layout

This study was conducted during the 2023 growing season in an open greenhouse at the Department of Horticulture, and the location of the experiment should be stated as one of the nurseries affiliated with babylon Governorate Iraq, characterized by moderate temperatures and adequate sunlight conditions typical of semi-arid regions. The soil at the site was sandy-loam in texture, with good drainage and moderate fertility.

The experiment followed a randomized complete block design (RCBD) with three replications. Each plot consisted of five healthy freesia plants grown in individual containers with equal volumes of prepared soil mixture. Treatments involved combinations of organic fertilizer application and foliar spraying with calcium chloride.

Planting Materials and Growing Conditions

Uniform-sized freesia corms were selected and sterilized with 1% sodium hypochlorite solution for ten minutes before planting to minimize contamination. The planting medium consisted of soil mixed with decomposed organic manure at a recommended rate. Corms were planted at a depth of approximately 5 cm and irrigated uniformly throughout the growing period using a drip system.

The plants were exposed to natural daylight and protected from excessive wind and pests. Ambient temperature ranged between 18°C and 27°C, and relative humidity remained between 60% and 70% throughout the growth period.

Calcium chloride was applied as a foliar spray at a concentration of 2% at three different stages: the vegetative phase, early bud development, and full flowering. Organic fertilizer was incorporated into the soil two weeks prior to planting.

1. Vegetative Characteristics

Leaf Area

Leaf area was determined using Digimizer software, which allowed for precise surface measurements. Leaves were collected randomly from the bottom to the top portion of five plants per treatment. Each leaf was scanned, and the area measured was multiplied by the total number of leaves per plant to estimate the overall leaf area.

Number of Leaves

The total number of fully expanded leaves was counted manually on five randomly chosen plants in each experimental unit. The average was used for further analysis.

Fresh Weight of Corms

At the end of the growing cycle, five corms were harvested randomly from each treatment. After cleaning, the fresh weight was measured using a precision electronic balance.

Dry Matter Content in Corms

Corms were first air-dried under room temperature and then oven-dried at 70°C for 48 hours. The dry matter percentage was calculated using the following formula:

Dry Matter (%) = (Dry Weight / Fresh Weight) × 100

2. Biochemical Attributes

Leaf Carbohydrate Content

Total carbohydrates in the leaves were analyzed following the method of Herbert et al. (1971). A 0.1 g sample of dried and finely ground leaf tissue was extracted with 10 ml of distilled water. The solution was centrifuged at 5000 rpm for 5 minutes, and the process was repeated. The combined extracts were treated with phenol and sulfuric acid. The absorbance was measured at 490 nm using a Bichrom-Libra S22 spectrophotometer. The carbohydrate content was determined based on a standard glucose curve and calculated as:

Carbohydrates (%) = (mg glucose / volume of test sample) × 100

Leaf Chlorophyll Content

Chlorophyll was extracted from 1 g of fresh leaf tissue using 80% acetone. The extract was centrifuged at 3000 rpm for 15 minutes (Hettich EBA 35 centrifuge, Germany), and the process was repeated until all green pigment was extracted. Absorbance was read at 663 nm and 645 nm, and total chlorophyll was calculated according to the formula provided by Mackinney (1941):

$$\text{Chlorophyll (mg/g)} = [(20.2 \times A645) + (8.02 \times A663)] \times V / (1000 \times W)$$

Where:

V = final volume of extract (ml)

W = weight of fresh tissue (g)

A = absorbance at specific wavelengths

3. Statistical Analysis

All data were subjected to analysis of variance (ANOVA) using SPSS software (version 25). Treatment means were compared using Duncan's Multiple Range Test (DMRT) at a 5% significance level ($p \leq 0.05$). Results were presented as mean ± standard error (SE).

RESULTS AND DISCUSSION

1. Leaf Area

Table 1 illustrates that the application of organic fertilizers had no statistically significant effect on the average leaf area of freesia plants. In contrast, calcium chloride exerted a notable impact, with treatment C2 achieving the largest leaf area at 29.9 cm^2 per plant, significantly surpassing C0 and C1 treatments, which recorded 21.7 and 21.8 cm^2, respectively.

