Effect of Foliar Spraying with Potassium Silicate and Calcium Chloride on the Flowering Traits of Lilium Plants Before and After Harvest

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Abstract

The experiment was conducted in the plastic greenhouse of the Sarchinar Nursery, Directorate of Horticulture, General Directorate of Agriculture in Sulaymaniyah, during the 2024–2025 growing season, on Lilium spp. cultivar Rising Moon. The study involved two factors: potassium silicate at three concentrations (0, 1000, and 2000 mg L^{-1}), and calcium chloride at three concentrations (0, 500, and 1000 mg L^{-1}), applied as foliar sprays. The experiment was laid out as a factorial arrangement in a Randomized Complete Block Design (RCBD) with three replications. The results showed that foliar application of potassium silicate led to a significant increase in all quality traits of cut flowers, including: time required for flower opening, number of flowers per plant, vase life, fresh weight of the flowering stem, flower diameter, length of the flowering stalk, and the amount of water absorbed during the vase life. The treatment with 2000 mg L^{-1} of potassium silicate recorded the highest values for these traits, respectively.As for the calcium chloride treatments, they showed significant differences among the means for all studied traits mentioned (time required for flower opening, vase life, fresh weight of the flowering stem, flower diameter, length of the flowering stalk, and the amount of water absorbed by the flowers), except for the number of flowers per plant, which was not significant. The treatment with 1000 mg L^{-1} of calcium chloride recorded the highest values, respectively.Moreover, the interaction treatment between 2000 mg L^{-1} of potassium silicate and 1000 mg L^{-1} of calcium chloride resulted in the highest values across all studied traits.

Keywords: Potassium silicate, Calcium, Bulbs, Lilium.

-1Introduction

Lilium, renowned for purity and nobility, casts its regal beauty across gardens worldwide as one of nature's finest flowers. Rising high from bulbs, grand blooms unfold in a spectacle of color and form, attracting admiration through millennia [1]. Scientifically designated Lilium spp., its etymology traces to the Greek "Leirion," signifying truth. Within the family Liliaceae, Lilium comprises herbaceous plants growing from underground storage organs [2]. The ‘Rising Moon’ cultivar is characterized by its large flowers, with diameters ranging from 15 to 20 cm. The flowers are funnel-shaped and exhibit a creamy white color that gradually shifts to light pink at the edges, with a greenish center. They are also strongly fragrant. Under optimal conditions, the plant can exceed a height of 150 cm. Flowering occurs from mid to late summer and typically lasts for about 3 to 4 weeks. It is cultivated in full sun or partial shade and is noted for its moderate cold tolerance [3[

The splendid quality of cut Lilium stems significantly supports marketing of flowering bulbs [4]. Yet splendid beauty fades, for vase life proves fleeting as floral tissues brown and wilt. This decline, limiting ornamental value,

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stems from blocked conduits, heightened reactivity, macromolecular decay, and oxidative stress disrupting delicate balance [5]. Thus, postharvest performance results from morphology, cellular changes, and physiology. Weight loss directly indicates well-being, a metric assessing status [6]. Numerous studies employing diverse techniques aim to prolong splendor and enhance cut Lilium, though full success eludes [7.[

Silicon makes up the second most prevalent element found naturally on Earth's surface after oxygen, where it generally exists bonded with other elements in soils as silicate minerals and various compounds. The bioavailable form of silicon taken up by plants from soil solution is monosilicic acid (H_4SiO_4), usually presenting at concentrations between 0.1 and 0.6 mM—significantly higher than levels of phosphorus (P) [8]. Plants internalize silicon and transport it throughout their tissues, depositing it as crystalline silicon dioxide (SiO_2) in cell walls, intracellular spaces, and vacuoles [9]. The aptitude of different plant species to accumulate silicon varies greatly, ranging from just 0.1% to as much as 10% of dry weight [10,11]. Thus, the responses exhibited by plants to silicon fertilization depends on plant type [12.[

In an investigation led by [13] to determine the role of calcium silicate on the growth and flowering of Gerbera, various concentrations of silicate (0, 1.5, and 3 g per pot) were tested. The highest concentration of calcium silicate applied (3 g per pot) significantly increased leaf quantity, chlorophyll content, and fresh weight of leaves relative to the control. Regarding floral characteristics, the same high concentration significantly raised inflorescence diameter, peduncle length, and peduncle diameter compared to untreated plants. Meanwhile, treatment with 1.5 g per pot notably elevated vase life and dry weight of inflorescences when pitted against the control.

