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Effect of Silicon and Nutrients on Growth, Flowering and Corm Traits of Gladiolus under Normal Soil Conditions

Kishan Swaroop [a*], K. Sindhu [a], Kanwar P. Singh [a], V. K. Sharma [b], Reeta Bhatia [a] and Arun Kumar [a]

[a] Division of Floriculture and Landscaping, ICAR-IARI, New Delhi, 110012, India.
[b] Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi, 110012, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the research farm of the Division of Floriculture and Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi, during the year 2021-22 to know the effect of silicon and nutrients on growth, flowering and corm traits of gladiolus under normal soil conditions. The experiment was laid out in randomized block design with twelve treatment combinations and three replications. A gladiolus variety, Pusa Shanti with different levels of nutrients and silica oxide concentrations with soil and foliar applications was accommodated in the experiment. The data for growth, floral, corms traits including physiological characters were collected and compiled, statistically analyzed. The results of experiment indicated that combined application of silicon with soil and foliar spray along with nutrients significantly influenced all the vegetative, flowering and corm characters in gladiolus and treatment T_{10} ($S_1F_1N_1N_2$) i.e. silica oxide @ 30 kg ha^{-1} with soil + 1% foliar application, five times (30 DAP),+10 tones ha^{-1} vermicompost + 200:100:100kg ha^{-1}NPK was the best and recorded plant height(135.00 cm), spike length (110.66

**Corresponding author: E-mail: kishan.swaroop@rediffmail.com;*

cm), length of rachis (82.33 cm), vase life in normal tap water (17.00 day) and number of corms/cormels per plant (3.66 and 50.33 respectively) followed by treatment T_{11} ($S_2F_1N_1N_2$) which had recorded the maximum sprouting % and more number of florets per spike and T_{12}, as compared to control treatment. Further results also indicated that treatment T_{10} ($S_1F_1N_1N_2$) had recorded maximum single corm's weight 51.66 g, diameter of corm 6.03 cm, dry weight of plant 26.33 g; whereas, treatment T_{11} had recorded maximum fresh weight of plant 155.66 g, total chlorophyll content (a+b) 2.28 mg/g, membrane stability index 82.40 and relative water content 85.33% as compared to control and remaining treatments.

Keywords: Gladiolus commercial traits; foliar and soil application of silicon; organic and inorganic manures.

1. INTRODUCTION

Gladiolus (sword lily) is known as queen of bulbous flower due to their elegant attractive spikes of different hues, varying sizes and long vase life, Jabbar et al. [1], which belongs to family Iridaceae. Gladiolus occupies fourth place in the international trade after rose, carnation and chrysanthemum, in the cut flower industry, Tirkey et al. [2]. Gladiolus as cut flowers is increasing day by day in domestic as well as international market. In recent years, several new cultivars of gladiolus with wide range of colors have been developed for marketing. These varieties require more nutrients for higher growth, production and quality of flowers. The yield and quality of flowers and corms can be improved by adopting integrated nutrient management practices which include the judicious and combined use of organic, inorganic fertilizers, Singh et al. [3]. One of the most important environmental factors limiting plant growth and productivity is salinity, Kaya et al. [4]. In most arid and semiarid areas, this problem is accentuated by competition for high quality water among agriculture, industry [5]. Salt stress can affect plant survival, biomass, plant height and plant morphology and affect the capacity of a plant to collect water and nutrients, Parida and Das, [6]. In this concern, Silicon is also considered somewhere between an essential and nonessential element for plants, as it is not required for the survival of most plants, but plants benefit and are better adapted to different environmental stress conditions in the presence of silicon, Luyckx et al. [7]. Silicon (Si) is the 2nd major element in the soils present as silicic acid. Application of Si in stress conditions improves growth and yield in a number of plant species, Epstein, 2009 [8]. Several studies suggested that silicon has several beneficial effects on different aspects of the plant growth such as stimulation of photosynthesis, reduction of transpiration, crop quality, enhancement of plant resistance to abiotic and biotic stresses and postharvest quality parameters, Hodson and Sangster, [9], Liang et al. [10], Seebold et al. [11] and Zhou et al. [12]. Improvement with the application of silicon has been reported in roses by Savvas et al. (15). One of the most important facts is that silicon in the soil helps plants survive in the bad conditions like water shortage and drought by decreasing transpiration in cells with higher silicon concentration, Gao et al. [14]. The positive effects of Si observed in agronomic crops have generated interest for research with horticultural crops as well. Application of Silicon either as soil drench or foliar application resulted in improved vegetative, floral and corm characteristics in gladiolus, Farooq et al. [15]. As a result of these positive responses, interest in using Si in ornamental crop production has increased. Unfortunately, no work on silicon and nutrients and quality has been done so far in gladiolus crop for flowering and corm traits under Delhi conditions.

