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Effect of Potassium Silicate on Growth and Leaf Epidermal Characteristics of Begonia and Pansy Grown in Vitro

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Abstract. This study was carried out to investigate the effect of potassium silicate on the growth and leaf epidermal characteristics of horticultural crops viz., begonia (*Begonia semperflorens* Link et Otto) 'Super Olympia Red' and 'Super Olympia Rose' and pansy (*Viola* × *wittrockiana* Hort.) 'Matrix White Blotch' and 'Matrix Yellow Blotch' in vitro. Seeds after germination were grown on a quarter strength MS medium supplemented with potassium silicate (K_2SiO_3) at 0, 100, 200, or 300 mg·L^{-1} and were maintained under a photoperiod of 16 hours at 25℃. Growth parameters such as plant height, root length, chlorophyll content, fresh, and dry weights have been recorded after a growth period of 58 days for begonia and 94 days for pansy. In begonia, fresh weight was significantly greatest in the 200 mg·L^{-1} K_2SiO_3 treatment in both 'Super Olympia Red' and 'Super Olympia Rose'. In both pansy cultivars, fresh weight was the greatest in the 200 mg·L^{-1} K_2SiO_3 treatment than other treatments. Chlorophyll content was significantly greater in the 100 mg·L^{-1} K_2SiO_3 treatment for both the cultivars of begonia. Leaf area significantly increased with the higher concentrations of K_2SiO_3 treatment in both cultivars of pansy. Stomatal structures on the leaf epidermis were observed with scanning electron microscopy (SEM). In begonia 'Super Olympia Rose', the structure of stomata were more compact in size in the 300 mg·L^{-1} K_2SiO_3 treatment than in the control. Similarly, in pansy 'Matrix White Blotch' the surface of stomata appeared to be smoother in the 300 mg·L^{-1} K_2SiO_3 treatment than those wrinkled appearance in the control. The surface of the leaf epidermis appeared to be compact due to Si deposition, and thus results indicated that Si positively affected the growth and biomass production of these species. Our data show that the effect of Si on growth parameters is strongly dependent on cultivar of the plant species tested.

***Additional key words*:** chlorophyll content, dry weight, fresh weight, SEM

Introduction

Silicon (Si) promotes plant growth and has a unique role in conferring tolerance in plants to various abiotic and biotic stresses (Liang et al., 2007). Transporters involved in the uptake and translocation of Si have been identified in Si-accumulating species, including rice, barley, and maize (Ma and Yamaji, 2006, 2008). Si has found its place as a fertilizer and it is frequently used for rice (Datnoff et al., 1997) and other Poaceae crops, and it is also supplemented to cucumber, melon, and lettuce grown hydroponically (Bae et al., 2010). An uncharged molecule, silicic acid, is the form in which Si is readily absorbed by the plants. However, amount of uptake and deposition varies from species to species. Foliar sprays of Si on rice and some plants of Cucurbitaceae have been reported to control powdery mildew, improve light reception (Menzies et al., 1992), increase photosynthesis efficiency, and thus increase growth and yield.

Begonias are classic bedding plants because they are beautiful for the entire season and easy to grow. Though commonly grown as annuals these are actually evergreen perennials. The pansy is a large group of hybrid plants cultivated as garden flowers. The majority of research focused on greenhouse-produced horticultural crops has reported numerous beneficial effects of Si supplementation.

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Supplementation of Si have enhanced the growth in flowering plants such as sunflower (Kamenidou and Cavins, 2008), zinnia (Riaz et al., 2008), and gerbera (Kamenidou et al., 2010). Such bedding plants as begonia and pansy are reported to be attacked by fungus and suffer from downy mildew and powdery mildew, respectively. Supplementation with Si may help to control this problem and promotes growth in plants. There are reports on many flowering plants, but not on in vitro-culture of begonia and pansy plants. Thus, evaluation of the effect of Si on bedding plants is worthy, and hence, the objective of this study was to evaluate the effect of Si on the growth and characteristics of the leaf epidermis of these crops grown in vitro.