Furthermore, the interaction between calcium chloride and organic fertilizer was statistically significant. The treatment combination C2F0 resulted in the highest recorded leaf area (32.8 cm^2), while the lowest value (18.8 cm^2) was observed in C0F0.

Table 1. Effect of organic fertilizers, calcium chloride, and their interaction on leaf area (cm^2 per plant)

Organic Fertilizers (F)	C0	C1	C2	Average
F0	18.8	21.4	32.8	24.3
F1	20.7	23.6	25.9	23.4
F2	25.6	20.4	31.1	25.7
Average	21.7	21.8	29.9	

L.S.D (0.05): C = 5.78 | F = N.S | Interaction = 10.01

The significant influence of calcium chloride can be attributed to its role in promoting meristematic cell division and enhancing CO_2 assimilation during photosynthesis, ultimately improving vegetative growth and increasing leaf area (Abu Dhahi, 1988; Al-Sahhaf, 1989). These findings align with previous studies by Al-Abdali (2002), Al-Rubaie (2003), and Al-Alawi (2004), which reported enhanced leaf expansion following foliar calcium treatments.

The significant interaction observed may be linked to the physiological effects of humic acid, which enhances enzymatic activity, facilitates translocation of photosynthates, and stimulates cell division and elongation (Fawzy, 2007). Similarly, seaweed extracts—rich in plant hormones such as cytokinins—have been shown to enhance vegetative growth and branching (Basak, 2008; Kuwada, 2006). Al-Hamzawi (2019) also reported similar findings in Dianthus chinensis.

2. Number of Leaves

As shown in Table 2, neither organic fertilizer nor calcium chloride had a statistically significant effect on the number of leaves per plant. Additionally, the interaction between these factors was also non-significant, indicating no influence on this particular vegetative trait.

Table 2. Effect of organic fertilizers, calcium chloride, and their interaction on the number of leaves (leaves per plant)

Organic Fertilizers (F)	C0	C1	C2	Average
F0	9.24	9.33	9.42	9.33
F1	9.33	6.49	9.25	9.36
F2	9.33	9.17	9.83	9.44
Average	9.30	9.33	9.50	

L.S.D (0.05): C = N.S | F = N.S | Interaction = N.S

3. Percentage of Dry Matter in Corms

Table 3 demonstrates that neither calcium chloride nor organic fertilizers alone significantly influenced the dry matter percentage in corms. However, their interaction was significant. The treatment C1F1 showed the highest dry matter content at 63.7%, while C2F0 recorded the lowest at 50.3%.

Table 3. Effect of organic fertilizers, calcium chloride, and their interaction on dry matter in corms (%)

Organic Fertilizers (F)	C0	C1	C2	Average
F0	53.4	52.2	50.3	52.0
F1	63.7	57.4	53.1	58.1
F2	55.9	56.2	57.0	56.4
Average	57.7	55.3	53.5	

L.S.D (0.05): C = N.S | F = N.S | Interaction = 10.99

The significant interaction may be explained by the synergistic role of humic acid and calcium chloride in enhancing root biomass and corm development (Zhang, 2004). Potassium from seaweed extracts further aids in carbohydrate translocation and protein synthesis (Fuller et al., 1987), promoting higher dry matter accumulation. Calcium's role in enhancing photosynthetic efficiency also contributes to this outcome (Reddy & Sarkar, 2016).

4. Fresh Weight of Corms

The findings in Table 4 indicate that both organic fertilizers and calcium chloride had significant effects on the fresh weight of freesia corms. Among the treatments, F2 resulted in the highest average fresh weight (6.06 g), while F0 recorded the lowest (4.92 g). Similarly, among calcium chloride treatments, C2 showed the highest fresh weight (6.06 g), whereas C0 recorded the lowest (4.94 g).

A statistically significant interaction was observed between the two factors, with the C2F2 treatment yielding the highest fresh corm weight (6.06 g), while the lowest value (3.97 g) was recorded in treatment C0F2.

