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Evaluation of gerbera cultivars and silicic acid applications under polyhouse condition

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Abstract
A study on performance of gerbera cultivars for different levels of silicic acid application was carried out under protected condition. The results revealed that among all seven cultivars, 'Marinilla' recorded with highest number of flowers (15.11) and lowest number of flowers observed with cultivar 'Vilassar' (13.11). Regarding leaf length, cultivar 'Nijela' (30.02 cm) recorded significantly higher leaf length than 'Amlet' (26.41 cm), but was on par with 'Marinilla' (29.64 cm), 'Rionegro' (29.03 cm), 'Amelie' (28.50 cm) and 'Vilassar' (28.38 cm) cultivars. Leaf width recorded was not significantly influenced due to cultivars of gerbera'. However, cultivar 'Marinilla' (10.60 cm) recorded higher leaf width than cultivar 'Amelie' (9.90 cm). Regarding leaf area per plant recorded with cultivar 'Marinilla' (1230.13 cm^2) was significantly higher than 'Nijela' (1055.96 cm^2) cultivar. The extent of increase in leaf area per plant in 'Marinilla' was 16% more than 'Vilassar' cultivar. Soil nutrients like available nitrogen, available phosphorus and available potassium contents did not vary significantly due to silicic acid levels.

Keywords: Evaluation, gerbera, cultivars, polyhouse, condition

Introduction

(Si) is the second most abundant element in the soil after oxygen but not yet classified as an essential nutrient. Although Si is abundant in the earth's crust, its availability in soil is very low because of its low solubility from soil source (Lindsay 1979). Plants can only absorb Si in the form of soluble monosilicic acid (H_2SiO_4), a noncharged molecule, which plays a significant role in imparting biotic and abiotic stress resistance (Ma, Nishiramra, and Takahashi 1989) [19]. Silicon exists in all plants grown in soil and its content in plant tissue ranges from 0.1 to 10% (Epstein 1999; Elmer and Datnoff 2014) [20, 3]. In modern agriculture, Si has already been recognized as a functional nutrient for a number of crops, particularly rice and sugarcane, and plays an important role in the growth and development of crops, especially gramineae crops (Epstein 1999; Hodson *et al*. 2005) [20]. Horticultural crops grown in Si-amended substrates exhibit a variety of responses related to abiotic and biotic stresses and morphology. For example, Si supplementation has been reported to reduce incidence of powdery mildew of miniature potted roses (*Rosa hybrid* L.) (Datnoff *et al*., 2006; Larsen, 2008) [2, 15]. 'Meipelta' shrub rose irrigated with Si-supplemented water had decreased black spot disease occurrence (Gillman *et al*., 2003) [5]. Botrytis infection was significantly decreased in calcium silicate-amended sunflowers (*Helianthus annuus* L. 'Ring of Fire') and Si-supplemented plants had an extended postharvest life compared with control plants (Kamenidou *et al*., 2002) [14]. Pythium colonization was reduced on roots of a greenhouse grown bitter gourd (*Mormodica charantia* L.) that received continuous Si supply in the irrigation water (Heine *et al*., 2007) [7]. However, powdery mildew [*Podosphaera fusca* (Fr.) U. Braun & Shishkoff (2000)] severity of gerbera (G*erbera jamesonii* Bolusex. Hook f. 'Snow White') was unaffected by Si treatment (Moyer *et al*., 2008) [24]. Si foliar sprays were effective in ameliorating bracted burn in poinsettia (*Euphorbia pulcherrima* Willd. 'Supjibi Red') (McAvoy and Bible, 1996) [22].

Taking all the above facts into consideration and the paucity of research work on silicon nutrition under protected conditions of Bagalkote, the present study on gerbera cultivars was conducted.

Material and Methods

Treatment details

The study consists of 3 silicic acid levels and 7 gerbera cultivars. Silicon is supplied in the form of silicic acid as a foliar spray. 4 sprays of silicic acid are done. First spray of silicic acid was initiated during the month of August. Four foliar sprayings were carried out with the gap of one month each. The observations on growth and yield parameters were recorded at monthly intervals.

Main plot (Gerbera cultivars): C1. Rionegro (light pink), C2. Nijela (purple)**,** C3. Marinilla (orange)**,** C4. Natasha (red)**,** C5.Vilassar (yellow)**,** C6. Amlet (red)**,** C7. Amelie (white).