Materials and Methods

Plant Materials and Si Supplementation

Begonia (*Begonia semperflorens* Link et Otto) 'Super Olympia Red' and 'Super Olympia Rose', and Pansy (*Viola* × *wittrockiana* Hort.) 'Matrix White Blotch' and 'Matrix Yellow Blotch' were used to carry out the experiments. Seeds of the horticultural crops were procured from Matrix™, Korea. Experiment was conducted from 26th December 2008 to 6th May 2009. Pansy and begonia seeds were immersed in a solution of 70% (v/v) ethanol for 30 seconds and then washed three times with sterile water. Then they were further treated with 1.5% (v/v) sodium hypochlorite solution for 10 min and washed again thrice with sterile water. After surface sterilization, seeds were cultured on the half strength MS medium till the cotyledonary stage (7 and 9 days for pansy and begonia, respectively) under controlled culture conditions of light and temperature mentioned below. Then from the seedlings, roots were removed, and the remaining cotyledonary leaves were used as the explant for experimental sets. Potassium silicate (K_2SiO_3) (Dae Jung, Korea) at 0, 100, 200, or 300 $mg \cdot L^{-1}$ was supplemented to the quarter-strength of the MS medium (Murashige and Skoog, 1962). The pH of the medium was adjusted to 5.70 prior to autoclave. For each 3.7×10^{-4} m^3 polycarbonate culture vessel (GA_7 Magenta box, Sigma Co. Perth, USA), 50 mL culture medium was dispensed. Each control and treated group consisted of 5 replications per treatment.

Culture Conditions and Growth Measurements

Cultures were maintained at a temperature of 25℃ with a photosynthetic photon flux density (PPFD) of 92.95 μmol $\cdot m^{-2} \cdot s^{-1}$ at the level of vessel cap. The cool-white fluorescent lamps (FL 40EX-W, Osram, Korea) were used as a light source for the culture room. A photoperiod regime of a 16 h day 1ight and 8 h dark period were maintained with 70-80% relative humidity.

Growth parameters like plant height, number of leaves, leaf area, and chlorophyll content after taking plant sample from GA_7 vessel were measured. Fresh weight and dry weight have also been quantified. For dry weight, the plant samples were kept in an oven at a constant temperature of 65℃ for 72 h and then dry weight was measured immediately. Leaf chlorophyll content was measured using a chlorophyll content meter (SPAD 502, Minolta, Japan). The SEM has been conducted to detect any change in the leaf structure, focusing mainly stomata structures.

Sample Preparation for SEM

Leaves were separated from in vitro-grown plants. Mature and old leaf samples were cut into 0.5 mm^2 and fixed in 2.5% (v/v) glutaraldehyde (pH 7.50) overnight. Samples were washed three times with 0.1 M phosphate buffer solution (PBS), and then post fixed in 1.0% (w/v) osmium tetroxide (pH 7.20) for 2 h at 4℃. The samples were washed four times with a PBS buffer, dehydrated through an ethanol series (30, 50, 70, 90, and 100% alcohol for 20 min each) (Bae et al., 2010), and then dried with a critical point dryer (CPD2, Pelco, CA, USA). Dried samples were positioned on aluminum stubs with double stick tape prior to gold coating in a sputter coater (SC7640, Polaron, Sussex, UK). The samples were analyzed using field emission scanning electron microscope (XL30S FEG, Philips, the Netherlands) at 15kV.

Statistical Data Analysis

Data were analyzed for statistical significance by the SAS (Statistical Analysis System, v. 9.1, Cary, NC, USA) program. The experimental results were subjected to an analysis of variance (ANOVA) and Duncan's multiple range tests.

Results and Discussion

The effect of potassium silicate on the growth of in vitro-cultured begonia 'Super Olympia Red' and 'Super Olympia Rose' for 58 days, and pansy 'Matrix White Blotch' and 'Matrix Yellow Blotch' for 94 days are shown in Fig. 1. On supplementation of potassium silicate the growth of the plant species was enhanced as compared to the control.

Growth Parameters

***Chlorophyll content and leaf area*:** Addition of potassium silicate increased the leaf area and chlorophyll content significantly. In begonia, leaf area was the greatest in the 200 $mg \cdot L^{-1}$ potassium silicate treatment in 'Super Olympia Red' and in the 100 $mg \cdot L^{-1}$ treatment in 'Super Olympia

Rose'. However, leaf area decreased in both the cultivars when concentration of potassium silicate was 300 mg · L^{-1}, even though it was greater than the control (Table 1).

In the present study, chlorophyll content was significantly greater for both cultivars of begonia at 100 mg · L^{-1} Si treatment than others. This result is in concomitance with Ahmed et al. (2011), who reported that addition of potassium silicate to sorghum plants resulted in increased leaf area and chlorophyll content.

