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Effect of Silicon and/ or NPK Treatments on Growth, Flowering and Corm Production in Gladiolus

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A POT EXPERIMENT was consummated in the open at the experimental farm of Hort. Res. Inst., ARC, Giza, Egypt during 2011/2012 and 2012/2013 winter seasons. The effect of silicon in the form of diatomite applied as foliar spray or soil drench at the rates of 1,2 and 4 g/ l and NPK (2:1:2) mixture at 2 g /pot as soil drench on *Gladiolus grandiflorus* Andrews cv. Flora Red plant production. The effect of combined treatments between Si at 1, 2 and 4 g/l and NPK mixture at 2 g/pot was also studied. The control plants received no fertilization.

The results of this experiment have shown that all treatments used in this study caused a significant increment in the means of all vegetative growth parameters, flowering stalk length and number of florets/spike, and decreased the number of days to flowering. A similar trend was also obtained regarding the mean number of corms and cormels/plant, diameter of corm and cormel, fresh and dry weight of corm and cormel, as well as leaf contents of Si, chlorophyll a, b, carotenoids, N, P and K. The results also indicated that means of all previous measurements increased progressively with increasing silicon level regardless of application method (foliar or drench). However, soil drench application method gave better results than foliar spray. Moreover, the combining between Si and NPK mixture induced an additional improvement in the means of various a forenamed characters in the two seasons. The combining between Si at 4 g/l and NPK mixture at 2 g/pot gave the utmost high values compared to the other sole and combined treatments.

Hence, it can be advised to treat gladiolus cv. ″Flora Red″ plants cultivated in pots with silicon in the form of diatomite powder at 4 g/l plus NPK mixture (2:1:2) at 2 g/pot applied as soil drench.

Keywords: Gladiolus, NPK, Si, Diatomite, Vegetative growth, Flowering, Corm.

Gladiolus (*Gladiolus grandiflorus* Andrews cv. Flora Red) which belongs to Fam. Iridaceae, is an appreciated ornamental plant worldwide (Hossian *et al.*, 2011). It has a high demand in global cut flowers trade on account of its attractive spikes, florets of huge forms, dazzling colours, varying sizes and long vase life (Ahmad *et al.*, 2008). It is native to Europe, Mediterranean region, the Near East, but chiefly to tropic and South Africa (Bailey, 1976). It is originated from a corm and from the underground stem a new corm is formed, which produces cormels at its base. These two structures are used as vegetative seeds (Cantor and Tolety, 2011).

The growth, flower quality and spike length of gladiolus can be improved by adopting proper cultural practices, mainly application of plant nutrients, which can play a vital role to produce good quality flowers. In this concern, Militiu *et al*. (2002) mentioned that nitrogen is one of the most important nutrients influencing growth and yield in gladiolus. Leaf analysis indicates that the leaves should contain on dry weight basis 2.5-3 % N or more for optimum yield, while quantity of phosphorus required by gladiolus is about one tenth that of N. Lehri *et al*. (2011) concluded that for obtaining maximum number of florets per spike, number of corms/plant, number of cormels/corm, longer spike length and higher content of N,P and K, application of nitrogen and phosphorus at 175+200 kg/ha may be the best. Likewise, Ahmad *et al.* (2013) found that 3 applications of humic acid and NPK (17:17:17), applied at planting, 3- leaf and 6- leaf stages of plant development proved best for early and uniform sprouting, more foliage growth/plant, greater leaf area, total leaf chlorophyll content, earlier spike emergence, greater number of florets/spike, longer stems and spikes, greater diameter of spike, longer vase life, higher number of cormels/clump and greater cormel diameter and weight. On *Gladiolus grandiflorus* vars. ″Borrega Roja″ and ″Espuma″, Gonzalez- Peres *et al*. (2014) reported that 40.5 N-24.0 P-171.0 K-23.0 Mg-37.2 Ca - 0.2 B and 8.5 S kg/ha fertilization treatment gave the best growth, flowering, corm fresh weight, number of cormels and cormel size and fresh weight. The development of *Fusarium* colonies was reduced by 100 % in cormel internal tissue.

