Effect of spraying with silicon and methyl Jasmonate on vegetative and flowering of *Digitalis purpurea* L.

Mervat Najem Fakhri Abboud **Abdul Kareem A.J. Mohammad Saeed**
mervtnagm12@gmail.com
Department of Horticulture and Landscape Gardening, College of Agriculture, University of Diyala, Iraq.

Abstract

The experiment was conducted in one of the greenhouses of the Baquba Arboretum Research Station Center / Diyala Agricultural Directorate during autumn season of the year 2021-2022. To study the effect of spraying silicon and methyl Jasmonate on the growth and flowering of Digitalis purpurea L. The first factor involved spraying the vegetative growth with silicon at two concentrations, 0 and 100 mg L^{-1} and methyl Jasmonate at different concentrations of 50 and 100 mg L^{-1}, A factorial experiment (2 × 3 × 3) was conducted according to the randomized complete block design (RCBD) with three replicates, and the results of the experiment were as follows:

The results showed that there was a significantly excelled when spraying with silicon at a concentration of 100 mg L^{-1} in the traits of plant height (39.19 cm), number of leaves (18.86 leaf $plant^{-1}$), leaf area (2069.6 cm^{2}), and chlorophyll content in leaves (2.59 mg 100 gm^{-1}).The dry weight of the leaves (10.84 g), the early flowering time (94.77 days), the number of inflorescences (9.35 $inflorescences^{-1}$), the number of florets per inflorescence (38.10 florets. $inflorescences^{-1}$), the fresh weight of the inflorescence (13.13 g), and the dry weight of the inflorescence (3.12). cloud). The results showed that there was a significantly excelled when spraying Methyl Jasmonate at a concentration of 100 mg L^{-1} in plant height (38.07 cm). The number of leaves (18.15 plant $leaves^{-1}$), the leaf area (1939.8 cm^2), the relative chlorophyll content in the leaves (2.55 mg 100 gm^{-1}), the dry weight of the leaves (10.13g), the early flowering time (95.08 days), the number of inflorescences (8.91 inflorescences. $plant^{-1}$) and the number of florets per inflorescence (36.89 florets $plant^{-1}$) The fresh weight of the inflorescence was (12.81 g) and the dry weight of the inflorescence was (2.93 g). The results of the interactions between the two factors of the study indicated a significant effect in improving most of the vegetative and flowering growth traits of the digitalis plant, and the interactions Si100×Mj100 excelled in recording the best results.

introduction

Medicinal plants are defined as a part of the plant, or more than one part, which contains one or more chemical substances in a low or highest concentration and can treat a specific disease or more, or reduce the symptoms of infection if it depends on this part either in its natural form, Either through the effective chemicals extracted from it, and that everything of plant origin that is used medicinally is a medicinal plant, and this definition includes the plant kingdom, not excluding the lowest species to the most advanced and complex [28]. Digitalis purpurea L., commonly referred to as purple foxglove, is a flowering plant in the family Plantaginaceae [30] native to North Africa and Europe as well as central and western Asia [16]. The doctor Withering describes the digitalis as a biennial plant that does not tolerate dryness of the soil and blooms from late spring to early summer [32]. Digitalis is an herbaceous plant with dark green leaves that bears conspicuous purple flowers from which its scientific name is derived [30;32]. Although digitalis has been used medicinally for more than 700 years, its medicinal properties were first described by Doctor Withering in 1785 as a treatment for dropsy, which is now referred to as heart failure or congestive heart failure [31; 32]. Silicon (Si) is the second most abundant element in soil and is found as silica or silicates in nature. It ranges from 1% to 10% or higher in the dry

