Trends in Horticulture 2024, 7(2), 6134.
https://doi.org/10.24294/th.v7i2.6134

Communication

Beneficial element (vanadium) improves *Zinnia elegans* flowers

Evelyn Hernández-Quezada, Víctor García-Gaytán*

Consultant, Horticulture and Advanced Plant Nutrition, Mexico 68600, Mexico
*** Corresponding author:** Víctor García-Gaytán, dr.garvictan85@gmail.com

CITATION

Hernández-Quezada E, García-Gaytán V. Beneficial element (vanadium) improves Zinnia elegans flowers. Trends in Horticulture. 2024; 7(2): 6134. https://doi.org/10.24294/th.v7i2.6134

ARTICLE INFO

Received: 30 April 2024
Accepted: 24 May 2024
Available online: 20 June 2024

Abstract: Our study evaluated the effect of vanadium (V) on the behavior of *Zinnia elegans* "double variegated". In this experiment, *Zinnia* plants grown in a greenhouse were fed with a nutrient solution and two concentrations of vanadium (0, 6, and 10 µm) applied four times during the experiment. The V at its levels of 6 µm and 10 µm increased plant length, number of inflorescences and fresh weight. We observed that during the development and appearance of flower buds, and flowering were earlier with the addition of 6 µm and 10 µm. During harvest the changes in size and shape were homogeneous with the control treatment. With the addition of 6 µm, flowers of different sizes were induced, with non-uniform petals, but with different shades of color. With 10 µm the shape of the petals, the distance between them and changes in the shades of the flowers were modified. The postharvest life for the flowers of the control treatment was shorter (15 days), the petals, anthers and floral disc at this time were observed in a poor condition. While 6 µm and 10 µm had a longer postharvest life (20 days), the flowers had a good presentation, their colors were more intense compared to the harvest stage. The application of this beneficial element contributed to the development and flowering of *Zinnia* in the greenhouse. It is suggested that future research be carried out on the accumulation and/or concentration of vanadium in the different stages of growth or its effect on the concentration of other nutrients.

Keywords: *Zinnia* elegans; vanadium; flowers; plant nutrition

1. Introduction

Beneficial elements are not considered essential for all crops, but are vital for certain plant taxa. The distinction between beneficial and essential is often difficult in the case of some trace elements. The effect of beneficial elements at low levels deserves more attention, with respect to their use to fertilize crops and to boost production. And it is pertinent that the beneficial elements improve resistance to abiotic stress and biotic stress at their low levels. In addition, to improve the use of other nutrients, stimulate and promote the growth and development of plants [1,2]. Elements that have been described as beneficial for plants are aluminum (Al), iodine (I), sodium (Na), cobalt (Co), lanthanum (La), titanium (Ti), vanadium (V), silicon (Si), cerium (Ce) and selenium (Se) [3]. V has rich redox chemistry and is a typical compound with various oxidation degrees (+2, +3, +4, and +5) [4]. Found mainly as vanadate anions, for organisms, the toxicity of the pentavalent cation (+V) is considered six to ten times greater than that of vanadyl V (+IV) [4]. V accumulates mainly in the roots of plants with very limited translocation to shoots [5]. The objective of this study was to analyze the behavior of *Zinnia* plants subjected to two concentrations of vanadium. Evaluate growth parameters, flower bud formation, early flowering and post-harvest life.

2. Materials and methods

Zinnia elegans "double variegated" Hortaflor® seeds were used, its vegetation is vigorous with rigid stems. The variables determined and observed were plant length, number of inflorescences and fresh weight. In addition, the characteristics of *Zinnia* plants were observed during their development and flowering. During harvest and post-harvest. The seeds germinated 5 days after sowing. And they were transplanted in containers with a capacity of 1 kg. At 15 days after transplanting, the growth/beginnings and development of the flowers were evaluated (16 May 2022). The harvest was determined on 27 May 2022. The post-harvest was determined on 20 June 2022.

The microenvironment conditions were as follows: CO_2: 606 ppm, air temperature: 99% and relative humidity: 25.5%. Twenty days after germination, a 25% nutrient solution [6] was applied. The nutrient solutions were formulated based on the Steiner Universal Nutrient Solution, where 100% concentration in molc m^{-3} is as follows: 12.0 NO_3^-, 1.0 $H_2PO_4^-$, 7.0 SO_4^{2-}, 7.0 K^+, 9.0 Ca^{2+}, and 4.0 Mg^{2+}, with an osmotic potential of −0.072 MPa. The nutrient solution was supplemented with micronutrients at the following concentrations (mg L^{-1}): 5.0 Fe; 2.33 Mn; 0.47 Zn; 0.19 Cu; 0.43 B and 0.17 Mo. The pH of the nutrient solution was 5.9 and it was monitored every day. Two concentrations of NH_4VO_3 (6 and 10 µM V) plus the control (0 µM) were evaluated. Four replicates were used per treatment. The beneficial element used was reagent grade (Karal®: Analytics Reactives, Mexico).

