Scientific J. Flowers & Ornamental Plants
www.ssfop.com/journal
ISSN: 2356-7864
doi: 10.21608/sjfop.2021.249390

IMPACT OF POTASSIUM SILICATE AND SALICYLIC ACID ON GROWTH, FLOWERING AND QUALITY CHARACTERS OF *DENDRANTHEMA GRANDIFLORUM* PLANTS UNDER GREENHOUSE CONDITIONS

O.A. Abdelsadek; Naglaa F.S.I. Elbohy and Randa I. Diab
Ornamental Plants and Landscape Gardening Research Department, Horticulture Research Institute, Agricultural Research Center, Egypt

Scientific J. Flowers & Ornamental Plants, 8(4):483-496 (2021).

Received:
29/11/2021
Accepted:
25/12/2021

Corresponding author:
Randa I. Diab
randa_ebrahem@yahoo.com

ABSTRACT: The impacts of foliar spraying with different potassium silicate concentrations (0.0, 300, 600 and 900 ppm) and salicylic acid (0.0, 100, 200 and 300 ppm) on growth, flowering aspects and some chemical constituents of *Dendranthema grandiflorum* (Ramat.) Kitamura plant cv. White Rivor were evaluated. Under plastic house conditions, this experiment was carried out at Ornamental Nursery of Faculty of Agriculture, Zagazig University, Egypt, during the consecutive summer seasons of 2019 and 2020. The treatments were laid out in a factorial randomized block design (4 × 4) with three replicates per treatment. The plant height, number of branches and leaves, root length and total fresh and dry weights per plant were significantly greater with 900 ppm potassium silicate treatment compared to the other ones; likewise, the number of inflorescences and flower heads per plant, as well as flower stalk length, were significantly higher. Early flowering and the largest flower heads were achieved in the foliar spray plot with 600 ppm potassium silicate. Using 900 ppm potassium silicate concentration significantly increased total carbohydrates percentage and total chlorophyll content compared to control. In the same trend, using 300 ppm of salicylic acid as foliar spray significantly increased all growth parameters, flowering traits and chemical constituents compared to the other ones under study. From these results, it can be concluded that the interaction treatment application of potassium silicate at 900 ppm plus salicylic acid at 300 ppm proved to have beneficial effects on the growth, flowering and quality of *Dendranthema grandiflorum* cv. White Rivor plant.

Key words: *Dendranthema grandiflorum*, potassium silicate, salicylic, growth, flowering.

INTRODUCTION

In the flower industries, a growing prominence is being given in the last years to chrysanthemum as pot flowers and cut flower. Chrysanthemum (*Dendranthema grandiflorum* (Ramat.) Kitamura) is an important trade cut flower, belonging to the Asteraceae (Compositae) family, with more or less 200 cultivars. It is one of the top ten upper-class cut flowers globally, due to its various dazzling colors, shapes, excellent vase life and varying sizes (Leoni *et al*., 2019). In addition, the harvest stage of chrysanthemums must be carried out when their flowers are nearly perfectly open (Han, 2000).

The efficacious impact of potassium silicate (K_2SiO_3) might be returned to the contained potassium (K) and silicon (Si) in soluble form, K plays a major function in sundry of the fundamental regulatory functions in the plant development and growth (Abou-Baker *et al*., 2011). Moreover, K plays a major positioning under biological or/and non-biological stresses on plant (Marschner, 1995). Furthermore, potassium silicate ($KSiO_3$) is a good source of silicon (Si) for cut flower plants especially chrysanthemum as a foliar application which used to raise resistance to biotic (disease and aphid insect) and abiotic (salinity and drought stress) stresses which led to enhancing plant growth (Jeong *et al*., 2012), flowering aspects (Abdalla, 2009) and chemical compositions (Hajipour *et al*., 2019).

The plant growth regulators (PGR) like salicylic acid (SA) also play a serious role in the regulation of certain functions in plant flowering (Raskin, 1992). SA may help to regulate many functions of plants, like systemic acquired resistance to pathogens and flower formation. There is little research on the impact of salicylic acid on growth, flowering and chemical composition (Jabbarzadeh *et al*., 2009). However, it has also been found that SA induced flowering in chrysanthemum plants (Kumar *et al*., 2019). Also, foliar spray with SA at 150 mg l^{-1} was superior in increasing number of leaves, leaves dry weight, number of flowers, early of flowering date and flower fresh and dry weights of *Gazania* plant compared to control (Abdul Kareem and Saeed, 2020).

The main objective of this study was to investigate the impact of foliar spray with potassium silicate and salicylic acid on plant growth and flowering aspects especially early flowering date of *Dendranthema grandiflorum* (Ramat.) Kitamura cv. White Rivor.