2. MATERIALS AND METHODS

The present study was conducted at the Research Farm of the Division of Floriculture and Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi, during winter season of 2021-22. The soil of experimental plot was alluvial, sandy loam in texture, alkaline in reaction, having pH 7.4 and free from salinity occurring on nearly level to very gently sloping land. The available N, P, and K in soil was 203.40, 18.65 and 178.60 kg ha^{-1}respectively. The experiment was laid out in randomized block design with twelve treatment combinations and three replications. A gladiolus variety, Pusa Shanti with different levels of nutrients and silica oxide concentrations with soil and foliar applications was accommodated in the experiment. The details of experiment and its treatments were: T_1 : S_0 F_0 N_0 [Control], T_2 : S_0 F_0 N_2 [RDF],T_3 : S_1 F_0 N_2 [30kg ha^{-1} Silicon + RDF], T_4 : S_2 F_0 N_2 [60kg ha^{-1}Silicon + RDF], T_5 :

S_3 F_0 N_2 [90kg ha^{-1} Silicon + RDF], T_6 : S_1 F_1 N_2 [30kg ha^{-1} Silicon + Foliar-1% + RDF], T_7 : S_2 F_1 N_2 [60kg ha^{-1}Silicon + Foliar-1% + RDF],T_8 : S_1 F_2 N_2 [30kg ha^{-1}Silicon + Foliar-2% + RDF], T_9 : S_2 F_2 N_2 [60kg ha^{-1} Silicon + Foliar-2% + RDF],T_{10} : S_1 F_1 N_1 N_2 [30kg/ha Silicon + Foliar-1% + vermicompost + RDF],T_{11} : S_2 F_1 N_1 N_2 [60kg ha^{-1} Silicon + Foliar-1% + vermicompost RDF], T_{12}: S_3 F_0 N_1 N_2 [90kg ha^{-1} Silicon + Vermicompost + RDF]

The silicon and nutrients were applied as, S_0, Control, S_1, 30 kg ha^{-1}silicon, S_2, 60 kg ha^{-1} silicon, S_3, 90 kg ha^{-1}silicon, F_0, Control, F_1, Silicon foliar spray (1%), F_2, Silicon foliar spray (2%), N_0, Control, N_1, Vermicompost, N_2, RDF (200:100:100 kg ha^{-1}NPK). The granulated silicon and powdered active silicon were applied along with vermicompost and FYM. The recommended dose of NPK fertilizers @ 200:100:100 kg ha^{-1}were also applied in the form of urea, (half as basal and half as top dressing)' whereas, single superphosphate and muriate of potash as basal and entire dose was applied before planting. FYM and vermicompost were incorporated in the soil as per the treatments of respective plots. All inputs were applied treatment wise before and after planting of corms. The experimental field was prepared well by ploughings followed by planking to a fine tilth of soil. The weeds, stubbles of previous crops, stone pieces, whatsoever, were removed to attain clean and levelled field with fine soil texture. Irrigation was given from time to time as per prevailing weather conditions. Weeding, hoeing, earthing up and plant protection measures were done regularly from time to time. The observations for five plants selected randomly in each replication were recorded. The data for growth, floral, corms traits including physiological characters were collected and compiled, statistically analyzed as suggested by Gomez and Gomez, [16]. The appropriate standard error of mean (S.Em±) and the critical difference (C.D.) were calculated at 5 per cent level of significance.