3. Results

Plant roots preferentially accumulate V. Low doses of V have a stimulating effect on roots and leaf development. The pH of 5.0–6.0 improves the absorption of V. Obviously it will depend on the plant species. In biological systems V is found as the vanadate anion (−V), the toxicity of the pentavalent cation (+V) is the dominant form, while vanadyl (+IV) is the reducing form. Vanadate by its nature influences the phosphate metabolizing system by inhibiting phosphatases and other enzymes. Hence the importance of V to be reduced to the less soluble form (IV) through an inorganic H_2S reaction or by specific microorganisms. (IV) has the ability to be strongly absorbed into soil particles, and at different pHs it can form complexes. V in soil depends on properties, such as V concentration, particle distribution, sand, clay, silt, soil pH, CEC, OM, Fe, and aluminum hydroxide. The microbiota has the ability to detoxify or use this element as an electron acceptor (**Figure 1**).

In this communication, the application of 6 µM of V stimulated the length of *Zinnia* plants by 57.87 cm. This treatment being the longest compared to the rest of the treatments (**Figure 2a**). The number of inflorescence and fresh weight had an ascending effect due to the effect of V, that is, with 10 µM of V, the two variables evaluated increased (**Figure 2b,c**). The stimulating effect of V positively influenced the appearance of buds and early flowering with 6 µm and 10 µm (**Figure 3**). At 6 µm V, the flowers were of different shades of different sizes. In this experiment we observed that the highest level of V can induce important changes, both in flower morphology and coloration (**Figure 4**). In the postharvest phase we observed that V increases the useful life of the flower, which is beneficial for the floriculture industry

(**Figure 5**).

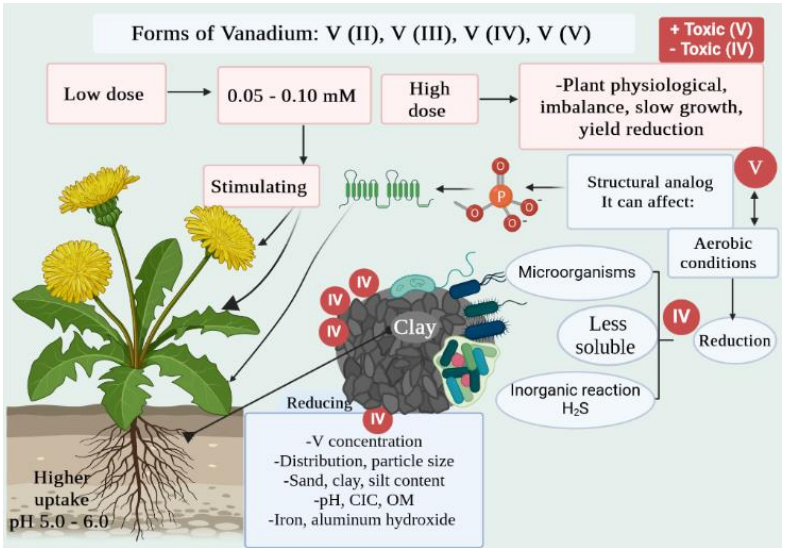

Figure 1. Role of vanadium in the plant system.

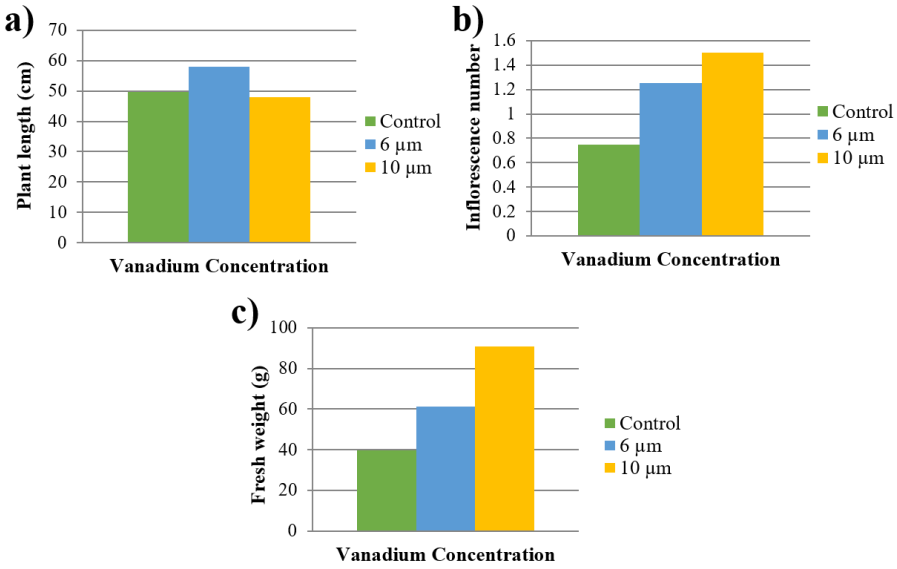

Figure 2. Effect of vanadium on plant height, inflorescence number and fresh weight in *Zinnia*; **(a)** control; **(b)** 6 µm; **(c)** 10 µm.