MATERIALS AND METHODS

This study was conducted in a plastic house at Ornamental Nursery, Fac. Agric., Zagazig Univ., Egypt, during the two consecutive summer seasons of 2019 and 2020. The experiment included 16 treatments, which were the combinations between four potassium silicate concentrations (0.0, 300, 600 and 900 ppm) and four salicylic acid concentrations (0.0, 100, 200 and 300 ppm). These treatments were examined on growth parameters, flower aspects and some chemical constituents of *Dendranthema grandiflorum* (Ramat.) Kitamura plant. Chrysanthemum cv. White Rivor rooted cuttings were planted on 2nd March of 2019 and 2020 in soil beds (3.00 × 1.25 m) at a density of 10 plants/1.0 m^2 in a randomized block design with three replicates, and each replication contained 10 plants. All seedlings were similar in growth (having 7-8 leaves and 2-3 main roots per seedling) and 12 cm in length. The physical and chemical properties of the utilized soil are shown in Table (1) according to Chapman and Pratt (1978).

The chrysanthemum plants were topped to seven nodes (Langton, 1987) after 15 days from the planting date. Supports for plants were established with wire mesh with square holes. When the chrysanthemum plants reached about 40 cm in length, the plants were exposed to a short day by the covering with a black net from 16:30 O'clock in the evening until 8:00 O'clock in the morning for nine weeks. Short-day treatment was started after 18 days from the pinching date and

Table 1. Physical and chemical properties of experimental soil.

Physical analysis				Soil texture
Clay (%)	Silt (%)	Fine sand (%)	Coarse sand (%)	
41.39	19.26	15.62	23.73	Clay

Chemical analysis													
pH	EC mmohs/cm	Organic mater (%)	Soluble cations (meq/l)				Soluble anions (meq/l)			Available (ppm)		
			Mg^{++}	Ca^{++}	K^{+}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.82	0.98	0.58	2.7	1.5	1.6	3.9	4.5	1.7	3.5	17	8.3	71

terminated when the flower buds showed color (June, 8th). Moreover, all ordinary agricultural practices of growing chrysanthemum (*Dendranthema grandiflorum*) plants were done whenever necessitated.

Tap water was utilized as a control treatment (0 ppm for KSi). KSi is prepared from a commercial compound named (potassium silicate, 32% K_2SiO_3) which was obtained from the UAD company (United Agriculture Development). The source of SA ($C_7H_6O_3$) was TG Company (Techno Gene), Dokky, Giza, Egypt. In addition, chrysanthemum plants were sprayed with different KSi and SA concentrations five times per season exactly at 30, 45, 60 and 75 days after the planting date.

The statistical layout of this experiment was a factorial design experiment between potassium silicate (four concentrations) as factor A and salicylic acid (four concentrations) as factor B in a randomized complete block design (RCBD) with 3 replicates. The interaction treatments between potassium silicate and salicylic acid concentrations consisted of 16 treatments.

Data recorded:

Plant growth:

After 95 days from the transplanting date, plant height (cm), number of branches and leaves/plant, root length (cm) and total fresh and dry weights (branches + leaves + roots)/plant (g) were determined.

Flowering aspects:

At the harvest stage (about 116-125 days after planting) number of days to flower as well as number of inflorescences/plant, number of flower heads per plant, inflorescence stalk length (cm) and flower head diameter (cm) were recorded.

Chemical constituents:

After 95 days from the planting date, total carbohydrate percentage in chrysanthemum leaves was determined according to the method described by Dubois *et al.* (1956). Also, total chlorophyll content (SPAD unit) was determined in leaves by using SPAD-502 meter (Markwell *et al*., 1995).

Statistical analysis:

The obtained data were statistically analyzed and the means were compared utilizing the least significant difference (L.S.D.) test at 5% level as described by Gomez and Gomez (1984). The means were compared utilizing the computer program of Statistix version 9 (Analytical software, 2008).

RESULTS AND DISCUSSION

Plant growth:

Data presented in Tables (2, 3 and 4) demonstrate that spraying chrysanthemum (*Dendranthema grandiflorum*) plants with potassium silicate concentrations especially at 600 or 900 ppm significantly increased plant height, branch and leaf number per plant, root length and total fresh and dry weights of the plant compared to control. In general, increasing KSi concentration gradually increased plant growth parameters during both seasons, and, the highest values in this connection were achieved when plants were sprayed with KSi at 900 ppm. It is well known that potassium as an essential element to the plant could improve plant growth due to the role of K as an activator of many enzymes (Helgi and Rolfe, 2005). In the past years, Si was not beholden as an essential nutrient for higher plants. However, Epstein and Bloom (2005) located novel criteria of the primary elements for higher plants upon which Si could be considered an essential nutrient.

Salicylic acid at 300 ppm concentration significantly increased *Dendranthema grandiflorum* growth values compared to control and the other ones under study in both seasons (Tables 2, 3 and 4). Using all SA concentrations gave taller plants, more branches and leaves per plant, longer root

Table 2. Effect of potassium silicate, salicylic acid concentrations and their interactions on plant height and number of branches/plant of *Dendranthema grandiflorum* during 2019 and 2020 seasons.