3. RESULTS AND DISCUSSION

3.1 Growth and Floret Traits

There was significant effect of silicon along with nutrients on the growth and floral traits of gladiolus. The results of experiment indicated in (Table 1) that treatment T_{10} ($S_1F_1N_1N_2$) i.e. silica oxide @ 30 kg ha^{-1}with soil + 1% foliar application at five times (30 DAP),+10 tones ha^{-1}vermicompost + 200:100:100 kg ha^{-1}NPK was the best and recorded maximum plant height (135.00 cm), spike length (110.66 cm), length of rachis (82.33 cm) respectively, followed by treatment T_{11} ($S_2F_1N_1N_2$) which had recorded the maximum sprouting % and more number of florets per spike and also followed by treatment T_8 as compared to control plot. The results of other workers like Khenizy and Ibrahim, [17] stated that the *Gladiolus grandiflorus* cv. "Flora Red" plants grown in pots with silicon in the form of diatomite at 4g/l plus fertilization with NPK mixture (2:1:2) at 2g /pot applied as soil drench showed significant increment in the means of all vegetative growth parameters, number of florets/spikes, and decreased the number of days to flowering; whereas, Farooq et al.[15] reported that plants of gladiolus treated with GA-200 ppm + Si - 4g showed the best results related to vegetative and floral parameters, increase in stalk length, spike length, diameter of floret, diameter of spike, number of florets per spike and plant height. These are almost similar findings with the present investigation. In another investigation, Bayat et al. [18] studied the effects of silicon (0, 50 and 100 mg/l) and NaCl (0, 100, 200 mM) on the growth and ornamental characteristics of calendula. They revealed that foliar application of silicon (100 mg/l) had a positive effect on shoot, total dry weight and plant height. Ali and Hassan, [19] investigated the supplemental effects of Si nutrition on growth, flowering, and flower longevity of potted chrysanthemum. Potassium Silicate was added as foliar application at 25, 75 and 125 mg L^{-1} and soil drenches at 50, 100 and 150 mg L^{-1}. The results revealed that the supplementation of both silicon methods improved both vegetative and flowering characters along with early flowering. These results are also similar to present investigation.

3.2 Florets, Vase Life, Fresh and Dry Weight of Gladiolus

Further (Table 2) indicated that treatment T_{10} ($S_1F_1N_1N_2$) i.e. application of silica oxide @ 30 kg ha^{-1}with soil + 1% foliar application at five times (30 DAP),+10 tones ha^{-1} vermicompost + 200:100:100kg ha^{-1} NPK had recorded the maximum florets remain open at a time (9.66), vase life in normal tap water (17.00 day); while fresh weight of plant (151.66 g) and dry weight of plant (26.33 g) was found maximum under treatment T_{11} as compared to control and remaining treatments. Treatment T_{12} ($S_3F_0N_1N_2$) had recorded maximum floret diameter (9.00 cm) as compared to control (7.16 cm). However, it was at par with few treatments as shown in the (Table 2). Zaheer et al. 20) reported that application of silicon and potassium improved production of protein and proline in treated gladiolus plants and alleviated deleterious effects of cadmium toxicity and improved mineral nutrition, growth, biomass, photosynthetic pigments and osmolyte secondary metabolites of treated *Gladiolus grandiflora* plants. Reduced Cadmium uptake, H_2O_2 and MDA contents was

Table 1. Effect of silicon and nutrients on growth and flowering characters of gladiolus

Treatment S. N.	Treatment combination	Sprouting %	Days to first flowering	Plant height (cm)	Spike length (cm)	Rachis length (cm)	Number of florets per spike
1.	$S_0F_0N_0$	92.66	110.66	124.33	99.00	65.00	20.00
2.	$S_0F_0N_2$	93.00	111.00	127.00	103.00	67.33	20.00
3.	$S_1F_0N_2$	93.33	112.00	132.66	108.00	67.33	21.00
4.	$S_2F_0N_2$	95.66	112.00	129.00	101.66	69.33	20.00
5.	$S_3F_0N_2$	95.00	111.66	133.00	104.00	72.00	22.00
6.	$S_1F_1N_2$	97.33	112.33	129.00	102.33	69.66	22.00
7.	$S_2F_1N_2$	95.66	113.66	125.00	105.33	67.00	20.66
8.	$S_2F_1N_2$	99.33	111.33	129.00	103.66	76.33	22.66
9.	$S_2F_2N_2$	96.33	112.33	129.66	103.00	72.00	22.00
10.	$S_1F_1N_1N_2$	99.00	111.00	135.00	110.66	82.33	22.33
11.	$S_2F_1N_1N_2$	99.33	113.00	134.00	110.00	83.33	22.66
12.	$S_3F_0N_1N_2$	98.66	111.33	130.00	108.00	80.00	21.00
	C D at 5 %	3.021	0.530	2.626	9.859	9.736	1.273
	CV	1.837	1.530	4.844	5.387	8.033	3.539