In a recent investigation into the advantages of silicon nanoparticles, [5] looked into how varying concentrations of nano-silica particles impacted the quality and longevity of cut lilac flowers. Specifically, different amounts of 0, 200, 400, 600, 800, and 1000 mg/L of the nanoparticles were sprayed directly onto the leaves. Intriguingly, the findings demonstrated that applying nano-silica via foliar feeding significantly extended vase life, with some flowers lasting over 20% longer than the untreated control group. Furthermore, total chlorophyll content across all treated plants saw sizeable increases, with one concentration resulting in a staggering 65% boost.

Calcium plays a pivotal role in plant physiology, as the mineral is involved in numerous essential processes. It acts as a cofactor for various enzymes, including amylases and ATPases, assisting these proteins in carrying out their functions. Calcium also builds the fundamental infrastructure of cell walls, specifically forming the middle lamella, allowing for greater mechanical sturdiness and structure. Moreover, calcium facilitates both cell division and plasma membrane function by binding to anionic groups on the surface, serving to stabilize the membrane. The mineral additionally relays signals as a secondary messenger during hormonal and environmental responses. A scarcity of calcium negatively impacts plant development at the meristematic regions and causes irregular growth patterns.[14[

Calcium plays a consequential role in plant maturation and in numerous physiological procedures of blooms [15] because calcium is a low-flexibility component in plants and is seldom transported through the phloem tissue. Therefore, insufficiency indications regularly seem in dynamically developing locales, for example, the apical meristems or youthful development ranges. Leaves might turn out to be contorted or show up strap-like with dim or dull edges. What's more, calcium inadequacy can prompt the turn of events of short roots and the annihilation of vascular tissues at the base of the stem [16.[

[17]have directed different investigations to think about the impact of foliar dispersing with various centralizations of calcium chloride on floral turn of events. In one investigation, specialists applied calcium chloride arrangements of 0, 500, and 1000 mg L-1 to two gladiolus assortments: Nova Lux yielding yellow blooms and Trader Lux creating red blooms. Treatments with calcium chloride fixations of 500 and 1000 mg L-1 brought about a huge increment in all inspected attributes.

led on [18] Gerbera cultivar Esmara assessed the impacts of foliar application of calcium chloride at centralizations of 0, 125, and 250 mg L-1. The outcomes appeared that sprinkling plants with 250 mg L-1 calcium chloride essentially diminished the span from floral bud initiation to shading appearance and from bud initiation to full blooming. This treatment additionally brought about the most noteworthy huge estimations for inflorescence yield amid summer, fall, winter, and spring seasons, as well as the absolute yield. What's more, it altogether expanded inflorescence distance across, yield in all seasons, the length of the bloom stalk, and stalk distance across across all seasons. Moreover, it extended the vase life of cut blooms gathered amid summer, fall, winter, and spring contrasted with the control treatment.

Research Objective

The study aimed to investigate the effect of

foliar spraying with both potassium silicate and calcium chloride on the floral growth characteristics of Lilium plants .

Materials and Methods

This experiment was conducted inside one of the plastic greenhouses at Sarchinar Nursery, affiliated with the Directorate of Horticulture, General Directorate of Agriculture in Sulaymaniyah Governorate, during the 2024–2025 fall growing. The study was carried out on Lilium spp. cultivar Rising Moon. Imported bulbs from the Netherlands were used, with an average bulb diameter of approximately 35 mm. Upon arrival, the bulbs were stored in a refrigerator at 4°C for 21 days to break physiological dormancy. After this period, the bulbs were transferred to room temperature and kept there for 24 hours to acclimate them for the subsequent treatment phase.In the next stage, the bulbs were treated with a fungicidal solution containing copper sulfate at a concentration of 1 g/L, and soaking lasted for 24 hours to prevent fungal infections. Following this, the bulbs were soaked in gibberellic acid (GA_3) at a concentration of 100 mg/L for 12 hours to stimulate metabolic activity and enhance germination and growth potential.The bulbs were planted on October 24, 2024, in plastic pots with a diameter of 25 cm. The pots were filled with a growing medium consisting of a 1:3 mixture of soil and peat moss (soil: peat). One bulb was placed per pot and planted at a depth of 10 cm below the surface of the growing medium to ensure proper anchorage and provide optimal conditions for initial growth.

All agricultural practices were carried out uniformly throughout the experimental period and regularly as needed. These practices included shallow hoeing of the soil whenever necessary to improve aeration and reduce compaction, in addition to manual weeding to prevent competition with the plants. Irrigation was applied according to the moisture status of the growing medium ,

watering was done whenever needed. Regarding fertilization, a balanced compound fertilizer (NPK 20-20-20) was used at a

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concentration of 1 g/L and applied once monthly throughout the vegetative growth period of the plants.

A factorial experiment was conducted using a Randomized Complete Block Design (RCBD) with two main factors, implemented in three replications. Each factor consisted of three levels, resulting in 9 experimental units per replication and a total of 27 experimental units in the entire experiment. Each experimental unit comprised three plants as experimental observations, bringing the total number of plants used in the study to 81.