Potassium silicate concentration (ppm) (B)	Salicylic acid concentration (ppm) (A)				
	0.0	100	200	300	Mean (A)
			Plant height (cm)		
			2019 season		
Control	108.33	109.67	111.00	114.67	110.92
300	107.67	114.00	115.33	116.67	113.42
600	110.33	115.33	118.00	123.67	116.83
900	113.67	117.67	122.00	123.67	119.25
Mean (B)	110.00	114.17	116.58	119.67	
L.S.D. at 5%	A= 1.11		B= 0.98		A×B= 2.03
			2020 season		
Control	106.67	107.67	109.33	113.33	109.25
300	109.67	112.33	114.33	115.33	112.92
600	113.00	112.33	118.33	119.67	115.83
900	115.33	120.00	123.33	126.33	121.25
Mean (B)	111.17	113.08	116.33	118.67	
L.S.D. at 5%	A= 0.70		B= 0.80		A×B= 1.55
			Number of branches/plant		
			2019 season		
Control	5.20	5.43	5.57	6.10	5.58
300	5.43	6.10	6.43	7.10	6.27
600	5.90	7.10	7.23	7.90	7.03
900	6.43	7.43	8.10	8.10	7.52
Mean (B)	5.75	6.512	6.83	7.30	
L.S.D. at 5%	A= 0.27		B= 0.16		A×B= 0.39
			2020 season		
Control	4.57	5.80	6.23	6.43	5.76
300	5.10	6.10	6.90	7.57	6.42
600	5.53	6.57	7.10	8.10	6.83
900	5.57	7.57	8.43	8.57	7.53
Mean (B)	5.20	6.51	7.17	7.67	
L.S.D. at 5%	A= 0.23		B= 0.23		A×B= 0.46

Table 3. Effect of potassium silicate, salicylic acid concentrations and their interactions on number of leaves /plant and of *Dendranthema grandiflorum* during 2019 and 2020 seasons.

Potassium silicate concentration (ppm) (B)	Salicylic acid concentration (ppm) (A)				
	0.0	100	200	300	Mean (A)
			Number of leaves/plant		
			2019 season		
Control	21.10	23.47	24.43	24.77	23.44
300	21.57	23.10	25.23	26.43	24.08
600	22.33	24.43	25.97	28.23	25.24
900	25.10	26.23	27.57	31.57	27.62
Mean (B)	22.53	24.31	25.80	27.75	
L.S.D. at 5%	A= 0.43		B= 0.33		A×B= 0.72
			2020 season		
Control	21.77	22.90	25.10	26.00	23.94
300	22.43	24.57	25.77	27.23	25.00
600	23.90	26.57	28.10	29.10	26.92
900	26.90	28.57	30.57	30.87	29.23
Mean (B)	23.75	25.65	27.38	28.30	
L.S.D. at 5%	A= 0.48		B= 0.37		A×B= 0.79
			Root length (cm)		
			2019 season		
Control	17.53	18.67	19.63	20.73	19.14
300	18.17	19.20	20.20	20.77	19.58
600	18.83	20.23	21.80	21.87	20.68
900	19.00	21.40	22.93	24.50	21.96
Mean (B)	18.38	19.88	21.14	21.97	
L.S.D. at 5%	A= 0.64		B= 0.31		A×B= 0.83
			2020 season		
Control	16.03	17.17	17.60	18.60	17.35
300	16.67	17.97	19.10	19.43	18.29
600	18.50	20.50	22.367	22.80	21.04
900	19.53	20.37	21.37	23.07	21.08
Mean (B)	17.68	19.00	20.11	20.98	
L.S.D. at 5%	A= 1.08		B= 0.54		A×B= 1.43

Table 4. Effect of potassium silicate, salicylic acid concentrations and their interactions on total fresh and dry weights/plant of *Dendranthema grandiflorum* during 2019 and 2020 seasons.

Potassium silicate concentration (ppm) (B)	Salicylic acid concentration (ppm) (A)				
	0.0	100	200	300	Mean (A)
			Total fresh weight of plant (g)		
			2019 season		
Control	52.97	53.97	54.90	57.50	54.83
300	54.20	57.33	61.40	62.17	58.78
600	59.43	63.27	66.73	70.37	64.95
900	61.67	65.27	68.87	72.33	67.03
Mean (B)	57.07	59.96	62.98	65.59	
L.S.D. at 5%	A= 0.66		B= 0.50		A×B= 1.09
			2020 season		
Control	56.83	58.17	58.70	61.07	58.69
300	57.60	59.07	60.53	63.00	60.05
600	57.67	60.53	63.13	67.00	62.08
900	60.73	62.50	64.83	70.00	64.53
Mean (B)	58.21	60.07	61.80	65.27	
L.S.D. at 5%	A= 0.93		B= 0.56		A×B= 1.34
			Total dry weight of plant (g)		
			2019 season		
Control	12.17	12.43	12.80	13.13	12.63
300	13.03	13.70	14.70	16.13	14.39
600	15.17	16.67	17.63	18.97	17.11
900	14.80	17.43	18.17	20.37	17.69
Mean (B)	13.79	15.06	15.83	17.15	
L.S.D. at 5%	A= 0.32		B= 0.25		A×B= 0.54
			2020 season		
Control	12.60	13.00	13.43	15.100	13.53
300	12.80	14.20	14.27	16.433	14.43
600	13.63	14.47	16.17	17.200	15.37
900	14.33	15.30	16.60	18.900	16.28
Mean (B)	13.34	14.24	15.12	16.91	
L.S.D. at 5%	A= 0.34		B= 0.22		A×B= 0.51

