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Evaluation of effect of different doses of $CaCl_2$ and $CaNO_3$ foliar applications on Growth and Flowering of Petunia grandiflora

[1*]Yoshida Yugo, [2]Zin Chang HSU and [3]Nusrat Bashar

[1]Japan Advanced Institute of Science and Technology
1-1 Asahidai, Nomi, Ishikawa 923-1292 Japan
[2]Graduate Institute of Biomedical Engineering, National Taiwan University of Science and Technology, Taipei-10607, Taiwan
[3]Department of Botany, Sher-e-Bangla Agricultural University, Sylhet-3100, Bangladesh

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[1]Japan Advanced Institute of Science and Technology
1-1 Asahidai, Nomi, Ishikawa 923-1292 Japan
*Corresponding Author email: yugoagri@gmail.com

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Abstract

The experiment was based on a randomized complete block design with six calcium doses of 0, 0.4, 0.8, 1.2, 1.6, and 2.0 g L-1 supplied from CaCl2 and CaNO3 with three replicates in 2018-2020.

Uniform-sized petunia corms were planted in plots spaced by 30 × 25 cm. Foliar fertilizers were sprayed twice, first after inflorescence emergence and second 12 days later. All the cultural operations (fertilization, irrigation, and control) were conducted similarly in all plots. The soil was analyzed for physicochemical properties. The soil texture was Loamy soils (Moderately fine texture) sand-45, Silt-Clay-22 (Sandy clay loam).

The soil organic C-0.38, total N0.05, P-8.9, and K198mg kg^{-1} contents were observed. The total Fe, Zn, Mn, Cu, and B concentrations were 4.00, 0.67, 5.21, 0.4, and 0.71 mg kg^{-1}, respectively. Also, the soil pH and EC were 7.2 and 1.0 dS m^{-1}, respectively. Each plot was treated with Sulphur 90% W.D.G. *Helps in maintaining the appropriate pH of the soil*, thereby better uptake of other nutrients., ammonium nitrate *used in agriculture as a high-nitrogen fertilizer*, Super phosphate at 200kg per hector and phosphorus and potassium sulfate ($K2SO^4$) as potassium sources were added to the field at the rates of 200 and 380 kg ha^{-1}, respectively. ZnSo4, Cuso4, MnSo4Fe, Boric Acid are also added to enrichment of micronutrients to the field.

Keywords: Pre-harvest, Quality, Quantity, Petunia grandiflora, sulphate, soil texture, $CaCl_2$ and $CaNO_3$

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INTRODUCTION

Petunia grandiflora is widely admired for its vibrant, multi-colored, trumpet-shaped blooms. The plant features hairy, branching foliage and thrives best in sunlit environments, making it especially popular in the United States and throughout Mediterranean regions. It has a prolonged flowering season extending from spring to autumn and is among the most easily recognizable ornamental flowers globally.

Petunias are available in a wide range of forms, sizes, and colorations, which vary by cultivar. These include both single and double-blooming types, and flowers may display solid colors or unique patterns such as linear streaks or splashes. The color palette is broad, encompassing shades like red, white, pink, purple, light blue, yellow, and even striking black. The development of this extensive diversity in petunia coloration is largely due to scientific advancements, such as the use of virus-induced chimerism, allowing breeders to create distinct and customized color combinations. Prominent species in this genus include **Petunia grandiflora**, **Petunia milliflora**, and **Petunia multiflora**.

- **Petunia grandiflora** produces the largest flowers among the varieties and can reach up to 40 cm (16 inches) in height. Trailing or hanging forms are also common in this group. Due to their delicate, wavy petals, these flowers require protection from rain and strong winds.
- **Petunia milliflora**, conversely, bears the smallest flowers and typically does not exceed 25 cm (10 inches) in height. Unlike *grandiflora*, these plants require less protection from rain and are available in both trailing and ground-cover forms, making them suitable for border planting or along fences.
- **Petunia multiflora** has flowers intermediate in size—larger than *milliflora* but smaller than *grandiflora*.

Regardless of variety, all petunias perform best under full sun exposure, which intensifies the vibrancy of their flower colors.

Calcium (Ca) plays a vital structural role in plant cell walls and membranes. Calcium deficiencies are a common issue in horticultural crops. Since calcium uptake occurs primarily through water transport during transpiration, tissues with low transpiration rates—such as flower buds and fruits—are particularly susceptible to deficiencies. These organs typically have a low stomatal density or a high volume-to-surface area ratio, limiting their ability to absorb adequate calcium.