In case of pansy, chlorophyll content increased on Si application in 'Matrix White Blotch'. The leaf area of 'Matrix White Blotch' was the greatest in the 300 mg · L^{-1} K_2SiO_3 treatment. Similarly, 'Matrix Yellow Blotch' also depicted a gradual increase of leaf area as the Si concentration increased (Table 2). Parallely, Ranganathan et al. (2006) also reported enhanced leaf area and chlorophyll content in rice on Si treatment.

The effects of potassium silicate on growth performance and yield have been well studied, hence our findings are also parallel to them. Some positive effects of Si application have been attributed to proper maintenance of water in leaves thus, preventing destruction of photosynthetic process and

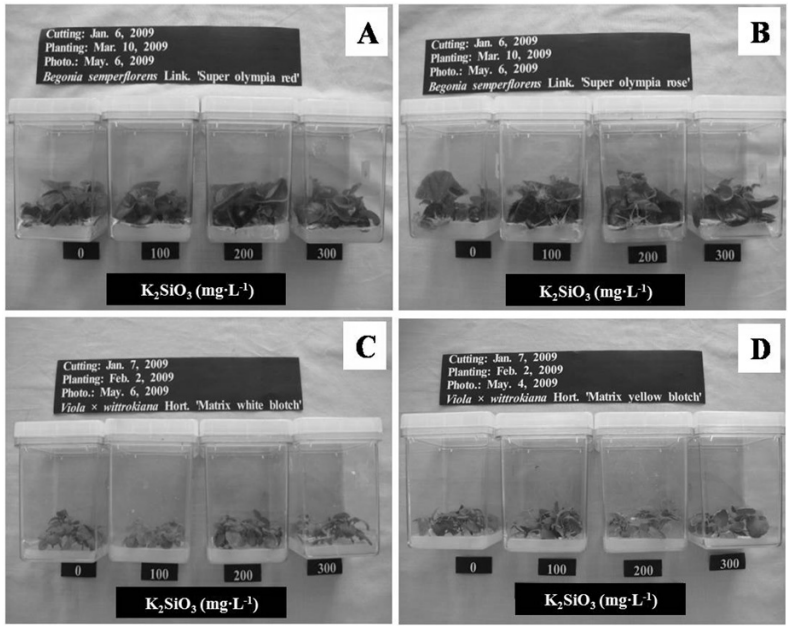

Fig. 1. Effect of potassium silicate concentration on the growth of two cultivars (A, 'Super Olympia Red'; B, 'Super Olympia Rose') of begonia cultured for 58 days and two cultivars of pansy (C, 'Matrix White Blotch'; D, 'Matrix Yellow Blotch') cultured for 94 days in vitro.

Table 1. Effect of concentration of potassium silicate on growth parameters of two begonia cultivars.

Cultivar (A)	K_2SiO_3 (mg · L^{-1}) (B)	Height (cm)	Root length (cm)	No. of leaves	Leaf area (cm^2)	Chlorophyll (SPAD unit)	Shoot fresh weight (mg)	Root fresh weight (mg)	Shoot dry weight (mg)	Root dry weight (mg)	Dry matter (%)
Super Olympia Red	0	2.1 ± 0.1	2.8 ± 0.2	6.6 ± 0.8	11.1 ± 0.9	33.1 ± 0.9	1,072.5 ± 68.8	323.3 ± 9.9	25.9 ± 1.8	21.5 ± 0.8	3.4 ± 0.1
	100	2.0 ± 0.1	2.4 ± 0.1	8.2 ± 0.5	13.6 ± 0.5	36.6 ± 1.2	976.3 ± 46.9	250.5 ± 41.1	27.8 ± 1.7	21.7 ± 3.0	4.0 ± 0.1
	200	2.3 ± 0.1	2.7 ± 0.3	9.5 ± 0.7	18.8 ± 1.7	35.2 ± 1.0	1,462.3 ± 163.7	468.8 ± 101.2	38.5 ± 7.1	38.4 ± 7.3	3.9 ± 0.3
	300	2.1 ± 0.1	2.5 ± 0.2	8.2 ± 0.3	15.2 ± 0.8	35.8 ± 1.7	1,224.8 ± 70.5	303.3 ± 57.9	29.7 ± 1.5	25.4 ± 5.6	3.6 ± 0.2
Super Olympia Rose	0	2.7 ± 0.7	3.0 ± 0.7	9.9 ± 1.6	18.4 ± 3.3	29.8 ± 1.3	1,105.5 ± 292.8	466.5 ± 118.8	31.7 ± 5.3	34.7 ± 6.3	4.4 ± 0.4
	100	2.6 ± 0.1	2.5 ± 0.1	9.2 ± 0.8	19.2 ± 1.6	34.9 ± 1.0	1,544.0 ± 109.2	384.5 ± 32.3	41.1 ± 2.5	37.1 ± 3.0	4.1 ± 0.2
	200	2.6 ± 0.2	2.9 ± 0.2	9.3 ± 0.6	18.0 ± 2.1	31.6 ± 1.5	1,600.0 ± 165.7	515.8 ± 83.5	38.4 ± 4.6	41.5 ± 7.5	3.7 ± 0.2
	300	2.4 ± 0.2	2.8 ± 0.2	8.7 ± 0.8	17.3 ± 0.7	32.1 ± 1.1	1,493.5 ± 72.6	349.5 ± 41.7	37.3 ± 1.5	30.7 ± 3.1	3.7 ± 0.1
F-test	A	*	NS	NS	**	**	*	NS	*	*	NS
	B	NS	NS	NS	NS	*	*	NS	NS	NS	NS
	A × B	NS	NS	NS	NS	NS	NS	NS	NS	NS	*