and heavier plants weight than control in 2019 and 2020 seasons. There was a gradual increase in these parameters with increasing the concentration of salicylic acid. In this regard, Chaudhary *et al*. (2015) reported that SA exogenous application before reproductive stage may result in higher total flavonoids content and biomass production which reflected in growth enhancement of marigold plants.

In addition, the interaction between the various concentrations of potassium silicate and salicylic acid treatments during 2019 and 2020 seasons can be seen in Tables (2, 3 and 4). The obtained results revealed that the prevalence of foliar application with the various interactions in enhancing chrysanthemum (*D. grandiflorum*) growth parameters as plant height, number of branches and leaves per plant and root length as well as total fresh and dry weights per plant. Moreover, the highest values in this regard were recorded with utilizing 900 ppm KSi and SA at 300 ppm in both seasons.

Generally, as previously mentioned, both potassium silicate and salicylic acid treatments (each alone) increased plant growth of *Dendranthema grandiflorum* plant, in turn, they together might maximize their impacts leading to better results in this regard. Likewise, Wróblewska and Dębicz (2011) proved that supplementary application of Si, positively influenced plant development and the number of lateral shoots and improved the quality of *Osteospermum ecklonis* 'Grande Pink Blush', *Argyranthemum frutescens* 'Blazer Rose', *Gaura lindheimeri* 'Corinas Choice' and *Xerochrysum bracteatum* 'Gold'. Also, Pacheco *et al*. (2013) indicated that application of SA in 1.0 mM concentration resulted in linear increases on No. of leaves/plant and biomass accumulation of marigold plant.

Flowering aspects:

From the data in Tables 5, 6 and 7, it is quite clear that, the minimum days to reach flowering stage (118.00 and 118.08 days

Table 5. Effect of potassium silicate, salicylic acid concentrations and their interactions on days for flowering from transplanting date of *Dendranthema grandiflorum* during 2019 and 2020 seasons.

Potassium silicate concentration (ppm) (B)	Salicylic acid concentration (ppm) (A) 0.0	100	200	300	Mean (A)
			Days for flowering		
			2019 season		
Control	124.67	122.33	122.00	119.67	122.17
300	123.33	122.33	120.67	120.33	121.67
600	119.67	118.33	117.33	116.67	118.00
900	119.67	120.33	120.67	118.67	119.83
Mean (B)	121.83	120.83	120.17	118.83	
L.S.D. at 5%	A= 0.80		B= 0.52		A×B= 1.19
			2020 season		
Control	123.33	123.00	122.33	120.33	122.25
300	122.67	121.67	120.67	120.67	121.42
600	119.33	118.00	117.67	117.33	118.08
900	120.33	120.67	121.33	118.33	120.17
Mean (B)	121.42	120.83	120.50	119.17	
L.S.D. at 5%	A= 1.02		B= 0.57		A×B= 1.41

Table 6. Effect of potassium silicate, salicylic acid concentrations and their interactions on number of inflorescences and flower heads/plant of *Dendranthema grandiflorum* during 2019 and 2020 seasons.

Potassium silicate concentration (ppm) (B)	Salicylic acid concentration (ppm) (A)				
	0.0	100	200	300	Mean (A)
			Number of inflorescences/plant		
			2019 season		
Control	5.43	5.57	5.90	6.10	5.75
300	5.57	6.03	6.57	6.57	6.18
600	6.20	6.80	7.20	7.57	6.94
900	6.80	7.33	7.90	8.20	7.56
Mean (B)	6.00	6.43	6.89	7.11	
L.S.D. at 5%	A= 0.15		B= 0.19		A×B= 0.36
			2020 season		
Control	5.10	5.43	5.57	6.43	5.63
300	5.47	6.10	6.43	7.10	6.28
600	5.90	6.43	7.00	7.57	6.73
900	6.10	6.90	7.67	7.90	7.14
Mean (B)	5.64	6.22	6.67	7.25	
L.S.D. at 5%	A= 0.29		B= 0.16		A×B= 0.40
			Number of flower heads /plant		
			2019 season		
Control	34.33	34.67	35.67	36.33	35.25
300	34.67	35.67	36.67	37.33	36.08
600	35.33	36.33	37.67	37.33	36.75
900	36.33	37.00	38.33	39.67	37.83
Mean (B)	35.17	35.92	37.083	37.75	
L.S.D. at 5%	A= 0.36		B= 0.35		A×B= 0.71
			2020 season		
Control	33.33	31.33	28.33	35.67	32.17
300	33.67	35.00	35.67	36.67	35.25
600	34.67	35.33	36.33	37.33	35.92
900	35.67	36.33	37.33	38.67	37.00
Mean (B)	34.33	34.50	34.42	37.08	
L.S.D. at 5%	A= 1.42		B= 2.00		A×B= 3.49