Table 4. Effect of organic fertilizers, calcium chloride, and their interaction on fresh weight of corms (g)

Organic Fertilizers (F)	C0	C1	C2	Average
F0	5.83	4.97	3.97	4.92
F1	6.83	6.18	5.16	6.06
F2	5.52	5.45	5.68	5.55
Average	4.94	5.54	6.06	

L.S.D (0.05): C = 1.101 | F = 1.101 | Interaction = 9.07

This enhancement in corm weight can be attributed to the synergistic physiological effects of humic substances, which act similarly to natural growth regulators like auxins and cytokinins (Zhang, 2004). Additionally, potassium in seaweed extracts aids in the synthesis of proteins and the movement of carbohydrates to storage tissues (Fuller et al., 1987; Mohammed Abdel Azim, 1977). Enhanced photosynthesis, facilitated by calcium-induced chlorophyll accumulation, likely contributed to the increased allocation of assimilates to corm development (Reddy & Sarkar, 2016).

5. Leaf Chlorophyll Content

Table 5 reveals a statistically significant effect of calcium chloride on leaf chlorophyll content. The highest value was recorded in treatment C0 (35.5%), while the lowest was observed in C2 (19.4%). Organic fertilizer treatments alone did not result in significant differences.

However, the interaction effect was significant. Treatment C0F2 showed the highest chlorophyll content (41.1%), while C2F1 showed the lowest (19.3%).

Table 5. Effect of organic fertilizers, calcium chloride, and their interaction on leaf chlorophyll content (%)

Organic Fertilizers (F)	C0	C1	C2	Average
F0	34.6	26.7	20.0	26.7
F1	30.9	36.5	19.3	28.9
F2	41.1	23.9	20.0	28.3
Average	35.3	29.0	19.4	

L.S.D (0.05): C = 9.09 | F = N.S | Interaction = 15.75

The higher chlorophyll content can be linked to the role of calcium in stabilizing chloroplast membranes and activating enzymes involved in chlorophyll biosynthesis (Al-Sahaf, 1989). The effectiveness of humic acid and seaweed extract in increasing chlorophyll concentration may be due to their rich hormonal composition (Basak, 2008; Kuwada, 2006), as well as the presence of betaine, which inhibits chlorophyll degradation. These results are consistent with those of Al-Hamzawi (2019), who observed enhanced pigment concentration in Dianthus chinensis following seaweed extract application.

6. Leaf Carbohydrate Content

According to Table 6, the individual effects of both organic fertilizers and calcium chloride on carbohydrate content were not significant. However, the interaction between the two was statistically significant. Treatment C1F1 recorded the highest carbohydrate content (59.7%), whereas C1F0 recorded the lowest (24.6%).

Table 6. Effect of organic fertilizers, calcium chloride, and their interaction on leaf carbohydrate content (%)

Organic Fertilizers (F)	C0	C1	C2	Average
F0	41.7	24.6	47.4	37.9
F1	28.7	59.7	43.1	43.1
F2	29.7	48.9	48.3	42.3
Average	33.3	44.4	-	

L.S.D (0.05): C = 14.38 | F = N.S | Interaction = 29.91

The increase in carbohydrate content under specific treatments may be related to the cumulative effects of humic acid on nutrient uptake and enzyme activation (Harper, 2000). Additionally, seaweed extracts enhance carbon assimilation by promoting chlorophyll synthesis and photosynthetic activity (Basak, 2008). These effects are consistent with studies by Nikbakh (2008), Baldotto (2013), and Baloch (2014).

Second: Storage Traits

1. Amount of Water Absorbed (g/day)

The results presented in Table 7 show that the application of organic fertilizers had no significant impact on water absorption rates in freesia plants. However, calcium chloride exhibited a significant effect, with treatment C1 recording the highest water absorption (16.83 g/day), while treatment C0 recorded the lowest (13.05 g/day).

Furthermore, a significant interaction was observed between the two factors. The highest absorption value (19.07 g/day) was recorded under treatment C1F0, whereas the lowest (11.15 g/day) was observed in C0F0.