Sub - plot (Silicic acid levels): S1: No silicic acid, S2: Silicic acid at 2 ml/L of water, S3: Silicic acid at 4 ml/L of water.

Source and composition of silicic acid

Concentrated soluble silicic acid (liquid) was obtained from Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru. The material is composed of 2.0% soluble Silicic acid (H_4SiO_4), K as KCl (1.2%), B as H_3BO_3 (0.8%), HCl (1.0%), Demi water (47.0%) and PEG-400 (48.0%).

Recording of observations

Observations were recorded from five uniformly grown plants in each treatment which were tagged. The observations were assessed to find the effect of silicic acid treatments on growth parameters, development, quality and yield of gerbera cultivars. And these observations were recorded after monthly sprays of silicic acid. Total four readings were recorded after each silicic acid spray. The first silicic acid foliar spray was taken during August month 2019. All the recorded observations were subjected to statistical analysis.

Soil nutrient analysis

Collection and analysis of soil samples

Soil samples from the experimental area were collected from depth of 0-15 cm at two stages. One initial soil sample was collected randomly from 3-4 spots of experimental area. And this sample was considered for further analysis of initial soil properties. After completion of treatment imposition, samples were collected from each treatment; soil on two sides of the tagged plants was collected using auger. These samples collected were air dried under shade. Air dried samples were powdered using the tools pestle and mortar. These samples were further sieved with 2mm sieve and stored in air tight polythene bags for further analysis. The analysis of soil samples for available N, available P and available K was followed using standard methods as below (Table 1).

Table 1: Methods employed for the analysis of soil samples

pParametersgf	Methods	References
Avail. N (kg ha^{-1})	Alkaline permanganate method	Subbiah and Asija (1956) [27]
Avail. P (kg ha^{-1})	Olsen's extractant method, Colorimetry	Jackson, (1973) [13]
Avail. K (kg ha^{-1})	N NH_4OAC extractant method, Flame photometry	Jackson, (1973) [13]

Statistical analysis

The data obtained from experimental area about all the above parameters was tabulated and analyzed statistically by adopting two factorial completely randomized design (CRD) procedures. The results were tested at 1% level of significance using Fischer's method. Critical difference was calculated whenever 'F' test was found to be significant.

Results and Discussion

Growth parameters

Leaf length: Leaf length after 2nd spray of silicic acid was significantly higher with cultivar 'Marinilla' (25.88 cm) over all the cultivars of gerbera (Table 2) and same trend was observed after 3rd spray as well, but after 4th foliar spray leaf length was significantly higher with cultivar 'Nijela' (30.02 cm) over rest of the gerbera cultivars (Table 2). Leaf length differed significantly with silicic acid levels at all the growth stages. After 1st spray revealed that, application of silicic acid levels at 2 ml /L and 4 ml/L of water produced significantly higher leaf length (21.57 cm) than 0 ml/L of water (21.23 cm) (Table 2). After 2nd foliar spray, silicic acid application levels with 4 ml/L of water recorded higher leaf length (25.18 cm) over 0 ml/L of water (23.08 cm) but were on par with 2 ml/L of water (23.87 cm) and similar trend was observed after 3rd and 4th sprays. Similar results with respect to plant growth characters of rice were observed by (IRRI 1965, 1966; Liang *et al*., 1996; Sawant *et al*., 1994) [11, 12, 16, 26], where silicon fertilization is reported to be responsible for increase in growth of rice plants during the entire growth stage.

Table 2: Leaf length (cm) of gerbera cultivars at different growth stages as influenced by silicic acid levels

Gerbera cultivars (C)	Leaf length (cm) after 1st spray Silicic acid (ml/L of water) -'S'			Mean 'C'	Leaf length (cm) after 2nd spray Silicic acid (ml/L of water) -'S'			Mean 'C'
	0 ml	2 ml	4 ml		0 ml	2 ml	4 ml	
C1- Rionegro	20.80	22.03	21.50	21.44	23.80	24.46	23.63	24.03
C2 – Nijela	22.46	21.63	23.83	22.64	24.43	22.96	27.06	24.82
C3 –Marinilla	24.03	23.43	23.43	23.98	25.63	26.06	25.96	25.88
C4 – Natasha	19.16	20.16	20.16	21.00	20.76	22.23	26.40	23.16
C5 – Vilassar	21.83	22.53	22.53	22.51	23.50	25.30	25.26	24.68
C6 – Amlet	19.53	20.03	20.03	20.21	21.36	22.20	22.83	22.13
C7 – Amelie	20.83	21.16	21.16	21.47	22.06	23.56	25.13	23.58
Mean 'S'	21.23	21.57	21.57		23..08	23.87	25.18	
S.Em(±) C D at 1%	Factor C 0.422 1.210	Factor S 0.276 0.792		Factor C*S 0.731 NS	Factor C 0.466 1.335	Factor S 0.305 0.874		Factor C*S 0.807 2.31