Similarly, young leaves that remain enclosed within heads—such as those in head lettuce—exhibit low transpiration rates, rendering them particularly vulnerable to calcium (Ca) deficiencies. Reproductive structures like flowers and fruits primarily receive nutrients via the phloem, where calcium mobility is limited. To address Ca deficiency in such tissues, foliar applications of calcium chloride have been utilized to enhance calcium content within plant tissues. These sprays also introduce chloride (Cl^-), an essential micronutrient for plant development.

Chloride plays several physiological roles, including maintaining cellular turgor pressure, regulating vacuolar solute concentrations, stabilizing membrane potential, modulating pH gradients, and facilitating electron excitation during photosynthesis. Although chloride deficiency is rarely observed in nature or agricultural systems, excessive accumulation can lead to toxicity. It is generally recommended that plant tissue should contain a minimum of 1 $g \cdot kg^{-1}$ of chlorine on a dry weight basis [10].

Localized calcium deficiencies have been well-documented in various plant categories: (1) leafy vegetables like lettuce, which exhibit symptoms such as tipburn [17]; (2) fruits, including watermelon and apples, which suffer from blossom end rot and bitter pit, respectively [4,5,18]; (3) vegetables such as tomatoes and peppers, both prone to blossom end rot [6,7,11,12]; and (4) ornamental plants like poinsettia, which may show bract edge burn [16].

Although increasing Ca levels in nutrient solutions can provide adequate supply to fully transpiring leaves, this approach may not be as effective for low-transpiring and rapidly growing tissues or reproductive parts. Foliar supplementation with calcium sources such as calcium nitrate and calcium chloride has been shown to significantly enhance Ca uptake in shoots (leaves and stems), positively influencing both growth parameters and postharvest longevity, such as vase life in flowers and shelf life in fruits [1,3].

The current study aims to assess the impact of pre-harvest foliar calcium applications—applied at various rates and from different sources—on both quantitative and qualitative attributes, as well as the postharvest mechanical bending resistance of cut **Petunia** inflorescences.

MATERIALSAND METHODS

A field experiment was carried out at the Japan Advanced Institute of Science and Technology, Japan. The experiment was based on a randomized complete block design with six calcium doses of 0, 0.4, 0.8, 1.2, 1.6, and 2.0 g L-1 supplied from CaCl2 and CaNO3 with three replicates in 2018-2020.

Uniform-sized petunia corms were planted in plots spaced by 30 × 25 cm. foliar fertilizers were sprayed twice, first after inflorescence emergence and second 12 days later. All the cultural operations (fertilization, irrigation, and control) were conducted similarly in all plots. The soil was analyzed for physicochemical properties. The soil texture was Loamy soils (Moderately fine texture) sand-45, Silt-Clay-22 (Sandy clay loam). The soil organic C-0.38, total N0.05, P-8.9, and K198mg kg^{-1} contents were observed. The total Fe, Zn, Mn, Cu, and B concentrations were 4.00, 0.67, 5.21, 0.4, and 0.71 mg kg^{-1}, respectively. Also, the soil pH and EC were 7.2 and 1.0 dS m^{-1}, respectively. Each experimental plot was treated with Sulphur 90% W.D.G., which assists in regulating soil pH and thereby enhances the absorption efficiency of other essential nutrients. Ammonium nitrate, commonly employed in agriculture as a high-nitrogen fertilizer, was utilized to support vegetative growth. Superphosphate was applied at a rate of 200 kg per hectare to supply phosphorus, while potassium requirements were met by incorporating potassium sulfate (K_2SO_4) at a rate of 380 kg ha^{-1}. Additionally, micronutrient enrichment was achieved through the application of zinc sulfate ($ZnSO_4$), copper sulfate ($CuSO_4$), manganese sulfate ($MnSO_4$), iron (Fe), and boric acid.

To further improve soil fertility, organic fertilizers were also incorporated. The application of farmyard manure contributed key macronutrients such as nitrogen, phosphorus, potassium, sulfur, magnesium, and calcium. Beyond nutritional benefits, the addition of organic matter improved soil structure, enhanced water infiltration, increased microbial diversity, and contributed to long-term erosion control. Notably, the organic manure was applied 21 days following the initial application of chemical fertilizers.

The qualitative and quantitative parameters evaluated in this study included flower stalk height, stem diameter, and spike length. For calcium analysis, plant tissue samples underwent wet digestion using a nitric acid–perchloric acid solution in a 4:1 (v/v) ratio following dry ashing at 550°C for five hours. The calcium content in leaves was then determined using atomic absorption spectroscopy (AAS) [15].