Regarding of silicon (Si), it is not considered an essential plant nutrient, but several plant species demonstrate improved disease resistance, abiotic stress tolerance and altered morphological traits when Si is present (Epstein, 1999). Recent studies demonstrated that Si plays a role in enhancing growth and appearance of ornamentals flowering. In this connection, Sivanesan *et al*. (2010) clarified that addition of Si up to 50 or 100 ppm to marigold seedlings ″Boy Orange″ and ″Yellow Boy″ significantly increased stem diameter, number of lateral shoots, root length, chlorophyll content, fresh and dry weights as compared with the control. Furthermore, Frantz *et al.* (2010 a) mentioned that Si application reduced bract edge burn and improved shelf-life in poinsettia, reduced powdery mildew disease in zinnia, sunflower and phlox, increased flower size in gerbera, increased resistance to metal toxicity, but decreased growth of aphid populations in zinnia and improved salt-tolerance in Impatiens. Several reports were also suggested by Mattson and Leatherwood (2010) on petunia, Vendrame *et al.* (2010) on phalaenopsis orchid, Frantz *et al.* (2011) on zinnia and snapdragon, Kazemi *et al.* (2012) on gerbera, Sivanesan *et al.* (2013) on chrysanthemum and Zaky (2014) who postulated that $SiSO_4$ at 2 g/pot increased spike diameter, roots number, fresh and dry weights of roots, leaf content of chlorophyll a, b and carotenoids and the content of total carbohydrates, N, P and K in the leaves, inflorescence and rhizome of calla lily.

On other crops, similar observations were also attained by Angin *et al*. (2011) on strawberry, Abou Basha *et al*. (2013) on wheat and Sivanesan and Park (2014) on *Begonia semperflorens*, *Cattleya loddigesii*, *Coleus* hybridus, *Musa sp.*, *Oryza sativa*, *Picea abies*, *Psidium guajava* and *Vitis vinifera*.

The objective of this study was to examine the effect of both silicon and NPK mixture when applied solely or in combination on growth, flowering, corm productivity and chemical composition of gladiolus cv. ″Flora Red″ plant.

Materials and Methods

A pot experiment was carried out in the open at the Experimental Farm of Hort. Res. Inst., ARC, Giza, Egypt throughout the two successive winter seasons of 2011/2012 and 2012/2013.

Corms of *Gladiolus grandiflorus* Andrews cv. Flora Red at a size ranged between 6-7 cm circumference were purchased from the local farm which imported them from Holland, with the required cooling treatment already received. These corms were dipped in a fungicide solution of 0.25 % orthocide for 15 minutes, and then were planted on November, 15th for each season in 25-cm- diameter plastic pots (one corm/pot) filled with about 3 kg of an equal mixture of sand and loam (1:1, by volume) at a depth of 5 cm from the soil surface. The physical and chemical properties of the used sand and loam in the two seasons were determined according to the method of Richards (1954) and illustrated in Table 1.

TABLE 1. Physical and chemical analysis of the used soil mixture of sand and loam.

Soil type	**Particle size (%)**	**Cations (meq/l)**		**Anions (meq)/l**		**Other properties**			
		Ca^{++}	10.00	HCO^{-3}	1.30	N	425 ppm	B.D (g/cm^3)	1.255
Sand	50.39	Mg^{++}	8.02	SO^{-4}	0.30	P	380 ppm	WHC (%)	46
Silt	31.63	Na^{+}	1.00	Cl^{-}	0.45	K	564 ppm	pH	7.22
Clay	17.98	K^{+}	0.25	-------	-------		-------	E.C (ds m^{-1})	1.02

B.D= Bulk density, WHC= Water holding capacity.

One month later (on December, 15th), plants received all agricultural practices needed for such plantation. Pots were arranged in a complete randomized design with three replicates, each one contained 3 plants. Fertilization treatments were accomplished as follows:

- No fertilization, referred to as control.
- The diatomite in the form of very fine– grained powder was applied either as foliar spray or as soil drench at the rates of 1, 2 and 4 g/l. Diatomite is characterized by containing 3.4% MgO, 33.7% SiO_2 , 19.0% CaO, 5.95% Al_2O_3,

5.1% Na_2O, 2.9% Fe_2O_3 and other trace minerals such as, titanium, boron, manganese, copper, sulphur, cobalt and zirconium, besides 3.29% organic matter, 0.09% N and 0.02% K (Epstein, 1999).

- A mixture of NPK (2:1:2) at the rate of 2 g/pot, added as a soil drench. Ammonium sulphate (20.5% N), Ca- superphosphate (15.5% P_2O_5) and K-sulphate (48.5% K_2O) fertilizers were used to obtain the required ratio.
- Each level of diatomite was combined with a mixture of NPK at 2 g/pot to formalize the following 3 combinations:

a. Diatomite at 1 g/l + 2 g NPK mixture/pot.
b. Diatomite at 2 g/l + 2 g NPK mixture/pot.
c. Diatomite at 4 g/l + 2 g NPK mixture/pot.