ISSN 2072-3857

matter of the plant. Silicon can benefit plant growth and development in several ways. Some of these benefits include increased plant growth and crop quality. It stimulates photosynthesis, reduces the rate of transpiration, increases plant resistance to biotic and abiotic stresses, and is a stimulus or elicit for secondary metabolites in plants. The beneficial effects of silicon are usually expressed more clearly when plants are under stress conditions. Plants take up silicon in the form of silicic acid Where it is transferred to the vegetative branches. After losing water, it polymerizes in the form of silica gel on the surface of leaves and stems. It is also the only ingredient that does not cause serious harm to plants in excess amounts [18]. Jasmonates include both jasmonic acid (JA) and methyl Jasmonate (MeJA), along with their intermediates, which are important molecular signals, widespread in the plant kingdom and playing critical roles in biotic and abiotic stress responses. As well as in the processes related to plant growth and development. Jasmonates are also involved in several developmental processes and vegetative growth, such as increase in fruit size and mass[19], chlorophyll pigment concentration, and root system development [7], He stated that one of the effective ways to increase the production of secondary metabolite compounds in plants is treatment with chemicals such as methyl Jasmonate, and many studies have shown that Jasmonate compounds lead to stimulation of the accumulation of secondary metabolite compounds, such as glycosides, alkaloids and anthocyanins, in plants [8]. Given the importance of silicon in plant growth and development and its association with important physiological functions in the plant and its enhancement of plant resistance to abiotic and biotic stresses and the importance of the methyl Jasmonate compound in stimulating the accumulation of secondary metabolites and mitigating the impact of environmental stresses as well and the importance of the digitalis plant being a medicinal plant. Accordingly, this study aims to study the effect of foliar spraying of each of silicon and methyl Jasmonate on the vegetative and flowering growth of the digitalis plant.

Materials and methods

The experiment was conducted in one of the greenhouses affiliated to the Baquba Arboretum Research Station, Center / Diyala Agriculture Directorate, in autumn season of the year 2021-2022.The experiment was conducted from 1/3/2022 to 5/15/2022. The seeds of the Digitalis purpurea L. plant, imported from the Swiss company Syngenta flowers, were grown in tray containing peat moss on 11/17/2022. One seed was planted in each pit and left in the plastic house. The land of the plastic house was prepared from the operations of cleaning the soil, leveling it, and covering it with a black (polyethylene) plastic cover to prevent the growth of weeds and maintain the cleanliness of the experiment site. river soil was obtained from the banks of the Tigris River. Samples were taken from agricultural soil, and some of its chemical and physical properties were analyzed in the Central Laboratory for Soil, Water and Plant Analysis, University of Baghdad / College of Agricultural Engineering Sciences, Table (1).

The experiment included a study of two factors. The first factor involved spraying the vegetative growth with silicon at two concentrations, 0 and 100 mg L^{-1}, symbolized by Si. As for the second factor, it represented spraying the vegetative growth with a compound of methyl Jasmonate at different concentrations of 50 and 100 mg L^{-1}, in addition to spraying with distilled water as a comparison treatment and symbolized by Mj0, Mj50, and Mj100, and this included the second factor. Methyl Jasmonate was prepared by supplementing the volume to 100 ml using ethanol and then supplementing to 1 liter of

ISSN 2072-3857

distilled water. The plants were sprayed twice, the first after the appearance of 4-5 pairs of true leaves, and the second after 30 days from the date of seeding, with an interval of two days between spraying each of the study factors. A dispersing agent (liquid soap) was added with the spray solution. The plants were sprayed until completely wet using a 2-liter hand sprayer. A barrier was placed between the experimental units to prevent the spray from spreading to other treatments.

Table 1: Some chemical and physical traits of agricultural soil

values	Units	measured trait	
2.47	dS m^{-1}	Electrical Conductivity EC 1:1	
7.18	--------	PH 1:1	
33	mg.kg^{-1}	available nitrogen	
5.15			
254.10		available phosphorous P	
4.60		available Potassium K	
130.1	g.kg^{-1}	organic matter	
7.7		Calcium carbonate CaCO3	
6.11	Meq.L-1	soluble calcium Ca^{+2}	
3.25		Mg+2 dissolved magnesium	
1.3		Dissolved Sodium Na^{+2}	
20.55		dissolved bicarbonate HCO3	
1.01		Dissolved chlorine	
876	g.kg^{-1}	Sand	Soil separators
64		Silt	
69		Clay	
SAND		soil texture	

A factorial experiment (2 × 3 × 3) was carried out according to the Randomized Complete Block Design (RCBD) and with three replicates [2]. The data were analyzed according to the statistical program [27], and the arithmetic means were compared using the Duncan multiple tests. The limits are at a probability level of 0.05. Experimental measurements included some vegetative traits, plant height (cm), number of leaves and leaf area (cm^2). Leaf area was calculated using Digimizer software according to [25] and total chlorophyll content in leaves (100g^{-1} mg fresh weight) according to [14], leaf dry weight (g), In addition to flower growth characteristics, such as the date of opening of the first basal flower, the number of inflorescences (inflorescence. plant^{-1}), the number of florets in the inflorescence (inflorescence. plant^{-1}), the fresh weight of the inflorescence (gm), and the dry weight of the inflorescence (gm).