Table 7. Effect of potassium silicate, salicylic acid concentrations and their interactions on inflorescence stalk length (cm) and flower head diameter (cm) of *Dendranthema grandiflorum* during 2019 and 2020 seasons.

Potassium silicate concentration (ppm) (B)	Salicylic acid concentration (ppm) (A)				
	0.0	100	200	300	Mean (A)
			Inflorescence stalk length (cm)		
			2019 season		
Control	65.00	65.90	65.87	67.00	65.94
300	65.17	66.50	67.50	68.00	66.79
600	66.33	67.33	68.20	69.97	67.96
900	66.67	67.53	70.40	72.00	69.15
Mean (B)	65.79	66.82	67.99	69.24	
L.S.D. at 5%	A= 0.48		B= 0.32		A×B= 0.73
			2020 season		
Control	65.13	65.27	66.03	66.37	65.70
300	65.30	66.17	66.80	67.63	66.48
600	66.63	67.60	68.70	70.20	68.28
900	67.30	68.37	69.30	70.90	68.97
Mean (B)	66.09	66.85	67.71	68.78	
L.S.D. at 5%	A= 0.25		B= 0.25		A×B= 0.51
			Flower head diameter (cm)		
			2019 season		
Control	6.20	6.40	6.63	7.40	6.66
300	6.53	7.50	7.53	7.67	7.31
600	7.90	8.17	8.33	8.37	8.19
900	7.83	8.00	8.07	8.13	8.01
Mean (B)	7.12	7.5167	7.65	7.89	
L.S.D. at 5%	A= 0.22		B= 0.13		A×B= 0.31
			2020 season		
Control	6.43	7.00	7.37	7.67	7.12
300	6.97	7.20	7.63	8.00	7.45
600	7.93	8.33	8.50	8.60	8.34
900	7.47	7.77	8.13	8.23	7.90
Mean (B)	7.20	7.58	7.91	8.13	
L.S.D. at 5%	A= 0.17		B= 0.12		A×B= 0.27

after planting date) were obtained with the application of 600 ppm potassium silicate concentration in 1st and 2nd seasons, respectively. Furthermore, the highest values in number of inflorescences and flower heads per plant, inflorescence stalk length and flower head diameter of chrysanthemum (*Dendranthema grandiflorum*) were recorded in plants sprayed with KSi at 900 ppm compared to control and the other ones under study. Flowering parameters gradually increased as potassium silicate concentration increased in both seasons, in most cases. In addition, Alaedeen *et al*. (2020) reported that using potassium at 2 g/l for had a significant effect on all traits of freesia and recorded the highest number of days to first floret opening and longest stalk compared to control.

Chrysanthemum plants sprayed with SA at 300 ppm concentration caused early flowering (118.83 and 119.17 days after planting date) as shown in Table (5). In the same time, using 300 ppm SA gave the greatest number of inflorescences and flower heads per plant, longest inflorescence stalk and flower head diameter of chrysanthemum (*Dendranthema grandiflorum*) compared to control and the other concentrations under study during the two consecutive seasons (Tables, 6 and 7). Moreover, SA is also utilized for induction and initiation of flowering in marigold (Chaudhary *et al*., 2015).

The best interaction treatment for early flowering (116.67 and 117.33 days after planting date) was KSi at 600 ppm combined with SA at 300 ppm compared with control and the other interaction treatments, in both seasons, respectively (Table, 5). While, the more inflorescences and flower head number per plant, the taller stalk length and the wider flowers of *Dendranthema grandiflorum* were obtained with the interaction treatment of KSi at 900 ppm + SA at 300 ppm (Tables, 6 and 7). On some cultivars of *Dendranthema grandiflorum*, Sivanesan *et al*. (2013) reported that potassium silicate at 50 or 100 ppm enhanced flowering parameters, Also, Ghorbani *et al*. (2013) showed that salicylic acid significantly affected flower diameter, flower stem length, fresh weight and dry matter percentage of violet flower compared to unsprayed plants. The maximum gerbera inflorescence diameter was noticed in 400 ppm salicylic acid treatment compared to control (Aghajani and Jafarpour, 2016). Moreover, Zeb *et al*. (2017) demonstrated that SA at 100 mg l^{-1} increased the number of flowers plant^{-1}, flower persistency, flower stalk length and flower diameter of zinnia cultivars. Days to flowering (33 days) were lowest in the experimental unit sprayed with SA at 200 mg l^{-1}.