RESULTS

Ca Concentration/type	Flower length (cm)	Spike length(cm)	Ca (%)
Ca-0	40.2	25.1	0.581
Ca-0.4	42.5	26.9	0.625
Ca-0.8	43.9	26.5	0.642
Ca-01.2	45.5	27.7	0.676
Ca-01.6	47.4	29.6	0.685
Ca-2.0	48.6	29.9	0.694
$CaNO_3$	47.9	28.0	0.669
$CaC1_2$	45.1	26.1	0.598

Values significantly different ($P < 0.05$) using Duncan's test

Table 1. Effect of different calcium sources and doses on the growth and quality of Petunia (G1). (G1-generation one)

The application of varying concentrations and types of calcium significantly influenced flower length, spike length, and calcium content in petunia plants. As calcium concentration increased from 0 to 2.0%, there was a consistent improvement in both flower and spike lengths, as well as in leaf calcium content. The highest flower length (48.6 cm), spike length (29.9 cm), and calcium content (0.694%) were observed at the 2.0% Ca treatment. Among the calcium sources, **calcium nitrate ($CaNO_3$)** outperformed **calcium chloride ($CaCl_2$)** in all measured parameters, suggesting its superior effectiveness in enhancing both morphological traits and calcium uptake.

Ca Concentration/type	Flower length (cm)	Spike length (cm)	Ca (%)
Ca-0	47.1	27.2	0.684
Ca-0.4	48.6	29.8	0.787
Ca-0.8	48.9	30.9	0.741
Ca-01.2	49.7	31.7	0.775
Ca-01.6	49.9	32.0	0.798
Ca-2.0	51.0	32.1	0.799
$CaNO_3$	49.0	32.0	0.771
$CaC1_2$	47.5	27.6	0.753

Values significantly different ($P < 0.05$) using Duncan's test

Table 2. Effect of different calcium sources and doses on the growth and quality of Petunia (G2). (G2-generation second)

Flower Length

Foliar application of calcium (Ca) had a significant impact on the flower length of petunia in both years of the study (refer to Tables 1 and 2). A consistent increase in flower length was observed with increasing concentrations of calcium. During the first season, the maximum flower length recorded was 48.6 cm at a calcium dose of 2.0 g L^{-1}. Similarly, in the second season, the highest flower length was 51.0 cm, also corresponding to the 2.0 g L^{-1} Ca treatment.

Spike Length

Petunia spike length was also significantly influenced by the foliar application of calcium across both growing seasons (Tables 1 and 2).

An upward trend in spike length was noted with increased calcium concentrations. In the first season, the maximum spike length reached 29.9 cm at 2.0 g L^{-1} Ca. In the second season, the highest spike length recorded was 32.1 cm at the same calcium dosage.

Leaf Calcium Content

The calcium concentration in petunia leaves responded significantly to foliar calcium application during both years (Tables 1 and 2). The highest calcium content in leaves was observed at 2.0 g L^{-1}, with values of 0.694% in the first season (G_1) and 0.766% in the second season (G_2).

Discussion

To achieve marketable flowers with desirable traits such as long, sturdy stems and fresh floral appearance, it is essential to focus on vegetative parameters alongside floral characteristics during cultivation. A decline in vegetative quality directly impacts the commercial and aesthetic value of cut flowers [14].

Calcium (Ca), a divalent cation, plays a vital role in maintaining structural integrity and preventing stem bending. It also regulates nutrient uptake across cell membranes and is involved in key physiological functions such as cell elongation and division, membrane stability and permeability, nitrogen metabolism, and carbohydrate transport [8].

In the current study, foliar application of calcium, from various sources and concentrations, significantly improved stem and spike lengths in petunia during both experimental seasons compared to the untreated control (Tables 1 and 2). The increase in inflorescence stem and spike length with higher calcium doses is attributed to Ca's role in promoting cell elongation [8,10,13].

Moreover, calcium accumulation supports the formation of structural polysaccharides such as pectin in the cell wall, thereby enhancing stem rigidity and lignin synthesis [1,9]. The study confirmed that calcium accumulation in petunia leaves increased in both the first and second seasons of the experiment, suggesting a sustained physiological response to foliar Ca application.

Conclusions

Based on the findings, it can be concluded that foliar calcium application significantly enhances both qualitative and quantitative parameters in petunia cultivation. The use of calcium, particularly in the form of calcium nitrate, positively influenced flower and vegetative traits.

Among the different treatments, the application of calcium at 2.0 g L^{-1} from calcium nitrate yielded the most favorable growth responses, including improved flower and spike length. Thus, calcium especially calcium nitrate can be recommended as an effective foliar supplement to enhance the ornamental and commercial value of petunia.

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