Results

Traits of vegetative growth

The results in table (2) showed that there were significant differences when treated with silicon spray, which resulted in a significant increase in plant height, number of leaves, leaf area, and chlorophyll content and the dry weight of the leaves, where the spraying treatment with the concentration of 100 mg L^{-1}

ISSN 2072-3857

recorded 39.19 cm, 18.86 leaf-1, 2069.6 cm2, 2.59 mg 100 g^{-1}, and 10.54 g, respectively. While the control treatment recorded the lowest values of 33.48 cm, 14.42 leaf. $plant^{-1}$, 1383.9 cm2, 1.90 mg $100g^{-1}$, and 7.46 g, respectively.

Table (2): Effect of spraying silicon and methyl Jasmonate on some vegetative traits of digitalis

Characters / Treatments		Plant height (cm)	The number of leaves (leaf $plant^{-1}$)	Leaf area (cm^2)	Leaves relative chlorophyll content $Mg.100gm^{-1}$	Leaves dry weight (g)
Effect of Ir						
Si0		**33.48 b**	**14.42 b**	**1383.9 b**	**1.90 b**	**7.46 b**
Si100		**39.19 a**	**18.86 a**	**2069.6 a**	**2.59 a**	**10.84 a**
Effect of Mj						
Mj0		**34.13 b**	**15.46 b**	**1350.8 b**	**1.86 c**	**8.20 c**
Mj50		**36.81 a**	**16.31 b**	**1889.8 a**	**2.32 b**	**9.12 b**
Mj100		**38.07 a**	**18.15 a**	**1939.8 a**	**2.55 a**	**10.13 a**
Effect of Ir×Mj						
Si0	**Mj0**	**30.80 c**	**12.81 d**	**792.1 e**	**1.24 d**	**6.36 d**
	Mj50	**34.21 b**	**14.03 d**	**1709.0 cd**	**2.08 c**	**7.57 c**
	Mj100	**35.43 b**	**16.43 c**	**1650.7 d**	**2.37 b**	**8.45 c**
Si100	**Mj0**	**37.46 ab**	**18.11 b**	**1909.5 bc**	**2.47 b**	**10.04 b**
	Mj50	**39.42 a**	**18.60 ab**	**2070.6 ab**	**2.56 ab**	**10.67 b**
	Mj100	**40.70 a**	**19.87 a**	**2228.9 a**	**2.73 a**	**11.82 a**

The effect of spraying methyl Jasmonate significantly on plant height, number of leaves, leaf area, chlorophyll content and dry weight of leaves. The spraying treatment excelled with the concentration of 100 mg L^{-1} by recording the highest values of 38.07 cm, 18.15 leaf. $plant^{-1}$, 1939.8 cm 2, 2.55 mg 100 $g^{-1,}$ and 10.13 g, respectively. While the control treatment recorded the lowest values of 34.13 cm, 15.46 leaf-1, 1350.8 cm^2, 1.86 mg $100g^{-1}$, and 8.20 gm, respectively. The results of the interaction between silicon concentrations and methyl Jasmonate concentrations showed a significant effect on the characteristics of plant height, number of leaves, leaf area, chlorophyll content and dry weight of leaves. .73 mg $100gm^{-1}$ and 11.82gm, respectively, compared to the rest of the coefficients.

Traits of flowering growth

It is clear that the foliar spraying with silicon had a significant effect on the flowering date, where the spraying treatment with a concentration of 100 mg L^{-1} excelled by recording the lowest flowering date, which