Table 7. Effect of organic fertilizers, calcium chloride, and their interaction on water absorption (g/day)

Organic Fertilizers (F)	**C0**	**C1**	**C2**	**Average**
F0	11.15	19.07	18.24	16.15
F1	16.42	14.91	13.77	15.04
F2	11.58	16.50	16.31	14.80
Average	13.05	16.83	16.10	

L.S.D (0.05): C = 3.677 | F = N.S | Interaction = 6.368

The enhanced water uptake under calcium chloride application may be attributed to its role in maintaining membrane stability and improving cell wall permeability, thus facilitating more efficient water transport throughout plant tissues.

2. Amount of Water Lost (g/day)

As shown in Table 8, calcium chloride had a significant impact on water loss. Treatment C1 showed the highest water loss (23.99 g/day), while C0 recorded the lowest (16.19 g/day). No significant effects were observed from organic fertilizer alone.

However, the interaction between calcium chloride and organic fertilizer was significant. The greatest water loss (25.25 g/day) occurred in C1F0, whereas the lowest (14.82 g/day) was observed in C0F0.

Table 8. Effect of organic fertilizers, calcium chloride, and their interaction on water loss (g/day)

Organic Fertilizers (F)	**C0**	**C1**	**C2**	**Average**
F0	14.82	25.25	21.77	20.26
F1	17.78	22.35	17.21	19.12
F2	15.98	24.35	18.10	19.48
Average	16.19	23.99	19.03	

L.S.D (0.05): C = 5.030 | F = N.S | Interaction = 8.712

The elevated water loss under certain treatments may result from increased transpiration associated with enhanced leaf area and stomatal conductance induced by calcium chloride.

3. Water Balance (g/day)

According to Table 9, neither organic fertilizers nor calcium chloride alone had a significant effect on water balance. However, their interaction was statistically significant. Treatment C2F2 showed the highest (least negative) water balance at −1.00 g/day, while C1F2 had the most negative balance (−7.85 g/day).

Table 9. Effect of organic fertilizers, calcium chloride, and their interaction on water balance (g/day)

Organic Fertilizers (F)	C0	C1	C2	Average
F0	−3.59	−6.17	−3.53	−4.43
F1	−1.36	−7.44	−3.44	−4.08
F2	−4.40	−7.85	−1.00	−4.41
Average	−3.11	−7.15	−2.66	

L.S.D (0.05): C = N.S | F = N.S | Interaction = 3.547

The improved water balance under C2F2 could be attributed to optimized photosynthesis and transpiration rates, which are regulated by calcium and organic nutrient availability, enhancing plant water-use efficiency.

4. Flowering Duration (days)

Table 10 reveals that both calcium chloride and organic fertilizers significantly affected flowering duration. Among calcium treatments, C2 resulted in the longest flowering period (11.00 days), whereas C0 showed the shortest (8.56 days). Regarding organic fertilizers, treatment F2 yielded the longest flowering duration (10.33 days), while F0 produced the shortest (9.00 days).

The interaction between both factors was also significant. The combination C2F2 recorded the maximum flowering duration (12.00 days), while the minimum (8.00 days) was observed in C0F0.

Table 10. Effect of organic fertilizers, calcium chloride, and their interaction on flowering duration (days)

Organic Fertilizers (F)	C0	C1	C2	Average
F0	8.00	8.67	10.33	9.00
F1	9.00	8.33	10.67	9.33
F2	8.67	10.33	12.00	10.33
Average	8.56	9.11	11.00	

L.S.D (0.05): C = 1.099 | F = 1.099 | Interaction = 1.903

This extended flowering duration may be attributed to improved nutrient availability and physiological stability in plants, mediated by calcium's regulatory role in delaying senescence and organic fertilizers' support of hormonal balance.