^{NS,*,**,***}Nonsignificant or significant at P = 0.05, 0.01, and 0.001, respectively.

Table 2. Effect of different concentrations of potassium silicate on growth parameters of two pansy cultivars.

Cultivar (A)	K_2SiO_3 ($mg \cdot L^{-1}$) (B)	Height (cm)	Root length (cm)	No. of leaves	Leaf area (cm^2)	Chlorophyll (SPAD)	Shoot fresh weight (mg)	Root fresh weight (mg)	Shoot dry weight (mg)	Root dry weight (mg)	Dry matter (%)
Matrix White Blotch	0	2.7 ± 0.0	2.4 ± 0.0	11.2 ± 0.3	4.6 ± 0.3	31.4 ± 6.5	194.5 ± 8.5	11.2 ± 0.5	31.2 ± 3.2	5.1 ± 0.2	17.6 ± 0.7
	100	2.5 ± 0.2	2.3 ± 0.1	10.5 ± 0.4	4.6 ± 0.3	38.0 ± 0.1	178.5 ± 11.5	7.8 ± 0.9	28.9 ± 2.4	4.5 ± 0.6	17.9 ± 0.5
	200	2.6 ± 0.0	2.6 ± 0.2	11.9 ± 0.3	5.5 ± 0.4	38.2 ± 1.3	205.0 ± 5.0	8.5 ± 1.7	32.7 ± 1.7	5.3 ± 0.5	17.8 ± 0.3
	300	2.7 ± 0.2	2.1 ± 0.1	10.7 ± 0.1	5.7 ± 0.3	38.1 ± 1.5	189.5 ± 13.5	9.2 ± 1.1	33.7 ± 2.5	5.6 ± 0.2	19.8 ± 0.1
Matrix Yellow Blotch	0	2.9 ± 0.2	2.2 ± 0.3	7.6 ± 0.6	5.0 ± 0.5	52.8 ± 2.7	186.0 ± 2.0	3.7 ± 0.4	32.1 ± 0.9	2.7 ± 0.2	18.3 ± 0.3
	100	3.5 ± 0.2	1.5 ± 0.1	7.9 ± 0.1	5.9 ± 0.1	47.4 ± 0.2	199.0 ± 9.0	4.1 ± 0.2	36.2 ± 0.7	3.2 ± 0.3	19.4 ± 1.1
	200	3.3 ± 0.2	1.9 ± 0.1	9.0 ± 0.4	6.7 ± 1.0	50.9 ± 5.5	228.0 ± 42.1	6.0 ± 1.1	42.0 ± 10.9	4.6 ± 0.9	19.6 ± 1.4
	300	3.2 ± 0.1	1.8 ± 0.1	8.0 ± 0.4	5.9 ± 0.1	45.4 ± 1.1	201.0 ± 1.0	5.4 ± 0.7	40.3 ± 2.7	4.2 ± 0.7	21.6 ± 1.0
F-test	A	***	***	***	*	***	NS	***	NS	*	*
	B	NS	NS	*	NS	NS	NS	NS	NS	NS	*
	A × B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS,*,**,*** Nonsignificant or significant at P = 0.05, 0.01, and 0.001, respectively.

chlorophyll in leaves (Mali and Arey, 2008). Thus, it can be concluded that in the present study, there was advancement in leaf architecture with enhanced contents of chlorophyll, due to supplementation of silicates.