ISSN 2072-3857

reached 94.77 days, while the control treatment recorded a delay in the flowering date, which reached 100.36 days. The spray treatment with a concentration of 100 mg L^{-1} excelled in the number of inflorescences, the number of florets per inflorescence, the fresh and dry weight of the inflorescences, and gave 9.35 inflorescences. $plant^{-1}$, 38.10 inflorescences. $plant^{-1}$, 13.13 g and 3.12 g, respectively. Compared with the control treatment, which gave the lowest values, it was 6.35 $inflorescences^{-1}$, 31.28 $inflorescences^{-1}$, 10.18 g and 2.18 g, respectively. It is noted that foliar spraying with methyl Jasmonate had a significant effect on the flowering date, where the treatment with a concentration of 100 mg L^{-1} excelled by recording the lowest flowering date, which reached 95.08 days, while the control treatment recorded a delay in the flowering date, which amounted to 100.02 days. The spraying treatment with a concentration of 100 mg L^{-1} excelled in the number of inflorescences, the number of florets per inflorescence, the fresh and dry weight of the inflorescences, and gave 8.91 inflorescences plant-1, 36.89 florets inflorescence-1, 12.81 g and 2.93 g, respectively, compared with the control treatment that gave the lowest values were 6.84 $inflorescences^{-1}$, 32.54 $inflorescences^{-1}$, 10.49 g, and 2.34 g, respectively. The results of the interaction between the concentrations of silicon and methyl Jasmonate showed a significant effect on the flowering date, where the treatment Si100 × Mj100 recorded the lowest flowering date, which reached 92.48 days. The treatment Si100×Mj100 recorded the highest values in the number of inflorescences. The number of florets per inflorescence, the fresh and dry weight of the inflorescences, and gave 10.21 inflorescences $plant^{-1}$, 40.56 florets $inflorescence^{-1}$, 14.48 g, and 3.35 g, respectively, compared with the treatment of Mj0×Si0, which gave the lowest values of 5.19 inflorescences $plant^{-1}$ and 29.52 flower. inflorescences $^{-1}$, 8.88 grams and 1.79 grams, respectively.

ISSN 2072-3857

Table (3): Effect of spraying silicon and methyl Jasmonate on some flowering traits of digitalis plant

Effect of Ir						
Characters Treatments		Day to flowering	Number of flowers inflorescences (inflorescence plant^{-1})	Number of florets in an inflorescence (floret inflorescence^{-1})	Fresh weight of inflorescences (g)	Dry weight of inflorescences (g)
Si0		100.36 a	6.35 b	31.28 b	10.18 b	2.18 b
Si100		94.77 b	9.35 a	38.10 a	13.13 a	3.12 a
Effect of Mj						
Mj0		100.02 a	6.84 c	32.54 c	10.49 b	2.34 c
Mj50		97.60 b	7.92 b	34.65 b	11.67 ab	2.69 b
Mj100		95.08 c	8.91 a	36.89 a	12.81 a	2.93 a
Effect of Ir×Mj						
Si0	Mj0	103.26 a	5.19 e	29.52 e	8.88 d	1.79 e
	Mj50	100.13 b	6.27 d	31.11 e	10.53 cd	2.24 d
	Mj100	97.68 c	7.60 c	33.22 d	11.13 bc	2.51 c
Si100	Mj0	96.77 cd	8.58 b	35.55 c	12.11 bc	2.89 b
	Mj50	95.06 d	9.27 b	38.19 b	12.81 ab	3.13 ab
	Mj100	92.48 e	10.21 a	40.56 a	14.48 a	3.35 a

Discussion

The results of the experiment showed that the spraying of silicon led to a significant effect, where the treatment of spraying with a concentration of 100 mg L^{-1} was missed in improving the vegetative growth traits represented by plant height, number of leaves, leaf area, chlorophyll content in the leaves, and dry wegith of leaf. The reason may be due to the fact that the spraying of silicon led to an improvement in traits of vegetative growth by increasing the level of gibberellin in the plant, which is responsible for stimulating growth, or the reason may be due to the increase in the chlorophyll content in the leaves, which encourages the synthesis of sugars that are used in plant growth [20], or the reason may be due to the fact that silicon increased root growth, which increases the absorption of nutrients that contribute to plant growth [11], and the reason for increasing plant height may be due to the role of silicon in elongating and strengthening plant roots, which leads to increased uptake more nutrients than the soil solution [17], Perhaps the role of silicon in increasing the absorption of nutrients and water, which leads to accelerated growth [12], and the reason may be due to the important role of silicon in improving plant growth and

ISSN 2072-3857

development. Silicon helps to enhance mechanical strength, intercept light, and resist various biotic and abiotic stresses, which leads to improved vegetative growth traits. Foliar spraying of silicon leads to increased plant hardness due to increased nitrogen in the plant, which leads to improved vegetative growth traits [23], Silicon-mediated stress tolerance is the result of two main processes, physical and mechanical protection through the deposition of SiO_2 and by metabolic changes induced by biochemical responses[9], The reason for the increase in leaf area and the number of leaves resulting from the use of silicon may also be due to its influential role in the photosynthesis process by increasing the chlorophyll content and increasing the efficiency of photosynthesis [5]. In addition, the deposition of silicon in the epidermal cells will prevent water loss from the leaves and increase the efficiency of water use, which will be positively reflected in increasing the fresh weight of the shoot. These results are consistent with the findings of [15] when spraying silicon on borage plant.