The cumulative analysis of results indicates that the experimental treatments had a profound influence on the postharvest longevity and quality of freesia flowers. Among the treatments, humic acid emerged as the most effective factor in enhancing vase life. This can be primarily attributed to its role in increasing the internal levels of chlorophyll and carbohydrates, along with the enhanced uptake and assimilation of nitrogen and potassium in leaf tissues. The biochemical composition of humic acid—including essential nutrients, amino acids, and organic compounds—contributes to improved cell membrane permeability, facilitating the efficient movement of nutrients into the cells. This enhancement supports fundamental physiological processes such as photosynthesis, respiration, and hormone regulation, thereby improving overall plant health (Al-Sahaf et al., 2018).

Furthermore, humic acid has been shown to increase protein content, stimulate endogenous hormone activity, and maintain higher cellular turgidity, all of which collectively delay flower senescence. Its impact on increasing the efficiency of water absorption and maintaining internal hydration is particularly important during the postharvest stage. These effects align with prior findings that demonstrate its ability to enhance flower characteristics and prolong vase life through improvements in nutrient dynamics and metabolic activity (Zandonadi et al., 2007; Elhindi, 2012).

The inclusion of sucrose in the preservative solution was also shown to play a pivotal role. By serving as a vital source of energy, sucrose sustains cellular metabolism, delays tissue degradation, reduces the synthesis of ethylene—a hormone closely associated with senescence—and activates hormonal pathways that counteract aging processes (Mar et al., 2011).

Calcium chloride ($CaCl_2$) also demonstrated notable effects in extending the postharvest life of freesia. Its benefits are largely associated with its role in cell wall fortification through lignin biosynthesis, leading to stronger stem structures and reduced bending. In addition, calcium supports water retention, improves tissue rigidity, and reduces enzymatic degradation by limiting the activity of senescence-related enzymes such as polyphenol oxidase (PPO). This biochemical regulation contributes to delayed floral aging and better maintenance of visual quality (Perik et al., 2014).

Seaweed extracts further enhanced the longevity of freesia flowers through both hormonal and antioxidant mechanisms. These natural extracts contain plant hormones like cytokinins and auxins, which are well-documented for their ability to delay the onset of senescence and promote continued floral development. Moreover, the presence of various antioxidants in seaweed helps mitigate oxidative stress at the cellular level, thus reducing the appearance of early wilting symptoms and extending the aesthetic value of the flowers (Jones, 1988; Elansary, 2020).

Taken together, the integrated use of humic acid, calcium chloride, and seaweed extract appears to offer a promising strategy for improving postharvest quality and extending the commercial life span of freesia cut flowers. The physiological benefits observed—ranging from enhanced nutrient uptake to cellular stabilization—underscore the potential of combining biostimulants with essential nutrients as part of sustainable floriculture practices.

CONCLUSION AND PRACTICAL IMPLICATIONS

The findings of this study underscore the critical role of integrated nutrient management—particularly the combined application of organic fertilizers and calcium chloride—in enhancing the physiological performance, vegetative development, and postharvest longevity of Freesia spp. Among the treatments, humic acid demonstrated the most substantial effects on improving leaf area, carbohydrate accumulation, and dry matter content, while calcium chloride significantly contributed to chlorophyll retention, flower firmness, and extended vase life. Moreover, seaweed extracts and the use of sucrose in preservation solutions further contributed to delaying senescence symptoms and improving water balance, highlighting the synergistic potential of organic and mineral inputs.

From a practical perspective, these results suggest that floriculture producers can significantly improve the commercial value and postharvest shelf life of freesia cut flowers through sustainable agronomic practices that incorporate humic acid-based fertilizers and calcium chloride foliar sprays. These inputs not only enhance growth and flowering characteristics but also minimize the reliance on synthetic preservatives, making them compatible with environmentally friendly cultivation models. Additionally, applying seaweed extract during key growth stages may offer a non-chemical approach to extending flower freshness and improving visual quality during marketing and transport.

Despite the promising outcomes, the current research is limited by its focus on a single species (Freesia spp.) and specific environmental conditions. Variations in climate, cultivar type, and soil characteristics could influence the consistency of results. Moreover, the study did not evaluate the economic cost-benefit ratio of applying multiple biostimulants in commercial production systems, which could be essential for large-scale adoption.