Chemical constituents:

The total carbohydrates percentage and total chlorophylls content (SPAD) of chrysanthemum plants were impacted significantly by the different potassium silicate concentrations compared to unsprayed plants in both seasons (Table, 8). Moreover, chemical constituents of chrysanthemum leaves were increased gradually with increasing potassium silicate concentrations. Furthermore, the maximum increase in this concern was obtained from the treatment of high concentration of KSi (900 ppm). Additionally, it is clear known that K element involves in the enhancement translocation of carbohydrates and sugars through plant organs, increases protein synthesis and in different metabolic processes (Csirzinsky, 1999).

Data tabulated in Table (8) show that, any salicylic acid concentration significantly enhanced the total carbohydrates percentage and total chlorophyll content in leaves of chrysanthemum plant compared with control during the two consecutive seasons. The highest values of total carbohydrates percentage and total chlorophyll content of *Dendranthema grandiflorum* plant were recorded with the highest concentration of SA (300 ppm) during 2019 and 2020 seasons.

Also, in most cases, total carbohydrates percentage and leaves pigments of chrysanthemum were significantly increased

Table 8. Effect of potassium silicate, salicylic acid concentrations and their interactions on total chlorophyll content and total carbohydrates percentage of *Dendranthema grandiflorum* during 2019 and 2020 seasons.

Potassium silicate concentration (ppm) (B)	Salicylic acid concentration (ppm) (A)				
	0.0	100	200	300	Mean (A)
			Total carbohydrates percentage		
			2019 season		
Control	15.57	15.77	16.13	16.23	15.93
300	15.67	16.07	16.67	16.83	16.31
600	15.60	16.40	17.37	17.80	16.792
900	16.87	17.87	17.367	17.57	16.98
Mean (B)	15.74	16.28	16.88	17.11	
L.S.D. at 5%	A= 0.26		B= 0.20		A×B= 0.43
			2020 season		
Control	15.37	16.07	16.40	16.37	16.05
300	15.63	16.10	16.53	16.73	16.25
600	15.77	16.63	16.40	17.50	16.58
900	15.83	16.53	16.97	17.70	16.76
Mean (B)	15.65	16.33	16.58	17.08	
L.S.D. at 5%	A= 0.14		B= 0.14		A×B= 0.27
			Total chlorophyll content (SPAD)		
			2019 season		
Control	46.40	46.50	46.97	47.27	46.78
300	46.33	46.47	47.23	47.63	46.92
600	47.00	47.00	47.93	48.43	47.59
900	46.83	47.63	48.40	48.83	47.93
Mean (B)	46.64	46.90	47.63	48.04	
L.S.D. at 5%	A= 0.28		B= 0.21		A×B= 0.46
			2020 season		
Control	45.80	46.83	47.13	47.37	46.78
300	46.17	46.63	47.27	47.50	46.89
600	46.73	47.13	47.50	47.77	47.28
900	47.20	47.70	47.80	49.20	47.98
Mean (B)	46.48	47.08	47.43	47.96	
L.S.D. at 5%	A= 0.29		B= 0.20		A×B= 0.45

with all interaction treatments between potassium silicate and salicylic acid concentrations compared with control (without KSi and SA foliar application) during both seasons (Table, 8). Generally, under each level of potassium silicate, the above-mentioned determinations were increased gradually with increasing the salicylic acid concentration. Ashour (2018) found positive effects of potassium silicate at 100 ppm on total chlorophylls (a + b) of Monterey cypress plant. In addition, SA has a positive effect on photosynthesis in leaves and carbohydrates in leaves and stems of tuberose plants, and increased flower size (Anwar *et al*., 2014). Also, plant pigments (chlorophyll a, b and a + b) of *Ixora coccinea* were increased with SA at 300 ppm concentration (Gad *et al*., 2016).

CONCLUSION

From the above-mentioned results, it could be concluded that foliar application of potassium silicate (900 ppm) could be successfully utilized in addition to foliar application of salicylic acid with a concentration of 300 ppm to obtain the highest vegetative growth parameters, flower aspects and significantly enhanced total chlorophyll content of chrysanthemum (*Dendranthema grandiflorum*) plants under (black net) greenhouse conditions.

REFERENCES

Abdalla, M.Y.A. (2009). The response of *Dendranthema grandiflora*, Tzvelev, cv. Icecap plants to calcium silicate slag and DHT treatments. J. Agric. Sci., Mansoura Univ., 34 (6):6781-6790.

Abdul Kareem, A.J. and Saeed, M. (2020). Effect of ascorbic and salicylic acids on growth and flowering of *Gazania* cv. ‘Frosty Kiss Mixed’. Ornamental Horticulture, 26(4):537-544.