The results of the experiment showed that spraying methyl Jasmonate led to a significant effect, where the treatment of spraying at a concentration of 100 mg L^{-1} was missed in improving the vegetative growth traits represented by plant height, number of leaves, leaf area, chlorophyll content in leaves, and dry weight of leaves, and the reason for excelled of these traits may be due to the important role of methyl Jasmonate. As its main function is to regulate the process of opening stomata, cell division, plant growth, and foliar treatment, which causes the regulation of many physiological processes to help the plant resist many abiotic stresses [1], and the reason may be due to the increase in physiological processes, the most important of which is photosynthesis.[10] mentioned that Jasmonate compounds have an important role in regulating many vital processes in plants such as photosynthesis and the formation of reproductive organs. Many scientists also suggested that they have a major role in many other physiological processes such as flowering, defense responses and senescence, and in increasing plant tolerance to stress. biotic and abiotic and increase their resistance to pathogens, Which leads to an increase in the percentage of nitrogen and phosphorus in the plant and thus increase plant activity and improve the traits of vegetative growth, and that the diversity of effects of methyl Jasmonate in plant growth include the formation of storage organs, and increase plant defenses against biotic stress (such as insects, herbivores and pathogens) and abiotic (such as dryness and waterlogging). In addition, methyl Jasmonate can interact with other plant hormone pathways, particularly ethylene, to influence growth and development [24], The reason may be due to the fact that Jasmonate compounds have stimulating or inhibiting effects on the various processes necessary for plant development and growth, and the ability of Jasmonate compounds to act as regulators of growth, development, defense or protection, and has roles in flower growth and development [3].

The results of the experiment showed that the spraying of silicon led to a significant effect, as the spraying treatment with a concentration of 100 mg L-1 excelled in improving the inflorescence growth traits represented in the number of inflorescences, the opening date of the first basal inflorescence in the inflorescence, the number of florets per inflorescence, and the fresh and dry weights of the inflorescence. Silicon may improve vegetative growth due to its role in increasing root growth, which increases the absorption of nutrients that contribute to plant growth and increased growth and flowering buds [11], and the reason may be due to the fact that silicon is a nutrient as it increases the efficiency of water use. For plants exposed to stress, through closing the stomata, reducing transpiration, accumulating proline, increasing calcium ion and chlorophyll content. As the thick layer formed of silica gel attached to the cellulose cell walls helps prevent water loss and increase plant productivity from flowering [13], and the reason for the increase in leaf area may be attributed to the use of silicon and

ISSN 2072-3857

its influential role in the process of photosynthesis by increasing the content of Chlorophyll and increase the efficiency of photosynthesis [5],As for the increase in the number of inflorescences, the date of opening of the first basal floret in the inflorescence, the number of florets in the inflorescence, and the fresh and dry weights of the inflorescence, it may be due to the presence of silicon, which affects the absorption and transmission of many macro and microelements, as well as the role of silicon in increasing the activity of the HATPase enzyme. The reason may also be due to the fact that the use of silicon led to an improvement in the absorption of the macro nutrients nitrogen and phosphorous, which is reflected positively in flowering growth [21], as the foliar spraying of potassium led to an increase in vegetative growth as well as increased plant height, and this is consistent with what was found [22] on the dahlia plant. The results of the experiment showed that spraying methyl Jasmonate led to a significant effect on traits of flowering growth, and the spraying treatment with a concentration of 100 mg L-1 of methyl Jasmonate excelled in giving it the best results for traits represented by the number of inflorescences and the opening date of the first basal flower in the inflorescence. The number of florets of the inflorescence and the fresh and dry weights of the inflorescence. The reason may be due to the fact that Jasmonate compounds have stimulating or inhibiting effects on the various processes necessary for plant development and growth, and the ability of Jasmonate compounds to act as regulators of growth, development, defense or protection and have roles in the growth and development of the flower [3].These results are consistent with what was mentioned by [6], that spraying jasmonic acid on the chrysanthemum plant Calendula officinalis increased the dry weight of flowers and the number of flowers, and also agree with what was found by [29] on the artichoke plant Cynara cardunculus, The reason may also be due to the increase in physiological processes, the most important of which is the process of photosynthesis. [10] mentioned that methyl Jasmonate has an important role in regulating many vital processes in plants, such as photosynthesis and the formation of reproductive organs. other physiological processes such as flowering, defense responses, and aging, The reason for this increase could also be due to the variety of effects of methyl Jasmonate on plant growth, including formation of storage organs, and increased plant defenses against biotic and abiotic stress. In addition, methyl Jasmonate can interact with other plant hormone pathways, particularly ethylene, to influence growth and development.[24]. These results agree with what [4] found when spraying methyl Jasmonate on the Chinese aster plant, and what [26] found on Kalanchoe blossfeldiana.