Figure 3. Effect of vanadium during the development and appearance of flowers in *Zinnia*; **(a)** control; **(b)** 6 µm; **(c)** 10 µm.

Figure 4. Characteristics of *Zinnia* flowers treated with vanadium during harvest; **(a)** control; **(b)** 6 µm; **(c)** 10 µm.

Figure 5. Characteristics of *Zinnia* flowers during postharvest treated with vanadium; **(a)** control; **(b)** 6 µm; **(c)** 10 µm.

Low doses of appropriate V ions can stimulate plant growth and development, exert cytoprotective effects, and effectively improve the synthesis of some biologically active compounds [4]. Low concentrations of V showed a positive effect on the accumulation and translocation of P [7]. In fact, when *Arabidopsis thaliana* plants are treated with type V complex (IV), the plants have the highest survival rate in the presence of H_2O_2 [8]. Applications of 40 and 80 mg/L^{-1} of NH_4VO_3 reduce stem length, number of leaves, dry weight of leaf, stem and root in green mustard and tomato plants. These effects are not observed when the concentration of 20 mg/L^{-1} is applied [9]. When melatonin (ME) (100 µM) was applied in the presence of V in tomato seedlings, a notable effect of stress on growth parameters, chlorophyll content, root morphology, mineral nutrient homeostasis was observed, and there was a reduction in the accumulation of V [10]. Future research should be aimed at studying V in various stages of growth in plants, since we demonstrate that it can be stimulated or inhibited during these events. In addition, it is a promising candidate for therapeutic studies and health treatments.

Acknowledgments: To the social service student Evelyn Hernández-Quezada from the Instituto Tecnologico de la Piedad, Michoacan, Mexico for technical and experimental support.

Conflict of interest: The authors declare no conflict of interest.

References

1. Kaur S, Kaur N, Siddique KH, Nayyar H. Beneficial elements for agricultural crops and their functional relevance in defence against stresses. Archives of Agronomy and Soil Science. 2016; 62: 905-920.
2. Bautista J, Hernández-Mendoza F, García-Gaytán V. Impact on Yield, Biomass, Mineral Profile, pH, and Electrical Conductivity of Cherry Tomato Fruit Using a Nutrient Solution and a Silicon-Based Organomineral Fertilizer. Advances in Agriculture. 2020; 1-7.
3. Gómez-Merino FC, Trejo-Téllez LI. The role of beneficial elements in triggering adaptive responses to environmental stressors and improving plant performance. Biotic and Abiotic Stress Tolerance in Plants. 2018; 137-172.
4. Hanus-Fajerska E, Wiszniewska A, Kamińska I. A dual role of vanadium in environmental systems—beneficial and detrimental effects on terrestrial plants and humans. Plants. 2021; 10: 1110.
5. Chen L, Liu JR, Hu WF, et al. Vanadium in soil-plant system: Source, fate, toxicity, and bioremediation. Journal of Hazardous Materials. 2021; 405: 124200.
6. Steiner AA. A universal method for preparing nutrient solutions of a certain desired composition. Plant and Soil. 1961; 15: 134-154.
7. Aihemaiti A, Jiang J, Gao Y, et al. The effect of vanadium on essential element uptake of Setaria viridis' seedlings. Journal of Environmental Management. 2019; 237: 399-407. doi: 10.1016/j.jenvman.2019.02.054
8. Rojek J, Kozieradzka-Kiszkurno M, Kapusta M, et al. The effect of vanadium (IV) complexes on development of Arabidopsis thaliana subjected to H_2O_2-induced stress. Functional Plant Biology. 2019; 46: 942-961.
9. Vachirapatama N, Jirakiattikul Y, Dicinoski G, et al. Effect of vanadium on plant growth and its accumulation in plant tissues. Sonklanakarin Journal of Science and Technology. 2011; 33: 255.
10. Altaf MA, Shahid R, Ren MX, et al. Protective mechanisms of melatonin against vanadium phytotoxicity in tomato seedlings: insights into nutritional status, photosynthesis, root architecture system, and antioxidant machinery. Journal of Plant Growth Regulation. 2021; 1-17.