Abou-Baker, A.H.; Abd-Eladl, M. and Abbas, M.M. (2011). Use of silicate and different cultivation practices in alleviating salt stress effect on bean plants. Aust. J. Basic and Appl. Sci., 5(9):769-781.

Aghajani, N. and Jafarpour, M. (2016). Effects of pre- and postharvest treatments of silicon and rice hull ash on vase life of gerbera. Int. J. Hort. Sci. Technol., 3(1):77-87.

Alaedeen, A.; Fanar, Y. and Bassam, I. (2020). Effect of foliar application of nano-iron and potassium on two cultivars of (*Freesia* × *hybrid*). Plant Cell Biotechnology and Molecular Biology, 21(7&8):114-121.

Analytical Software (2008). Statistix Version 9, Analytical Software, Tallahassee, Florida, USA.

Anwar, M.; Sahito, H.A.; Hassan, I.; Abbasi, N.A.; Ahmed, H.A.; Bhatti, M.A.; Hussain, A.; Iqbal, Z. and Abro, A.H. (2014). Effect of pre-harvest treatment of salicylic on growth and vase life of tuberose with aroma environment. Wudpecker Journal of Agricultural Research, 3(2):50-57.

Ashour, H.A. (2018). Influence of gibberellic acid and silicon different sources on growth and chemical constituents of Monterey cypress (*Cupressus macrocarpa* ‘Goldcrest Wilma’) plants. Middle East Journal of Agriculture Research, 7(1):210-226.

Chapman, D.H. and Pratt, R.F. (1978). Methods Analysis for Soil, Plant and Water. Univ. of California Div. Agric. Sci., 16:38.

Chaudhary, A.; Mishra, A.; Bola, P.K.; Nagar, K.K. and Chaudhary, P. (2015). Effect of foliar application of zinc and salicylic acid on flowering and yield of African marigold cv. Pusa Narangi Gainda. HortFlora Res. Spectrum, 4(4):351-355.

Csirzinsky, A.A. (1999). Yield response of herbs to N and K in sand in multiple harvests. J. Herbs. Spices and Medicinal Plants, 6(4):11-22.

Dubois, M.; Gilles, K.A.; Robers, J.H. and Smith, F. (1956). Colorimetric methods for determination of sugar and related substances. Anal. Chem., 28:350-356.

Epstein, E. and Bloom, A.J. (2005). Mineral Nutrition of Plants: Principles and Perspectives, 2nd Edition. Sinauer Associates, Sunderland, MA, USA, 380 p.

Gad, M.M.; Abdul-Hafeez, E.Y. and Ibrahim, O.H.M. (2016). Foliar application of salicylic acid and gibberellic acid enhances growth and flowering of *Ixora coccinea* L. plants J. Plant Production, Mansoura Univ., 7(1):85-91.

Ghorbani, N.; Moradi, H.; Akbarpour, V. and Ghasemnezhad, A. (2013). The phytochemical changes of violet flowers (*Viola cornuta*) in response to exogenous salicylic acid hormone. Journal of Chemical Health Risks, 3(4):1-8.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley & Sons Inc., Singapore, 680 p.

Hajipour, H.; Jabbarzadeh, Z. and Sadaghiani, M.H.R. (2019). Effect of foliar application of silica on some growth, biochemical and reproductive characteristics and leaf elements of chrysanthemum (*Dendranthema× grandiflorum* cv. Fellbacher Wein). J. Sci. & Technol. Greenhouse Culture, 10(1):46-53.

Han, S.S. (2000). Postharvest handling of some field-grown cut flowers. The cut Flower Quarterly, 12(3):35-36.

Helgi, O. and Rolfe, S.A. (2005). The Physiology of Flowering Plants, 4th Ed. Cambridge University Press, Cambridge, UK., The Physiology of Flowering Plants, 404 p.

Jabbarzadeh, Z.; Khosh- Khui, M. and Salehi, H. (2009). The effect of foliar applied salicylic acid on flowering of African violate. Australian Journal of Basic and Applied Sciences, 3(4):4693-4696.

Jeong, K.J.; Chon, Y.S.; Ha, S.H.; Kang, H.K. and Yun, J.G. (2012). Silicon application on standard chrysanthemum alleviates damages induced by disease and aphid insect. Kor. J. Hort. Sci. Technol., 30(1):21-26.

Kumar, A.M.; Malik, S.; Singh, M.K.; Singh, S.P.; Chaudhary, V. and Sharma, V.R. (2019). Optimization of spacing, doses of vermicompost and foliar application of salicylic acid on growth, flowering and soil health of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Guldasta. International Journal of Agriculture, Environment and Biotechnology, 12(3):213-224.

Langton, F.A. (1987). Apical dissection and light-integral monitoring as methods to determine when long-day interruptions should be given in chrysanthemum growing. Acta Hortic., 97:31-41.