References

1. **Walia H**, Wilson C, Condamine P, Liu X, Ismail AM, Close TJ (2007). Large-scale expression profiling and physiological characterization of jasmonic acid-mediated adaptation of barley to salinity stress. Plant Cell Environ. 30: 410-421
2. **Alrawi**, Khashaa Mahmoud, and Abdel Aziz Mahmoud Khalafallah. (2000). Design and Analysis of Agricultural Experiments. Second edition, University of Mosul. Ministry of Higher Education and Scientific Research. The Republic of Iraq.
3. **Al-Khafaji**, Makki Alwan. (2014). Plant growth regulators and their horticultural applications and uses. University House for Printing, Publishing and Translation, College of Agriculture, University of Baghdad. The Republic of Iraq.
4. **Youssef,** Aya Refaat. (2021). Effect of spraying with thiamine and jasmonic acid on the growth and flowering of a cultivar of Chinese aster Callistephus chinensis.. Master thesis. faculty of Agriculture. Diyala University. The Republic of Iraq.
5. **Abdelaal,** K.A., Mazrou, Y.S., & Hafez, Y.M. (2020). Silicon foliar

ISSN 2072-3857

application mitigates salt stress in sweet pepper plants by enhancing water status, photosynthesis, antioxidant enzyme activity and fruit yield. Plants, 9(6), 733.