The experiment included two factors:The first factor was the treatment with potassium silicate, applied at three different concentrations: 0 (control, no treatment), 1000, and 2000 mg L^{-1}. The foliar spraying of the solution was carried out directly on the plant canopy in three specific applications:The first application was performed after the appearance of four true leaves on the plant. The second application occurred 15 days after the first spray. The third application was done at the onset of flower bud formation. All spraying operations were conducted early in the morning to spray until runoff, ensuring complete coverage of the leaves and maximizing nutrient absorption.

The second factor was calcium chloride, applied at three concentrations: 0, 500, and 1000 mg L^{-1}. Foliar spraying was conducted twice on the plant canopy, with the first spray applied four days after the last spray of the first factor, and the second spray applied one month after the first calcium chloride spray. At the beginning of the flowering stage, the following traits were studied) Duration required for flower opening, Number of flowers, Flowering longevity, Fresh weight of the flowering stem, Flower diameter, Flower stalk length, Amount of water absorbed during the flowering period.(

The data were analyzed using the statistical software [19], and the means were compared according to Duncan's multiple range test at a significance level of 0.05%.

Results and Discussion

Table 1 shows that treatment with potassium silicate at a concentration of 2000 mg L^{-1} had a significant effect on the traits of flowering duration, number of flowers, flowering longevity, and fresh weight of the flowering stem. The highest values recorded were 216.18 days, 1.62 flowers per plant, 9.63 days, and 70.089 g, respectively, compared to the lowest values recorded in the control treatment (0 mg L^{-1}), which were 218.03 days, 1.25 flowers per plant, 7.48 days, and 46.76 g, respectively. Similarly, it is evident from the same table that calcium chloride at 1000 mg L^{-1} significantly increased all floral growth parameters except for the number of flowers, which showed no significant difference. The shortest duration for flower opening was 215.78 days, flowering longevity was 9.63 days, and fresh weight of the flowering stem was 65.88 g, compared to the lowest values recorded in the control treatment (218.37 days, 7.48 days, and 61.05 g, respectively). Furthermore, the interaction between the two factors showed a significant effect on all floral growth traits. The combined treatment of potassium silicate at 2000 mg L^{-1} and calcium chloride at 1000 mg L^{-1} recorded the highest values across all studied traits

Table 1. Effect of Foliar Spraying with Potassium Silicate, Calcium Chloride, and Their In teraction on the Floral Growth Traits of Lilium Plants.

Treatment		Duration to Flower Opening (days)	Number of Flowers (flowers/plant)	Flowering Longevity (days)	Fresh Weight of Flowering Stem (g)
Si	0	218.0344 a	1.25 b	7.4778 c	46.759 c
	1000	217.0333 b	1.55 ab	8.4044 b	55.581 b
	2000	216.1822 c	1.62 a	9.6267 a	70.089 a
Ca	0	218.3667 a	1.33 a	7.8856 c	57.017 b
	500	217.1078 b	1.55 a	8.4044 b	57.017 b
	1000	215.7756 c	1.55 a	9.2189 a	65.881 a
Si × Ca	Si0 × Ca0	220.1067 a	1.11 b	7.1100d	35.687 c
	Si0 × Ca1	217.8867 b	1.22 ab	7.5500 cd	43.190 c
	Si0 × Ca2	216.1100 c	1.44 ab	7.7733 cd	61.400 b
	Si1 × Ca0	217.8867 b	1.44 ab	7.4400 cd	54.353 b
	Si1 × Ca1	217.2167 b	1.77 a	8.2200 c	52.603 b
	Si1 × Ca2	215.9967dc	1.44 ab	9.5533 b	59.787 b
	Si2 × Ca0	217.1067 b	1.44 ab	9.1067 b	58.553 b
	Si2 × Ca1	216.2200 c	1.66 ab	9.4433 b	75.257 a
	Si2 × Ca2	215.2200 d	1.77 a	10.3300 a	76.457 a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

The results presented in Table 2 indicate that treatment of plants with potassium silicate at a concentration of 2000 mg L^{-1} had a significant effect on all measured traits (flower diameter, flower stalk length, and the amount of water absorbed during the flowering period(

The highest values recorded were 146.65 mm, 64.41 cm, and 206.67 mL, respectively, compared to the lowest values observed in the control treatment, which were 139.34 mm, 55.15 cm, and 143.33 mL, respectively.