Future research should explore the long-term effects of combined biofertilizers and calcium-based treatments across different ornamental species and growing environments. It is also recommended to investigate molecular-level responses to such treatments, including gene expression related to flower senescence, nutrient transport, and hormonal regulation. Incorporating life cycle assessments and economic feasibility studies would further support the development of comprehensive, sustainable protocols for ornamental horticulture.

REFERENCES

Abdel-Hafiz, A. A. E. (2008). The use of seaweed extracts to improve growth and efficiency of horticultural plants: A good step towards a sustainable agricultural system. Arab Publishing, University of Alexandria, Egypt.

Abu Dhahi, Y. M., & Al-Younis, M. A. (1988). Plant Nutrition Guide. Dar Al-Kutub for Printing and Publishing, University of Mosul, Ministry of Higher Education and Scientific Research, Iraq.

Ahmed, R., Saeed, M., & Khan, N. (2023). Sustainable use of organic fertilizers to improve floricultural quality: A case study of ornamental crops. Journal of Environmental Horticulture, 41(1), 22–30.

Al-Aaraji, J. M. A., & Al-Hamdani, R. I. A. (2012). Organic Agriculture and the Environment. College of Agriculture and Forestry, University of Mosul, Ministry of Higher Education and Scientific Research, Iraq.

Al-Abdali, H. M. M. Sh. (2002). Effect of some nutrients, gibberellic acid, and licorice extract on growth, flower production, and calyx opening in carnation (Dianthus caryophyllus L.) [Ph.D. dissertation, Department of Horticulture, College of Agriculture, University of Baghdad, Iraq].

Al-Alawi, R. H. A. (2004). Effect of photoperiod and licorice extract on vegetative and floral growth characteristics of some chrysanthemum cultivars (Dendranthema grandiflorum L.) [M.Sc. thesis, Department of Horticulture, College of Agriculture, University of Baghdad, Iraq].

Al-Hamzawi M. K. (2019). Effect of seaweed extract and micronutrients mixture on some growth characters and flowering of Dianthus chinensis 1. and Gazania splender 1. Plants. J. Phys.: Conf. Ser. 1294, 092001-092009. Doi: 10.1088/1742-6596/1294/9/092001 [CrossRef] [Google Scholar

Al-Rubaie, N. M. (2003). Effect of spraying with Al-Nahrain nutrient solution and licorice extract on growth, flowering, and flower longevity in Freesia hybrida L. [M.Sc. thesis, Department of Horticulture, College of Agriculture, University of Baghdad].

Al-Sahaf, F. H. R. (1989). Applied Plant Nutrition. University of Baghdad, Ministry of Higher Education and Scientific Research, Iraq.

Al-Sahaf, F. H. R., & Al-Zurfi, M. T. H. (2015). Effect of foliar spray with humus and boric acid on flowering of Freesia hybrid. Al-Kufa Journal for Agricultural Sciences, 7(2), 1–10.

AL-Sahaf, F. H. R., AL-Zurfi, M. T. H., Shalaan, R. A. and Abbas, Z. H. (2018). Growth and flowering responses of Snapdragon to soil applied Trichoderma harzianum and humic acid spray. Academia Journal of Agricultural Research, 6(5), 135-141.

Al-Zeidi, K. A. N. (2016). Effect of wheat bran addition and spraying with its extract on growth and production of red cabbage [M.Sc. thesis, College of Agriculture, University of Baghdad, Iraq.

Anonymous (2005). Humic Acid, Organic Plant Food and Root Growth Promoters. An Erth Friendly Company (ecochem) 17/2/2007. File : G : humic acid. htm. 253.

Basak, A. (2008). Effect of preharvest treatment with seaweed products, kelpak and goemar BM 86 on fruit quality in apple International Journal of Fruit Science, 8(1,2): 1-14

Elansary, HO.2020. Tree bark phenols regulate the physiological and biochemical performance of Gladiolus flowers.

Elhindi, K. M. (2012). Evaluation of several holding solutions for prolonging vase-life and keeping quality of cut sweet pea flowers (Lathyrus odoratus L.). Saudi Journal of Biological Sciences, 19(2), 195-202.