Treatment and Notations
Silica oxide soil application, S_0 = 0 (Control), S_1= 30 kg(Table 2), S_2= 60 kg(Table 2) , S_3= 90 kg(Table 2),
Silica oxide foliar application, F_0 = 0 % Control, F_1= 1 %, F_2= 2%,
RDF (200:100:100 kg (Table 2)NPK, N_0= Control, N_1= 10 tonnes (Table 2) (Organic manure), N_2=(200:100:100 kg(Table 2) , NPK
Silica oxide was sprayed five times after 30 days of planting at the interval of 15 days

Table 2. Effect of silicon and nutrients on florets, vase life, fresh and dry weight of gladiolus

Treatment S. N.	Treatment combination	Florets remain open at a time	Floret diameter (cm)	Vase life in normal tap water (days)	Fresh weight of plant (g)	Dry weight of plant (g)
1.	$S_0F_0N_0$	8.00	7.16	12.00	127.09	23.33
2.	$S_0F_0N_2$	8.33	7.33	13.00	128.00	21.33
3.	$S_1F_0N_2$	8.66	7.16	13.66	123.33	21.00
4.	$S_2F_0N_2$	8.66	7.16	14.00	134.00	22.00
5.	$S_3F_0N_2$	8.00	8.16	13.66	135.00	24.66
6.	$S_1F_1N_2$	9.00	8.33	14.33	142.66	25.33
7.	$S_2F_1N_2$	9.00	8.33	14.66	123.00	21.00
8.	$S_2F_1N_2$	9.33	6.50	15.00	132.66	23.00
9.	$S_2F_2N_2$	9.33	8.33	15.33	135.00	24.66
10.	$S_1F_1N_1N_2$	9.66	8.83	17.00	145.33	26.33
11.	$S_2F_1N_1N_2$	9.33	8.66	15.00	151.66	26.33
12.	$S_3F_0N_1N_2$	9.33	9.00	15.300	136.66	24.00
	C D at 5 %	0.577	1.108	1.307	2.973	2.523
	CV	11.321	8.166	5.362	16.699	18.527

Treatment and Notations
Silica oxide soil application, S_0 = 0 (Control), S_1= 30 kg/ha, S_2= 60 kg (Table 2) , S_3= 90 kg/ha,
Silica oxide foliar application, F_0 = 0 % Control, F_1= 1 %, F_2= 2%,
RDF (200:100:100 kg (Table 2) NPK, N_0= Control, N_1= 10 tonnes (Table 2), (Organic manure), N_2=(200:100:100 kg (Table 2), NPK
Silica oxide was sprayed five times after 30 days of planting at the interval of 15 days

exhibited by plants supplemented with Silicon and potassium under Cd stress. Farooq et al. 2020(4) reported that plants of gladiolus treated with GA-200 ppm + Si-4g showed the best results related to vase life, fresh weight of complete flower stalk. Bayat et al. (2) investigated the effects of silicon (0, 50 and 100 mg/l) and NaCl (0, 100, 200 mM) were studied on the growth and ornamental characteristics of calendula. The results revealed that foliar application of silicon (100 mg/l) had a positive effect on total dry weight. Ali and Hassan, (1) also found the similar results and supplemental effects of Si nutrition on shelf life of potted chrysanthemum. Potassium Silicate was added as foliar application at 25, 75 and 125 mg L^{-1} and soil drenches at 50, 100 and 150 mg L^{-1}. The results revealed that the supplementation of both silicon methods improved both vegetative and flowering characters along with vase life compared to control.