Leoni, B.; Loconsole, D.; Cristiano, G. and DeLucia, B. (2019). Comparison between chemical fertilization and integrated nutrient management: yield, quality, N, and P contents in *Dendranthema grandiflorum* (Ramat.) Kitam. cultivars. Agronomy, 202(9):1-17.

Markwell, J.; Osterman, J.C. and Mitchell, J.L. (1995). Calibration of the Minolta SPAD-502 leaf chlorophyll meter. Photosynthesis Res., 46:467-472.

Marschner, H. (1995). Mineral Nutrition of Higher Plants. 2nd ed. Academic Press. Harcourt Brace. Jovanovich Publisher, 674 p.

Pacheco, A.C.; Cabral, C.S.; Fermino, E.S.S. and Aleman, C.C. (2013). Salicylic acid-induced changes to growth, flowering and flavonoids production in marigold plants. J. Medi. Plants. Res., 42(7):3162-3167.

Raskin, I. (1992). Role of salicylic acid in plants. Annual Rev. Plant Physiol. Plant Mol. Bio., 43:439-463.

Sivanesan, L.; Son, M.S.; Song, J.Y. and Jeong, B.R. (2013). Silicon supply through the sub-irrigation system affects growth of three chrysanthemum cultivars. Hort. Environ. Biotech., 54(1):14-19.

Wróblewska, K. and Dębicz, R. (2011). The effect of silicon foliar application on the development of season ornamental plants, Part II: *Argyranthemum frutescens* 'Blazer Rose', *Xerochrysum bracteatum* 'Gold', *Osteospermum ecklonis* 'Grande Pink Blush' and *Gaura lindheimeri* 'Corinas Choice'. Acta Agrobotanica, 64(4):107–114.

Zeb, A.; Fazal Ullah, E.; Gul, E.S.L.; Khan, E.M.; Zainub, B.; Khan, M.N. and Amin, N. (2017). Influence of salicylic acid on growth and flowering of zinnia cultivars. Sci. Int. (Lahore), 29(6):1329-1335.

تأثير سيليكات البوتاسيوم وحمض الساليسيليك على النمو والتزهير وصفات الجودة لنباتات الأراولا تحت ظروف الزراعة المحمية

أوسامة أحمد عبد الصادق ، نجلاء فتحي صلاح الدين إبراهيم البوهى ، راندا إبراهيم دياب
قسم بحوث الزينة وتنسيق الحدائق، معهد بحوث البساتين، مركز البحوث الزراعية، مصر

قُيِّمَ تأثير الرش الورقي بتركيزات مختلفة من سيليكات البوتاسيوم (صفر، ٣٠٠، ٦٠٠، ٩٠٠ جزء/المليون) وحمض الساليسيليك (صفر، ١٠٠، ٢٠٠، ٣٠٠ جزء/المليون) على النمو والصفات الزهرية وبعض المكونات الكيميائية لنبات الأراولا صنف 'ريفور الأبيض'. أجريت هذه التجربة تحت ظروف البيوت البلاستيكية في مشتل الزينة بكلية الزراعة جامعة الزقازيق بمصر خلال فصلي الصيف المتتاليين لأعوام ٢٠١٩ و ٢٠٢٠. تم توزيع المعاملات (٤ × ٤) في تصميم القطع المنشقة مرة واحدة في تصميم القطاعات كاملة العشوائية في ثلاث مكررات لكل معاملة. أدى استخدام ٩٠٠ جزء/ المليون من سيليكات البوتاسيوم إلى زيادة ارتفاع النبات، وعدد الأفرع والأوراق/نبات، وطول الجذر والوزن الطازج والجاف الكلي للنبات معنوياً مقارنة بالتركيزات الأخرى. وكذلك، كان عدد النورات والرؤوس الزهرية/ نبات و طول ساق الزهرة أطول معنوياً مع ذات التركيز. تم الوصول إلى التزهير المبكر وأكبر قطر للرؤوس الزهرية عند الرش الورقي باستخدام سيليكات البوتاسيوم بتركيز ٦٠٠ جزء/ المليون مقارنة بالكنترول. أدى استخدام ٩٠٠ جزء في المليون من تركيز سيليكات البوتاسيوم إلى زيادة معنوية في النسبة المئوية للكربوهيدرات الكلية ومحتوى الكلوروفيل الكلي مقارنة بالكنترول. في نفس الاتجاه، أدى استخدام ٣٠٠ جزء في المليون من حمض الساليسيليك كرش ورقي إلى زيادة معنوية في جميع معاملات النمو وصفات التزهير والمكونات الكيميائية مقارنة بالتركيزات الأخرى قيد الدراسة. من هذه النتائج ، يمكن أن نستنتج أن استخدام معاملة التفاعل بسيليكات البوتاسيوم بتركيز ٩٠٠ جزء في المليون وحمض الساليسيليك بتركيز ٣٠٠ جزء في المليون ثبت أن له تأثير إيجابي على نمو وإزهار وجودة نبات الأراولا صنف 'ريفور الأبيض'.