6. **Ataei**, N., Moradi, H., and Akbarpour, V., (2013). Growth parameters and photosynthetic pigments of marigold under stress induced by jasmonic acid. Notulae Scientia Biologicae, 5(4), 513-517.
7. **Awang**, N.A.A., Ismail, M.R., Omar, D., & Islam, M.R., (2015). Comparative study of the application of jasmonic acid and pesticide in chilli: effects on physiological activities, yield and viruses' control. *Bioscience Journal*, *31*(3), 672-681
8. **Belhadj**, A, Telef N, Saigne C, Cluzet S, Barrieu F, Hamdi S, Merillon J., (2008). Effect of methyl jasmonate in combination with carbohydrates on gene expression of PR proteins, stilbene and anthocyanin accumulation in grapevine cell cultures. Plant Physiol Biochem. 46: 493-499
9. **Bhat,** J.A., Shivaraj, S.M., Singh, P., Navadagi, D.B., Tripathi, D.K., Dash, P.K., ... & Deshmukh, R. (2019). Role of silicon in mitigation of heavy metal stresses in crop plants. Plants, 8(3), 71.
10. **Cheong, J**.J., and Do Choi, Y., (2003). Methyl jasmonate as a vital substance in plants. TRENDS in Genetics, 19(7), 409-413
11. **Debicz,** R., Pawlikowska, A., Wroblewska, K., & Babelewski, P. (2016). Influence of foliar treatment with silicon contained in the Actisil Hydro Plus preparation on the growth, flowering and chemical composition of *Gazania rigens (L.) Gaertn., Salvia farinacea Benth and Verbena hybrida Voss. Journal of Elementology, 21(3).*
12. **Epstein**, E., (2001). Silicon in plants: facts vs. concepts. In: Datnoff LE, Snyder GH, Korndöfer GH, editors.Silicon in agriculture. Amsterdam: Elsevier Science; p. 1–15.
13. **Gao, X.**, Zou, C., Wang, L., & Zhang, F. (2005). Silicon improves water use efficiency in maize plants. Journal of plant nutrition, 27(8), 1457-1470.
14. **Goodwin,** T.W. (1976). Chemisty & Biochemisty of plant pigment. 2nd Academic. Press, Landon, New York. San Francisco: 373.
15. **Kimiaei**, M.R., Sirousmehr, A., & Fakheri, B.A. (2022). The Effect of Silicon on Quantitative and Physiological Characteristics of Borage (*Borago officinalis L*.) under Irrigation Regimes. *Journal of Crops Improvement*, *24*(2), 631-643.
16. **Lin**, C.C., Yang, C.C., Phua, D.H., Deng, J.F., & Lu, L.H., (2010). An outbreak of foxglove leaf poisoning. [Case Reports]. *J Chin Med Assoc*, *73*(2), 97-100. doi: 10.1016/S1726-4901(10)70009-5.
17. **Ma**, J. F., & Yamaji, N. (2006). Silicon uptake and accumulation in higher plants. Trends in plant science, 11(8), 392-397
18. **Ma,** J.F. and E. Takahashi. (2002). In: Soil, fertilizer, and plant silicon research in Japan. Elsevier, Amsterdam. p1-20
19. **Martínez-Esplá**, A., Zapata, P.J., Castillo, S., Guillén, F., Martínez-Romero, D., Valero, D., & Serrano, M., (2014). Preharvest application of methyl jasmonate (MeJA) in two plum cultivars. 1. Improvement of fruit growth and quality attributes at harvest. *Postharvest Biology and Technology*, *98*(12), 98-105.
20. **Mikiciuk,** G. and M. Mikiciuk. (2008). Physiological reaction of strawberry (*Fragaria ananassa Duch.)* cultivar Senga Sengana on foliar fertilization potassium-silicate. Ann. UMCS, Agric., 63(2), 81-85.
21. **Mills,** T.S. (2017). Effect of LED lighting and silicon supplementation on growth and flowering of cut flowers (Doctoral dissertation, Oklahoma State University).

ISSN 2072-3857

22. **Mohammed, S**.A., Abd-Allatif, S.A. ., & Obaid, A.A.. (2016). Effect of Foliar Application with Potassium Sulphate and Ascorbic Acid on Growth and Flowering of Dahlia (*Dahlia variabilis* L. cv. Arizona). Diyala Agricultural Sciences Journal, 8(1), 232–243.
23. **Parimala**, M., & Singh, J. (2022). Soil and foliar application of silicon on quality parameters and yield of horticultural crops.
24. **Rohwer**, C.L., & Erwin, J.E. (2008). Horticultural applications of jasmonates. The Journal of Horticultural Science and Biotechnology, 83(3), 283-304.
25. **Sadik,** K.S., A.A. Al-Taweel, N.S Dhyeab and M.Z.Khalaf.)2011(. New computer program for several vegetable crops. American Journal of Sustainable Agriculture. 304-309.
26. **Saniewski**, M., Horbowicz, M., Puchalski, J., & Ueda, J. (2003). Methyl jasmonate stimulates the formation and the accumulation of anthocyanin in *Kalanchoe blossfeldiana*. Acta Physiologiae Plantarum, *25*, 143-149.
27. **SAS. (**2003). SAS / STAT Users Guide for Personal Computers Release 7. 0. SAS Institue Inc., Cary, NC., USA.
28. **Srivastava,** A.K. (2018). Significance of medicinal plants in human life. In Synthesis of Medicinal Agents from Plants (pp. 1-24). Elsevier.
29. **Thaler,** J.S., Owen, B., and Higgins, V.J.,)2004(. The role of the jasmonate response in plant susceptibility to diverse pathogens with a range of lifestyles. Plant physiology, 135(1), 530-538
30. **USDA,** N., (2012). The PLANTS. Database Retrieved 03/08, from (http://plants.usda.gov)
31. **Whitfield**, A.G., (1985). The William Withering bicentennial lecture. William Withering and 'an account of the foxglove'. [Biography Historical Article]. *Q J Med, 57*(223), 709 711.
32. **Withering**, W., (1785). An Account of the Foxglove and some of its Medical Uses. Birmingham: M Swinney

ISSN 2072-3857