***Fresh weight and dry weight*:** In the present endeavor, with the increase in Si concentration, both fresh weight and dry weight of begonia 'Super Olympia Red' and 'Super Olympia Rose' increased. The fresh weight of shoot and root was the greatest at 200 $mg \cdot L^{-1}$ concentration potassium silicate in both cultivars of begonia (Table 1). The dry weight of shoot and root of 'Super Olympia Red' was the lowest when there is no potassium silicate in the medium i.e. the control.

Similarly in pansy cultivars, the same trend was observed. At the concentration of 200 $mg \cdot L^{-1}$ fresh and dry weight of 'Matrix Yellow Blotch' was greatest than the other treatments, including the control (Table 2). In 'Matrix White Blotch', when compared to the control, dry weight gradually increased as the potassium silicate concentration increased. The results indicated that supplementation of potassium silicate enhances fresh and dry weights of both begonia and pansy plants. Our results are in accordance to Bae et al. (2010), who reported that fresh and dry weights were the greatest when treated with silicate fertilizers in potted kalanchoe and carnation plants. Similarly, Gillman and Zlesak (2000) described that Si treatment increased root fresh and dry weights in mist-applied rose cuttings. In vitro cultures of rice have also been reported to have enhanced callus induction and plant regeneration by application of silicates (Islam et al., 2005). There are other studies which reported growth promotion in plants by Si supplementation due to its various favorable roles.

In begonia 'Super Olympia Red' at 200 $mg \cdot L^{-1}$ K_2SiO_3 concentration, plant height and number of leaves increased in comparison to the control. In case of begonia 'Super Olympia Rose', not much affect of Si on plant height, root length and number of leaves was observed (Table 1).

In pansy 'Matrix White Blotch' at different concentrations of potassium silicate root length was greatest at 200 $mg \cdot L^{-1}$ K_2SiO_3 concentration (Table 2). It has been observed that number of leaves was significantly greatest in the 200 $mg \cdot L^{-1}$ K_2SiO_3 treatment for both cultivars.While in 'Matrix Yellow Blotch' at 200 $mg \cdot L^{-1}$ only plant height increased on Si treatment whereas root length was greater in the control than Si treated.

The results are in conformity with Mali and Arey (2007), who also observed that Si additions increased the root and shoot lengths, and leaf area of *Vigna unguiculata*. Similarly Guo et al. (2006) reported that Si application to the Si-deficient soil resulted in a significant increase in root and shoot growth of alfalfa. It has also been revealed that there is a correlation between growth rate and cell wall extensibility. Silicon stimulates growth of rice and some other Poaceae seedlings by increasing cell wall extensibility (Hossain et al., 2002). It is generally known that increased photosynthetic rate leads to increased plant growth in most of the plants. Therefore, in the present investigation increase in number of leaves is directly correlated to chlorophyll content and thus enhanced plant growth. This increase in plant growth was positively associated with the plant photosynthetic attributes.

This was a preliminary study, and we selected only one cultivar randomly from the two cultivars in each plant species. For the stomatal configuration, SEM observations of leaves have been recorded for begonia 'Super Olympia

Rose' and pansy 'Matrix White Blotch' at 0 and 300 mg · L^{-1} K_2SiO_3 concentrations respectively (Figs. 2 and 3).

It is reported that many species in begonia have stomata that occur in clusters, which is an unusual character and have an extremely limited distribution among the higher plants. Researchers also suggested that these stomatal clusters in begonia are morphological adaptations for conserving water which also help to reduce transpiration (Hoover, 1986). Gan et al. (2010) hypothesized that the stomatal clusters could be induced by certain degrees of drought or salt stress and bear a different ecological significance according to the type of clustering.