The previous treatments were applied four times before flowering with 15 days interval and only once after flowering (on March, 20th). In addition, the regular agricultural practices recommended for this plantation were done whenever needed.

During flowering phase, number of days from planting to first floret open , flowering stalk length (cm), number of florets/spike, plant height (cm), stem diameter at the base (cm), number of leaves/plant, leaf length (cm), as well as leaves fresh and dry weights (g) were measured. At the end of each season (on 15th of April), plants were lifted to measure the mean number of corms and cormels/plant, corm and cormel diameter (cm) and the mean fresh and dry weights (g) of corm and cormel. In fresh leaf samples, photosynthetic pigments (chlorophyll a, b and carotenoids, mg/g F.W.) content was evaluated using the method described by Saric *et al.* (1967), while in dry leaf ones, silicon content (mg/kg D.W.) as well as nitrogen, phosphorus and potassium (mg/g D.W.) were assessed using the methods of Chapman and Pratt (1961), Black (1956), Wide *et al.* (1985) and Jackson (1973), respectively.

Data were then tabulated and subjected to statistical analysis according to procedure reported by Silva and Azevedo (2009).

Results and Discussion

Effect of fertilization treatments on:

Vegetative growth characters:

It is obvious from data listed in Tables 2 and 3 that means of all vegetative growth traits, expressed as plant height (cm), stem diameter (cm), No. leaves/plant, leaf length (cm) and fresh and dry weights of the leaves were markedly increased with significant differences in response to the various used fertilization treatments when compared to control means in the two seasons. In general, means of growth parameters were progressively increased with increasing rate of silicon irrespective of method of the application, but soil drench application gave better results than foliar spray one in all cases of both seasons. Moreover, the combining between silicon and NPK mixture caused additional improvement in growth of fertilized plants more than the individual application of each in most cases of the two seasons. However, the superiority was for the combination of silicon at 4 g/l and NPK mixture at 2 g/pot, which gave the highest records in the two seasons and followed by the combined treatment between these two materials at 2 g/pot level for each.

This may be attributed to the synergistic effect of silicon as an enhancing agent for growth, development and yield of various plants and to alleviate various stresses including nutrient imbalance. It improves morphological, anatomical and physiological characteristics of leaves, enhances tolerance to low temperature and salinity, protects cells against metal toxicity, prevents oxidative phenolic browning and reduces the incidence of hyperhydricity in various plants (Sivanesan and Park, 2014), and the role of NPK mixture in providing the plants with the most important 3 macronutrients (N, P and K) necessary for good and healthy growth. In this regard, Angin *et al.* (2011) demonstrated that diatomite is an effective amendment to improve water holding capacity of light textured soils. Abou Basha *et al.* (2013) noticed that increasing the level of nitrogen up to 100 kg N/ fed with diatomite and potassium silicate (K_2SiO_4) as foliar spray increased growth, fresh and dry weights, chlorophyll a, b, carotenoids, N,P and K content of wheat plants.

The aforementioned results are in good accordance with those postulated by Ahmad *et al.* (2013) and Gonzalez-Peres *et al.* (2014) on gladiolus, Sivanesan *et al.* (2010) on marigold cvs ″Boy Orange″ and ″Yellow Boy″, Mattson and Leatherwood (2010) on petunia, Kazemi *et al.* (2012) on gerbera and Zaky (2014) on calla lily.

Flowering characters

Data in Table 4 exhibit that the longest period to flowering was achieved by control treatment that reached 120 days in the first season and 118 days in the second one. However, all fertilization treatments employed in this work caused a significant precocity in such parameter by shortening it to the minimal number of days, especially by the combined treatments that recorded the least number of days to flowering, with the mastery of 4g Si + 2g NPK combination which encouraged the plants to flowering after only 84 and 83 days in the 1st and 2nd seasons, respectively. Accelerating rate of vegetative growth by this combination may be the main reason for the highly significant earliness in flowering by about 35-36 days comparing to the control plants in both seasons in addition to, lumping the beneficial effects of both silicon and NPK mixture on promoting cell division and increasing flower primordial differentiation within the flower bud (Ahmad *et al.*, 2013).

TABLE 2. Effect of fertilization treatments on some vegetative growth traits of *Gladiolus grandiflorus* Andrews cv. Flora Red plants during 2011/2012 and 2012/2013 seasons.