Regarding the interaction effects between potassium silicate and calcium chloride, a significant influence was observed on all measured traits. The combined treatment of potassium silicate (2000 mg L^{-1}) and calcium chloride (1000 mg L^{-1}) showed superior performance in flower diameter, flower stalk

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length, and amount of water absorbed, recording the highest values of 152.20 mm, 70.22 cm, and 230.00 mL, respectively, compared to the lowest values observed in the control treatment, which were 137.09 mm, 44.11 cm, and 128.33 mL, respectively.

Table 2. Effect of Foliar Spraying with Potassium Silicate, Calcium Chloride, and Their Interaction on Floral Growth Traits of Lilium Plants.

Treatment		Flower Diameter (mm)	Flower Stalk Length (cm)	Amount of Water Absorbed (mL)
Si	0	139.342 b	55.147 b	139.342 b
	1000	144.641 a	61.886 a	a144.641
	2000	146.650 a	64.406 a	146.650 a
Ca	0	140.687 b	52.961 b	b 140.687
	500	141.483 b	63.442 a	b141.483
	1000	148.463 a	65.034 a	a 148.463
Si × Ca	Si0 × Ca0	137.090 d	44.110 e	137.090 d
	Si0 × Ca1	136.750 d	59.333 cd	136.750 d
	Si0 × Ca2	144.187 bc	61.997 bcd	144.187 bc
	Si1 × Ca0	141.690 cd	58.997 cd	141.690 cd
	Si1 × Ca1	143.23 bcd	63.773 abc	143.23 bcd
	Si1 × Ca2	149.003 ab	62.887 bcd	149.003 ab
	Si2 × Ca0	143.280 acd	55.777 d	143.280 acd
	Si2 × Ca1	144.470 bc	67.220 ab	144.470 bc
	Si2 × Ca2	152.200 a	70.220 a	152.200 a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5% .

Initial studies from the research indicate that potassium silicate significantly enhances the characteristics of flowers, as presented in Table (1-2). Silica facilitates the transportation of water and nutrients to cells, consequently promoting cell growth and maturation while abbreviating the flowering period. Additionally, silica can spur the synthesis of cytokinins, especially in plant branches, which advances the progression of floral buds and thereby raises the total number of flowers. Larger floral buds are likely to produce bigger blooms, progressively enlarging the flower diameter [20]. This advancement can also be attributed to silica, which boosts the function of ribonuclease (RuBisCo) and augments the chlorophyll content in leaves, thereby refining the photosynthesis process. This subsequently prolongs flowering and increases the buildup of solid matter in the organism, thereby increasing water absorption during blossoming. Furthermore, silica can induce the accrual of photosynthetic products in the organism and encourage cell partitioning,

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thereby advancing the elongation of the flower stem [21,22]. The rise in pedicel fresh weight may be owing to silica's impact on the content of carbohydrates, sugars and photosynthetic compounds [23]. Greater carbohydrate content heightens water permeability and promotes cell growth, eventually resulting in increased flower weight [24]. These results correspond with the findings of a study on the growth and flowering of violet [25] and a study on the growth and flowering of snapdragon [26]. The results in the same table also suggest that the observed improvement in floral traits was because of applying calcium chloride. This may be owing to the physiological effects of calcium ions, which play a crucial role in controlling plant cellular operations. Calcium is a multifaceted nutrient, and its soluble form impacts various physiological activities of plants at different growth phases, ultimately affecting flower quality [27]. This advancement may be ascribed to calcium's role in maintaining healthy cellular structure by sustaining cell membrane integrity and regulating selective ion transport of essential nutrients [28]. It also preserves membrane functionality and prevents its degradation. These mechanisms contribute to increasing flower longevity, diameter, and number [29]. Calcium can also act as a second messenger, playing a part in activating the signaling pathways of catalase, superoxide dismutase, and ascorbate peroxidase. This improves the plant's aptitude to scavenge free radicals produced during aging, decreases lipid peroxidation, and refines the membrane stability index Since calcium is a structural part of cell walls and cell membranes, it can enhance their integrity, thereby delaying membrane degradation and aging, in the long run prolonging the life of flowers [30]. Maintaining high intracellular water content is closely associated with the integrity of the cell membrane and preventing solutes from leaking outside the cell. Leakage in the cell membrane negatively affects the water balance inside and outside the cell. Calcium helps sustain this balance, ultimately resulting in the flower absorbing more water as it grows.[31 .[

Conclusions:

Based on the results of this study, we can highlight the most significant effects of foliar application of potassium silicate and calcium chloride, whether applied individually or in combination, on Lilium spp. plants, and their impact on key floral growth traits. It was concluded that the application of 2000 mg L^{-1} of potassium silicate and 1000 mg L^{-1} of calcium chloride led to significant improvements in most of the evaluated traits, including: the time required for flower opening, number of flowers, vase life, fresh weight of the flowering stem, flower diameter, flower stalk length, and the amount of water absorbed during the vase life

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