In begonia, average number of stomatal clusters observed were 5.5 in the control (0 mg · L^{-1} K_2SiO_3) and at 6.0 in the 300 mg · L^{-1} K_2SiO_3 treatment. The length and width of stomatal cluster were 195.8 and 155.5 μm in the control (0 mg · L^{-1} K_2SiO_3), and 162.5 and 102.5 μm in the 300 mg · L^{-1} K_2SiO_3 treatment (Table 3). Some structural changes in stomata were observed. In the 300 mg · L^{-1} K_2SiO_3 treatment, the structures of stomata were more compact in size than in the control. Stomata appeared to be dome shaped. The length and width of guard cell were 39.8 and 12.5 μm in the control (0 mg · L^{-1} K_2SiO_3), and 32.3 and 11.3 μm in the 300 mg · L^{-1} K_2SiO_3 treatment. The length and width of stomatal pore were 21.0 and 10.0 μm in the control (0 mg · L^{-1} K_2SiO_3), and 16.1 and 6.3 μm in the 300 mg · L^{-1} K_2SiO_3 treatment. This compactness in size might be due to deposition of Si. Number of stomata, stomatal cluster size, and number of stomata/stomatal cluster decreased significantly by the Si treatment (Table 3).

Stomata's are responsible for gas exchange, and closure of stomata leads to decrease in the leaf transpiration rate and therefore, reduced leaf internal CO_2 concentration. It is well known that transpiration from leaves of some plants is reduced considerably by Si application (Ma, 2004). This reduction in transpiration has been explained by a well

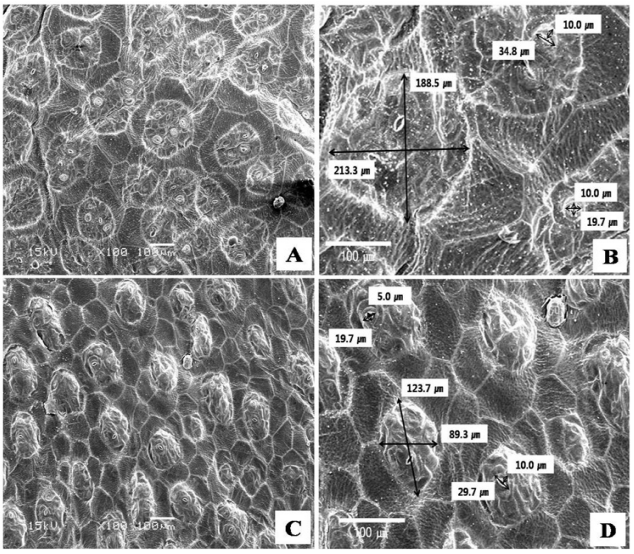

Fig. 2. Scanning electron micrographs (×100) of leaf surface of begonia 'Super Olympia Rose' cultured in vitro with supplementation of 0 (A, B) or 300 mg · L^{-1} K_2SiO_3 (C, D), where B and D are close up of A and C, respectively.

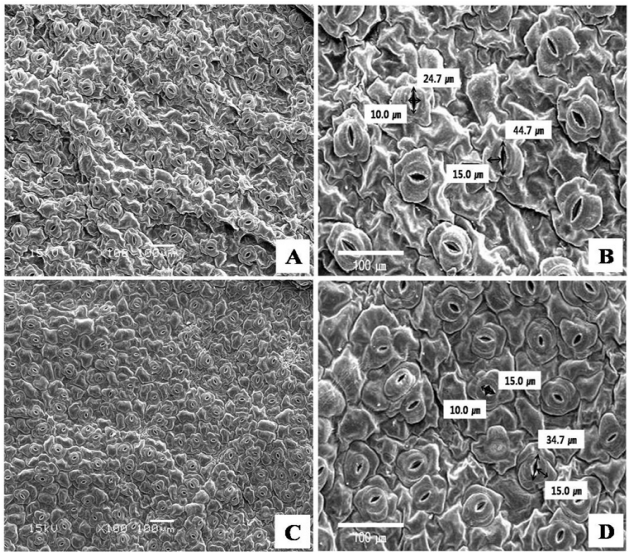

Fig. 3. Scanning electron micrographs (×100) of leaf surface of pansy 'Matrix White Blotch' cultured in vitro with supplementation of 0 (A, B) or 300 mg · L^{-1} K_2SiO_3 (C, D), where B and D are close up of A and C, respectively.

Table 3. Effect of concentration of potassium silicate on stomatal characteristics of begonia 'Super Olympia Rose'.