Treatments	Plant height (cm)		Stem diameter (cm)		No. leaves/plant		Leaf length (cm)	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Control	48 h	55.0 g	0.50 f	0.80 f	6.90 f	7.20 g	30.40 i	30.70 i
1 g Si (F. spray)	82 g	84.0 f	1.20 e	1.40 e	8.90 e	8.95 f	35.30 h	36.41 h
1 g Si (S. drench)	88 de	90.0 d	1.50 c	1.53 d	10.45 cd	10.51 de	38.20 f	39.15 f
2 g Si (F. spray)	84.33 fg	87.17 e	1.35 d	1.42 e	9.80 de	9.90 ef	37.18 g	37.50 gh
2 g Si (S. drench)	95.31 c	96.40 c	1.61 b	1.62 bcd	10.70 cd	10.90 de	43.67 d	44.53 d
4 g Si (F. spray)	85 f	87.30 e	1.48 c	1.55 cd	11.10 cd	11.20 cd	40.15 e	41.22 e
4 g Si (S. drench)	100.67 b	101.60 b	1.63 b	1.65 bc	11.50 c	11.48 cd	47.60 c	47.90 c
1 g Si + 2 g NPK (S. drench)	90.22d	90.57 d	1.31 d	1.35 e	14.10 b	14.20 b	48.13 bc	48.19 bc
2 g Si + 2 g NPK (S. drench)	90.45 c	97.67 c	1.64 b	1.66 ab	14.50 b	14.70 b	48.95 b	49.33 b
4 g Si + 2 g NPK (S. drench)	109.67 a	110.50 a	1.75 a	1.76 a	16.20 a	16.30 a	52.90 a	53.17 a
2 g NPK (S. drench)	85.41 ef	86.55 e	1.34 d	1.36 e	11.40 c	12.10 c	37.91 fg	38.50 fg

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5 % level.

TABLE 3. Effect of fertilization treatments on fresh and dry weights of *Gladiolus grandiflorus* Andrews cv. Flora Red leaves during 2011/2012 and 2012/2013 seasons.

Treatments	Leaves F.W. (g)		Leaves D.W. (g)	
	2011/2012	2012/2013	2011/2012	2012/2013
Control	9.17 g	10.58 f	1.35 j	1.75 j
1 g Si (F. spray)	12.90 f	13.12 e	2.08 i	2.09 i
1 g Si (S. drench)	14.12 e	15.00 d	2.82 g	2.90 g
2 g Si (F. spray)	13.37 ef	13.42 e	2.76 h	2.78 h
2 g Si (S. drench)	16.03 d	17.00 c	3.65 e	3.70 e
4 g Si (F. spray)	15.67 d	15.71 d	2.98 f	3.01 f
4 g Si (S. drench)	17.15 c	17.58 c	3.94 d	3.98 d
1 g Si + 2 g NPK (S. drench)	18.61 b	18.87 b	4.09 c	4.10 c
2 g Si + 2 g NPK (S. drench)	19.10 b	19.28 b	4.44 b	4.48 b
4 g Si + 2 g NPK (S. drench)	23.86 a	23.89 a	4.52 a	4.60 a
2 g NPK (S. drench)	18.52 b	18.58b	2.94 f	2.97 fg

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5 % level. F.spray = Foliar spray, and S. drench = Soil drench.

TABLE 4. Effect of fertilization treatments on flowering traits of *Gladiolus grandiflorus* Andrews cv. Flora Red plants during 2011/2012 and 2012/2013 seasons.

Treatments	No. days to flowering (days)		Flowering stalk length(cm)		No. florets/spike	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Control	120.00 a	118.00 a	12.70 h	13.45 i	7.40 h	7.51 g
1 g Si (F. spray)	110.00 b	108.00 c	28.41 g	28.52 h	8.34 gh	8.45 g
1 g Si (S. drench)	99.00 c	98.00 d	35.67 e	36.20 f	9.85 f	9.90 f
2 g Si (F. spray)	100.00 c	99.00 d	33.45 f	34.21 g	9.33 fg	9.67 f
2 g Si (S. drench)	95.00 c	93.00 e	37.54 d	37.66 e	11.33 de	12.67 de
4 g Si (F. spray)	98.00 c	97.00 d	38.33 d	38.56 de	10.33 ef	10.57 f
4 g Si (S. drench)	95.00 c	94.00 e	40.14 c	40.20 c	13.84 bc	13.95 bc
1 g Si + 2 g NPK (S. drench)	88.00 d	88.00 f	38.45 d	39.13 cd	12.67 cd	13.33 cd
2 g Si + 2 g NPK (S. drench)	86.00 d	85.00 g	42.17 b	42.89 b	14.67 b	14.78 b
4 g Si + 2 g NPK (S. drench)	84.00 d	83.00 g	43.33 a	44.12 a	16.33 a	16.78 a
2 g NPK (S. drench)	115.00 ab	113.00 b	28.15 g	29.10 h	12.10 d	12.00 e