Gerbera varieties (C)	Leaf length (cm) after 3rd spray Silicic acid (ml/L of water)-'S'			Mean 'C'	Leaf length (cm) after 4th spray Silicic acid (ml/L of water)-'S'			Mean 'C'
	0 ml	2 ml	4 ml		0 ml	2 ml	4ml	
C1 – Rionegro	26.10	26.53	26.60	26.41	27.26	29.83	30.00	29.03

C2- Nijela	26.76	26.63	28.80	27.13	28.26	31.16	30.63	30.02
C3 – Marinilla	27.80	27.80	28.33	27.97	28.36	30.16	30.40	29.64
C4 – Natasha	22.60	25.50	27.80	25.30	26.33	28.76	29.53	28.21
C5 – Vilassar	25.26	26.90	27.63	26.62	26.80	29.13	29.23	28.38
C6 – Amlet	23.60	24.36	25.50	24.48	25.50	26.86	26.86	26.41
C7- Amelie	24.53	25.53	27.36	25.81	26.36	29.33	29.80	28.50
Mean 'S'	25.23	26.19	27.31		26.98	29.32	29.49	
S.Em(±) C D at 1%	Factor C 0.561 1.608		Factor S 0.367 1.053	Factor C*S 0.972 NS	Factor C 0.627 1.79		Factor S 0.411 1.17	Factor C*S 1.087 NS

Leaf width

Leaf width did not vary significantly among cultivars at all growth stages. The leaf width did not differed significantly with silicic acid levels at various growth stages of gerbera cultivars, except after 2nd spray. After 2nd foliar spray, application of silicic acid at 4 ml/L of water significantly recorded higher leaf width (7.84 cm) over 0 ml/L of water (7.48 cm) (Table 3). Leaf width of gerbera was not influenced by interaction effect of cultivars and silicic acid levels at all growth stages, except after 2nd spray of silicic acid. Leaf width after 2nd spray was significantly higher with cultivar 'Marinilla' (8.46 cm) receiving silicic acid level with 4 ml/L of water. Silicon can indirectly promote plant growth and production, altering the plant architecture, making the plants more upright, increasing length and width, increasing structural tissue rigidity etc. (Epstein 2009; Ma & Yamaji, 2007) [4, 21]. These result are in agreement with many research outcome relating to Si application (Ashtiani *et al.*, 2012; Yoshida *et al.*, 1962; Hogendorp, 2008; Goto *et al.*, 2003) [1, 28, 9, 6].

Table 3: Leaf width (cm) of gerbera cultivars at different growth stages as influenced by silicic acid levels

Gerbera cultivars (C)	Leaf width (cm) after 1st spray Silicic acid (ml/L of water) –'S'				Leaf width (cm) after 2nd spray Silicic acid (ml/L of water) -'S'			
	0 ml	2ml	4 ml	Mean 'C'	0 ml	2 ml	4 ml	Mean 'C'
C1 – Rionegro	`6.33	6.75	6.23	6.44	7.40	7.83	7.33	7.52
C2 – Nijela	6.43	6.63	6.76	6.61	7.13	7.63	7.66	7.47
C3 – Marinilla	6.50	6.06	7.00	6.52	7.50	7.56	8.46	7.84
C4 – Natasha	6.20	6.70	6.73	6.54	7.16	8.10	8.00	7.75
C5 – Vilassar	6.46	7.10	6.73	6.76	7.50	8.03	7.56	7.70
C6 – Amlet	6.26	6.36	6.66	6.43	7.83	7.73	7.83	7.80
C7 – Amelie	6.63	6.53	6.66	6.61	7.83	7.66	8.06	7.85
Mean 'S'	6.40	6.59	6.68		7.48	7.79	7.84	
S.Em(±) C D at 1%	Factor C 0.124 NS	Factor S 0.081 NS		Factor C*S 0.215 NS	Factor C 0.121 NS	Factor S 0.079 0.227		Factor C*S 0.209 0.60