K_2SiO_3 (mg · L^{-1})	Guard cell size		No. of stomata[z]	Stomatal pore size		Stomatal cluster size		No. of stomatal clusters[y]	No. of stomata/ Stomatal cluster
	Length (μm)	Width (μm)		Length (μm)	Width (μm)	Length (μm)	Width (μm)		
0	39.8 ± 2.0	12.5 ± 1.4	9.3 ± 1.0	21.0 ± 1.3	10.0 ± 0.0	195.8 ± 6.0	155.5 ± 5.8	5.5 ± 0.3	2.0 ± 0.2
300	32.3 ± 1.4	11.3 ± 1.3	5.0 ± 0.9	16.1 ± 2.3	6.3 ± 1.3	162.5 ± 5.4	102.5 ± 3.3	6.0 ± 0.6	0.9 ± 0.1
F-test	*	NS	*	NS	*	***	***	NS	***

[z]No. of stomata in the 0.3 mm^2 (600 μm × 500 μm) leaf epidermis.
[y]No. of stomatal clusters in the 0.3 mm^2 (600 μm × 500 μm) leaf epidermis.
[NS,*,**,***]Nonsignificant or significant at P = 0.05, 0.01, and 0.001, respectively.

Table 4. Effect of concentration of potassium silicate on stomatal characteristics of pansy 'Matrix Yellow Blotch'.

K_2SiO_3 ($mg \cdot L^{-1}$)	Guard cell size		No. of stomata[z]	Stomatal pore size	
	Length (μm)	Width (μm)		Length (μm)	Width (μm)
0	39.8 ± 3.5	12.5 ± 1.4	19.0 ± 0.7	27.3 ± 1.4	10.0 ± 0.0
300	33.5 ± 2.4	12.5 ± 1.4	34.8 ± 1.8	14.9 ± 2.0	6.3 ± 1.3
F-test	NS	NS	***	**	*

[z]No. of stomata in the 0.3mm^2 (600 μm × 500 μm) leaf epidermis.
[NS,*,**,***]Nonsignificant or significant at P = 0.05, 0.01, and 0.001, respectively.

-thickened layer of silica gel associated with the cellulose in the epidermal cell walls (Savant and Kondorfer, 1999). However, in the present study, little change has been observed in the stomatal structure on exogenous application of Si. Similarly, Gao et al. (2006) revealed that there is no clear difference in the structure of stomata between Si-treated and Si-nontreated maize plants raised hydroponically.

In case of pansy, the length and width of guard cell were 39.8 and 12.5 μm in the control (0 $mg \cdot L^{-1}$ K_2SiO_3), and 33.5 and 12.5 μm in the 300 $mg \cdot L^{-1}$ K_2SiO_3 treatment (Table 4). The width of the cells was nearly same as of non-treated with Si but length varied. The surface of cells appears to be smoother (Fig. 3D) than wrinkled appearance in pansy 'Matrix White Blotch' (Fig. 3B). It might have been caused by Si deposition. However, for confirmation more experiments are to be conducted. The stomatal pore size was also measured and it was found that the length and width of stomatal pore were 27.3 and 10.0 μm in the control (0 $mg \cdot L^{-1}$ K_2SiO_3), and 14.9 and 6.3 μm in the 300 $mg \cdot L^{-1}$ K_2SiO_3 treatment. Number of stomata and stomatal pore size decreased significantly by the Si application. Number of stomata increased significantly to two folds by the Si treatment (Table 4). Franz et al. (2008) identified Si depositions very easily due to lack of wrinkled epidermal cells in various floricultural species. It has been reported in variety of species that Si accumulates at trichome bases or wherever xylem ends (Dayanandan and Kaufman, 1976; Dengler and Lin, 1970) and along the leaf margins (Frantz et al., 2005).

In conclusions, both cultivars of begonia and pansy were influenced by supplementation of Si. Our data show that the effect of Si on growth parameters is strongly dependent on cultivar of the plant species. Growth enhancement is an indication of positive effect of Si. Results of advancement in leaf architecture with enhanced contents of chlorophyll by Si supplementation were also cultivar-dependent. Hence, addition of Si significantly enhanced the growth and biomass production of these tested plants. The essential role of Si has not been well documented for the majority of the plant species. More investigations are required to estimate Si uptake by these plants and in future more experiments will be carried out to ensure the effect of silica deposition on transpiration rate and conductance in plants.

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