El-Sayed, H. A., Mahmoud, M. A., & Farag, M. M. (2020). Response of gladiolus plants to foliar application of calcium chloride under sandy soil conditions. Plant Archives, 20(2), 7810–7816.

Fawzy, Z.F.; M.A. El-Nemr and S.A. Saleh. 2007. Influence of level and methods of potassium fertilizer application of growth and yield of eggplant. J. of Applied. Sci. Res. 3(1): 42-49

Follett, R. F., Murphy, L. S., & Donahue, R. L. (1987). Fertilizers and Soil Terms. (T. A. A. Al-Tai, Trans.). Directorate of Dar Al-Kutub for Printing and Publishing, University of Mosul, Iraq.

Hassan;F.A.S(2005) Postharvest studies on some important flower crops Doctoral thesis.Dept. of floriculture and Dehdrology. Corvinus. Universty of Budapest

Jones PN.1988. The effect of natrakelp (seaweed concentrate) and cultar (Paclobutrazol) on the vase life of strut's desert pea flowers (Swainsona Formosa). Acta Hortic. 51. 454, 383-390.

Kadhim, M. A. (1977). Principles of Plant Nutrition. Dar Al-Kutub Printing Press, Iraq.

Kuwada, K.; Wamocho, L.S.; Utamura, M.; Mastushita, I. and Ishii, T. (2006). Effect of red and green algal extracts on hyphal growth of arbuscular fungi and on mycorrhizal development and growth of papaya and Passionfruit. Agron. J., 98: 1340-1344.

Mar, R. J., Hassani, A., Abdollahi, A. and Hanafi, S. (2011). Improvement of the vase life of cut gladiolus flowers by essential oils, salicylic acid and silver thiosulfate. Journal of Medicinal Plants Research, 5(20), 5039-5043.

Mousavi, S. A., Azarpour, E., & Moradi, M. (2021). Influence of organic and bio-fertilizers on the growth and flowering of ornamental plants. Horticultural Science Journal, 48(2), 145–155.

Perik RR, D Raze, DA Ferrante and WG Van Doorn. 2014. Stem bending in cut Gerbera jamesonii flowers: Effects of a pulse treatment with sucrose and calcium ions. Postharvest Biology and Technology. https://doi.org/10.1016/j.postharvbio.2014.06.008 98: 7-13. DOI:

Potter, G. (2005).www.Kaizenbsi.com, File //G./seaweed bonsnishtm.

Reddy and Reddy, A.S.N. (2004). Proteomics of calcium-signaling components in plants. Phytochemistry 65, 1745–1776.

Reddy, A. R. G., & Sarkar, M. M. (2016). Studies on the effect of foliar application of calcium on post-harvest, corm and cormel production in gladiolus CV. summer sunshine. International Journal of

Agriculture, Environment and Biotechnology, 9(1), 88. https://doi:10.5958/2230-732X.2016.00014.0

Reddy, A.G. and M.M. Sarkar. 2016. Studies on the effect of foliar application of calcium on post-harvest, corm and cormel production in gladiolus cv. summer sunshine. Int. J. Agric. Environ. Biotechnol. 9(1): 89.

Salunkhe, D.K.; Bhat, N.R. Desai, B. B. (1989). Postharvest Biotechnology of flower and ornamental plants. Mahatma Phule Agriculture University. Rahuri District. India. 1142pp

Zandonadi, D. B., Canellas, L. P. and Facanha, A. R. (2007). Indol acetic and humic acids induce lateral root development through a concerted plasma lemma and tonoplast H^+ pumps activation. Planta, 225(6), 1585-1595.

Zhang, X. and E.H. Ervin. 2004 Cytokinin containing seaweed and humic acid extracts associated and drought resistant. Crop Sci. 44: 1737-1747.

Zhang, Y., Liu, H., & Wang, L. (2022). Foliar calcium application enhances flowering and shelf-life in ornamental plants. Scientia Horticulturae, 292, 110658.