Means within a column having the same letters are not significantly different according to Duncan`s Multiple Range Test at 5 % level. F.spray = Foliar spray, and S. drench = Soil drench.

On the other side, means of flowering stalk length (cm) and number of florets per spike increased significantly as a result of applying the different treatments used in this study. Also, means of these two parameters increased gradually with raising Si rate and application of this mineral as soil drench gave better results than its application as foliar spry. Furthermore, the connecting between Si at 4 g /pot and NPK mixture at 2 g/pot treatment registered the utmost high means over the other individual and combined treatments in the two seasons occupying the first class, while the combining between Si and NPK mixture at 2 g/pot for each occupied the second class.

Improving the quality of spikes due to either Si in the form of diatomite or NPK mixture and both in the combinations may be reasonable because they provide the plants with macro- and micro- nutrients necessary for best growth and high quality. These findings are, however similar to those of Lehri *et al.* (2011) on gladiolus, Frantz *et al.* (2010 a) on poinsettia and gerbera and Frantz *et al.* (2011) on zinnia and snapdragon. In this regard, Mattson and Leatherwood (2010) noticed that treated petunia plants with 100 mg/l Si from K_2SiO_4 increased flower diameter.

Corms and cormels production

Data in Tables 5 and 6 clear that all of these parameters i.e number of corms and cormels/plant, diameter of corm and cormel (cm) and their fresh and dry weights (g), increased significantly by application of Si at any level either as foliar spray or soil drench and of NPK mixture at the rate of 2 g/pot either solely or in combination with Si at any level. Likewise, the soil drench application method scored better results than foliar spray one and the combined treatments gave higher records than individual ones. However, the prevalence in both seasons was also attributed to the joining between 4 g/l Si and 2 g/pot NPK mixture, which also followed by 2 g/l Si + 2 g/pot NPK mixture in the combined treatment.

This may explain the role of both Si and NPK mixture on promoting the synthesis of more assimilates stored in the new corms and cormels and make them relatively greater and heavier. In this connection, Hossian *et al.* (2011) revealed that P at rates higher than 40kg /ha induces larger corms and increases the number and size of cormels. On the same line, were those results detected by Lehri *et al.* (2011), Ahmad *et al.* (2013) and Gonzalez-Peres *et al.* (2014) on gladiolus, Kazemi *et al.* (2012) on gerbera and Sivanesan *et al.* (2013) on chrysanthemum.

TABLE 5. Effect of fertilization treatments on corm and cormels productivity of *Gladiolus grandiflorus* Andrews cv. Flora Red plants during 2011/2012 and 2012/2013 seasons.

Treatments	No. corms /plant		No. cormels /plant		Corm diameter (cm)		Cormel diameter (cm)	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Control	1.02 i	1.03 j	6.67 j	7.11 i	1.05 g	1.20 i	0.82 l	0.85 l
1 g Si (F. spray)	1.12 h	1.16 i	28.33 i	29.25 h	2.54 f	2.58 h	1.45 i	1.47 i
1 g Si (S. drench)	1.22 fg	1.26 g	35.33 h	36.33 g	3.03 de	3.10 de	1.67 f	1.68 f
2 g Si (F. spray)	1.18 gh	1.20 h	38.67 f	38.50 f	2.82 e	2.85 g	1.54 h	1.55 h
2 g Si (S. drench)	1.28 ef	1.30 f	40.50 e	41.31 e	3.16 d	3.20 d	1.70 e	1.70 e
4 g Si (F. spray)	1.23 fg	1.25 g	47.20 c	47.33 c	2.92 de	2.94 fg	1.65 g	1.66 g
4 g Si (S. drench)	1.45 d	1.55 d	50.22 b	51.40 b	3.79 c	3.81 c	1.82 b	1.83 b
1 g Si + 2 g NPK (S. drench)	1.70 c	1.80 c	36.20gh	37.10 g	3.70 c	3.72 c	1.73 d	1.75 d
2 g Si + 2 g NPK (S. drench)	1.88 b	1.91 b	45.67 d	46.30 d	4.60 b	4.70 b	1.78 c	1.81 c
4 g Si + 2 g NPK (S. drench)	2.77 a	2.80 a	54.33 a	55.00 a	5.20 a	5.60 a	1.88 a	1.89 a
2g NPK (S.drench)	1.35 e	1.38 e	37.00 g	37.20 g	2.98 de	3.01 ef	1.06 j	1.07 j