3.3 Physiological and Corms Traits

The results of experiment also indicated that treatment T_{11} ($S_2F_1N_1N_2$) recorded maximum total chlorophyll content (a+b) 2.28 mg/g, membrane stability index 82.40 and relative water content 85.33 %, number of corms 3.66, number of cormels 50.33 per plant as compared to control and remaining treatments. But, the single corm weight 51.66 g was found maximum under treatment T_9 which was at par with treatment T_{10}, this treatment recorded maximum corm's diameter (6.03 cm) as shown in (Table 3) also. Further, Zaheer et al. [20] reported that application of silicon and potassium improved photosynthetic pigments and osmolyte secondary metabolites of treated *Gladiolus grandiflora* plants. Reduced cadmium uptake, H_2O_2 and MDA contents. Similar results reported by Shahzad et al. [21] in an experiment on foliar application of silicon (control, 50, 100 and 150 mg L^{-1}) in tuberose and reported that physiological activities were improved. Ali and Hassan, (1) reported in their results that Si application increased the Chlorophyll content, stomatal resistance, MSI and total carbohydrates. So, the results of present experiments are almost similar with the application of silicon and nutrients with those of other workers in gladiolus and ornamental crops.

Table 3. Effect of silicon and nutrients on physiological and corm characters of gladiolus

Treatment S. N.	Treatment combination	Total fresh chlorophyll content (mg/g) (a + b)	Membrane stability index	Relative water content (%)	Number of corms per plant	Number of cormels per plant	Single corm weight (g)	Corm's diameter (cm)
1.	$S_0F_0N_0$	1.22	37.34	57.66	2.00	29.00	32.33	3.50
2.	$S_0F_0N_2$	1.47	40.92	67.00	2.66	29.66	34.33	4.10
3.	$S_1F_0N_2$	1.76	41.46	67.00	3.00	47.00	40.33	4.33
4.	$S_2F_0N_2$	1.83	42.99	72.00	3.00	39.66	44.66	4.50
5.	$S_3F_0N_2$	1.91	46.58	73.00	3.33	44.66	40.66	5.20
6.	$S_1F_1N_2$	2.10	55.09	76.00	3.00	48.00	43.00	5.00
7.	$S_2F_1N_2$	2.14	56.96	77.00	2.33	39.66	40.00	5.36
8.	$S_2F_1N_2$	2.21	66.31	79.00	3.00	44.33	44.33	5.40
9.	$S_2F_2N_2$	2.25	73.71	82.00	3.66	45.00	51.66	5.90
10.	$S_1F_1N_1N_2$	2.37	81.30	83.33	3.66	47.66	51.66	6.03
11.	$S_2F_1N_1N_2$	2.48	82.40	85.33	3.66	50.33	50.33	5.60
12.	$S_3F_0N_1N_2$	2.42	68.14	82.00	3.33	48.33	47.66	5.60
	C D at 5 %	0.071	6.295	3.935	0.411	4.90	11.476	0.633
	CV	2.056	6.394	3.073	5.031	21.00	15.509	7.368

Treatment and Notations

Silica oxide soil application, S_0 = 0 (Control), S_1= 30 kg(Table 2) , S_2= 60 kg(Table 2) , S_3= 90 kg(Table 2) ,

Silica oxide foliar application, F_0 = 0 % Control, F_1= 1 %, F_2= 2%,

RDF (200:100:100 kg(Table 2) NPK, N_0= Control, N_1= 10 tonnes(Table 2), (Organic manure), N_2=(200:100:100 kg(Table 2), NPK

Silica oxide was sprayed five times after 30 days of planting at the interval of 15 days

4. CONCLUSION

On the basis of present research findings, it was concluded from the experiment that gladiolus variety Pusa Shanti performed well in terms of almost all the vegetative, flowering, physiological as well as corm characters with the combined application of silicon with soil and foliar spray along with nutrients under treatment T_{10} ($S_1F_1N_1N_2$) i.e., application of silica oxide @ 30 kg (Table 2) with soil + 1% foliar application at five times (30 DAP), + 10 tones (Table 2) vermicompost + 200:100:100kg ha^{-1} (Table 2) NPK, followed by treatment T_{11} ($S_2F_1N_1N_2$).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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