Gerbera cultivars (C)	Leaf width (cm) after 3rd spray Silicic acid (ml/L of water) –'S'				Leaf width (cm) after 4th spray Silicic acid (ml/L of water) -'S'			
	0 ml	2 ml	4 ml	Mean 'C'	0 ml	2 ml	4 ml	Mean 'C'
C1 – Rionegro	8.80	9.06	8.73	8.86	9.93	10.19	10.56	10.23
C2 – Nijela	8.40	9.36	9.40	9.05	9.63	11.10	10.60	10.44
C3 – Marinilla	8.96	8.66	9.33	8.98	10.86	10.46	10.46	10.60
C4 – Natasha	8.33	9.00	9.10	8.81	9.93	10.86	10.13	10.31
C5 – Vilassar	8.86	9.06	8.86	8.93	10.23	10.13	9.80	10.05
C6 – Amlet	9.40	8.83	9.13	9.12	10.66	10.46	10.50	10.54
C7 – Amelie	8.93	8.76	8.96	8.88	9.76	10.10	9.83	9.90
Mean 'S'	8.81	8.96	9.07		10.14	10.47	10.27	
S.Em(±) C D at 1%	Factor C 0.237 NS	Factor S 0.155 NS		Factor C*S 0.441 NS	Factor C 0.218 NS	Factor S 0.143 NS		Factor C*S 0.377 NS

Leaf area per plant: The leaf area per plant differed significantly among gerbera cultivars at blooming stages. At blooming stage of cultivars, it was significantly higher with cultivar 'Marinilla' (1230.13 cm^2) than the other cultivars of gerbera (Table 4). Leaf area did not differ significantly with silicic acid levels at blooming stage. At blooming stage it revealed that, application of silicic acid levels with 4 ml /L of water produced highest leaf area per plant (1163.17 cm^2) followed by 0 ml/L of water (1149.92 cm^2) and 2 ml/L of water (1148.46 cm^2) (Table 6). Observation on leaf area per plant was not influenced significantly by interaction effect of cultivars and silicic acid levels.

Table 4: Leaf area (cm^2) per plant of gerbera cultivars at blooming stage as influenced by silicic acid levels

Gerbera cultivars (C)	Leaf area (cm^2) per plant Silicic acid (ml/L of water) –'S'			Mean 'C'
	0 ml	2 ml	4 ml	
C1 – Rionegro	1161.36	1163.64	1180.44	1168.48
C2 – Nijela	1047.69	1056.80	1063.38	1055.96
C3 – Marinilla	1230.25	1245.94	1214.21	1230.13

C4 – Natasha	1182.26	1158.95	1185.36	1175.52
C5 – Vilassar	1131.43	1129.93	1141.80	1134.39
C6 – Amlet	1196.42	1166.68	1180.34	1181.14
C7 – Amelie	1100.04	1117.28	1176.67	1131.33
Mean 'S'	1149.92	1148.46	1163.17	
S.Em(±) C D at 1%	Factor C 14.55 41.67	Factor S 9.52 NS		Factor C*S 25.20 NS

Yield parameters

Number of flowers produced did not vary significantly among cultivars of gerbera. However, highest numbers of flowers were produced in cultivar 'Marinilla' (15.11) and lowest in cultivar 'Vilassar' (13.11). Number of flowers produced per plant, differed significantly with silicic acid levels. The applicatifon of silicic acid levels with 2 ml/L of water recorded highest flowers (14.76) than 0 ml/L of water (13.14) (Table 5). Interaction effect of cultivars and silicic acid levels on number of flowers did not differ significantly. Flower diameter varied significantly among cultivars of gerbera. These results were also in agreement with those obtained by Rani and Narayanan (1994) who stated that, silicon supply might have been improved the photosynthetic activity which enable rice plant to accumulate sufficient photosynthates and this helped in increased dry matter production and these together with efficient translocation resulted in more number of filled grains with increased test weight and ultimately led to higher grain and straw yield.

Table 5: Number of flowers of gerbera cultivars as influenced by silicic acid levels

Gerbera cultivars (C)	Number of flowers Silicic acid (ml/L of water) -'S'			Mean 'C'
	0 ml	2 ml	4 ml	
C1-Rionegro	13.33	14.66	14.66	14.22
C2 – Nijela	13.66	15.66	14.00	14.44
C3-Marinilla	13.66	15.66	16.00	15.11
C4 – Natasha	13.33	14.66	14.00	14.00
C5 – Vilassar	12.00	14.00	13.33	13.11
C6 – Amlet	12.33	14.33	15.66	14.11
C7 – Amelie	13.66	14.33	14.00	14.00
Mean 'S'	13.14	14.76	14.52	
S.Em(±) C D at 1%	Factor C 0.514 NS	Factor S 0.337 0.964		Factor C*S 0.891 NS

Soil nutrient status

Soil nitrogen content (kg/ha) did not vary significantly among cultivars. The available nitrogen content (kg/ha) of soil was highest with cultivar 'Vilassar' (402.52 kg/ha). Available nitrogen content of soil (kg/ha) did not vary significantly with silicic acid levels. Soil available nitrogen (kg/ha) was not influenced significantly by interaction effect of cultivars and silicic acid levels (Table 6). Soil phosphorus content (kg/ha) varied significantly among cultivars. Available phosphorus content of soils (kg/ha) was significantly higher in cultivar 'Nijela' (44.81 kg/ha) over all the cultivars of gerbera (Table 6). Available phosphorus content (kg/ha) did not differed significantly with silicic acid levels in final soil samples. Interaction effect of cultivars and silicic acid levels on phosphorus content did not vary significantly in final soil samples. Available potassium content of soils (kg/ha) in final soil samples did not differ significantly among cultivars (Table 6). Available potassium contents (kg/ha) did not vary significantly with silicic acid levels in final soil samples. Mongia *et al.*, (2001) [23] and Huang (2011) reported application of silicon increased the nutrient availability.

Table 6: Available nitrogen (N) and available phosphorus (P_2O_5) and potassium (K_2O) contents of soils as influenced by gerbera cultivars and silicic acid levels

Gerbera cultivars (C)	Nitrogen (kg/ha) Silicic acid (ml/L of water)-'S'			Mean 'C'	Phosphorus (kg/ha) Silicic acid (ml/L of water)-'S'			Mean 'C'
	0 ml	2 ml	4 ml		0 ml	2 ml	4 ml	
C1 – Rionegro	357.83	415.40	381.16	384.80	32.46	31.10	40.93	34.83
C2 – Nijela	358.13	382.03	420.60	386.92	44.16	45.96	44.30	44.81
C3 – Marinilla	386.86	404.80	405.96	399.21	34.26	39.16	40.13	37.85
C4 – Natasha	389.66	386.26	401.53	392.48	32.86	43.16	35.53	37.18
C5 – Vilassar	418.66	369.90	419.00	402.52	36.50	30.53	34.23	33.75
C6 – Amlet	402.14	407.93	389.33	399.80	36.97	31.73	37.76	35.49
C7 – Amelie	365.63	393.13	422.66	393.81	35.06	33.33	34.86	34.42
Mean 'S'	382.70	394.21	405.75		36.04	36.42	38.52	
S.Em(±) C D at 1%	Factor C 11.44 NS	Factor S 7.489 NS		Factor C*S 19.81 NS	Factor C 1.71 4.89	Factor S 1.11 NS		Factor C*S 2.96 NS

Gerbera cultivars (C)	Potassium content - kg/ha			Mean 'C'
	Silicic acid (ml/L of water)-'S'			
	0 ml	2 ml	4 ml	
C1 – Rionegro	317.33	346.03	348.73	337.36
C2 – Nijela	356.13	365.86	338.80	353.60
C3 – Marinilla	367.13	339.03	340.60	348.92
C4 – Natasha	343.96	347.03	347.06	346.02
C5 – Vilassar	345.16	372.13	377.73	365.01
C6 – Amlet	347.33	337.43	368.23	351.00
C7 – Amelie	362.86	322.20	380.10	355.05
Mean 'S'	348.56	347.10	357.32	
	Factor C	Factor S	Factor C*S	
S. Em (±)	10.916	7.146	18.906	
C D at 1%	NS	NS	NS	

Conclusion
The results of the investigation showed that among cultivars 'Marinilla' showed superior results with respect to number of flowers. Leaf length with cultivar 'Nijela' was recorded highest (30.02 cm) than other cultivars. Lowest leaf width was recorded with cultivar 'Amelie' (9.90 cm). Leaf area per plant of cultivar 'Marinilla' was recorded with (1230.13 cm^2). Leaf length was observed highest (29.49 cm) with 4 ml/L of water silicic acid level. Highest leaf width (10.47 cm) was recorded with silicic acid level 2 ml/L of water. Application of silicon in the form of silicic acid did not change the available nitrogen, P, K contents in final soil samples.

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