Means within a column having the same letters are not significantly different according to Duncan`s Multiple Range Test at 5 % level.
F.spray = Foliar spray, and S. drench = Soil drench.

TABLE 6. Effect of fertilization treatments on fresh and dry weights of new corms and cormels produced by *Gladiolus grandiflorus* Andrews cv. Flora Red plants during 2011/2012 and 2012/2013 seasons.

Treatments	Corm F.W. (g)		Corm D.W. (g)		Cormel F.W. (g)		Cormel D.W. (g)	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Control	10.21 l	11.31 l	3.19 j	4.31 l	5.75 l	6.30 l	1.03 f	1.05 d
1 g Si (F. spray)	13.55 j	14.08 j	11.13 i	11.83 j	11.74 j	11.81 j	1.22 ef	1.24 d
1 gSi (S. drench)	15.35 i	15.70 i	12.89 h	13.31 i	12.07 i	12.11 i	1.26 ef	1.28 d
2 g Si (F. spray)	16.36 h	16.50 h	14.05 g	14.21 h	12.24 h	12.31 h	1.25 ef	1.29 d
2 gSi (S. drench)	31.13 f	31.56 f	16.05 e	16.20 e	12.56 g	12.71 g	1.85 cd	1.90 bc
4 g Si (F. spray)	28.51 g	29.03 g	15.22 f	15.67 f	13.02 f	13.07 f	1.55 de	1.60 cd
4 gSi (S. drench)	35.85 e	36.07 e	18.89 c	18.95 c	13.13 e	13.28 e	1.98 bc	2.08 bc
1 g Si +2 g NPK (S. drench)	39.54 c	39.63 c	16.83 d	17.33 d	13.45 c	13.62 c	3.33 a	3.35 a
2 g Si+2 g NPK (S. drench)	41.51 b	41.65 b	19.45 b	20.08 b	13.85 b	13.97 b	3.43 a	3.45 a
4 g Si+2 g NPK (S. drench)	52.31 a	53.11 a	23.63 a	23.85 a	14.68 a	14.77 a	3.65 a	3.70 a
2gNPK(S.drench)	38.05 d	38.11 d	13.63 g	14.53 g	13.37 d	13.44 d	2.29 b	2.41 b

Means within a column having the same letters are not significantly different according to Duncan`s Multiple Range Test at 5 % level.
F.spray = Foliar spray, and S. drench = Soil drench.

Chemical composition of the leaves

Similar to results obtained in case of vegetative growth, flowering, corm and cormels production were those results of leaf content of Si (mg/kg D.W.), chlorophyll a, b and carotenoids (mg/g F.W.), as well as N, P and K (mg/g D.W.). Data in Tables 7 and 8 showed that content of all a forenamed constituents increased markedly in the leaves of treated plants to reach the maximum by combined treatments in the following descending order: 4g Si + 2g NPK> 2g Si + 2g NPK > 1g Si + 2g NPK. Application of Si alone followed the same descending order (4g Si > 2g Si > 1g Si) and soil drench application method recorded better contents than foliar spray one. These results are reasonable because raising rate of application and combining between Si in the form of diatomite and NPK mixture provide the plants with enough macro- and micro-nutrients necessary for activating metabolic processes which finally lead to more gain in plant tissues.

These results are agreement with those attained by Hossian *et al.* (2011) and Ahmad *et al.* (2013) on gladiolus, Vendrame *et al.* (2010) on phalaenopsis orchid, Sivanesan *et al.* (2013) on chrysanthemum and Abou Basha *et al.* (2013) who elicited that addition of 100 kg N/feddan with 5% K-silicate remarkably increased chlorophyll a, b, carotenoids, N, P, K and protein content of wheat plants.

TABLE 7. Effect of fertilization treatments on silicon and pigments content in the leaves of *Gladiolus grandiflorus* Andrews cv. Flora Red plants during 2011/2012 and 2012/2013 seasons.

Treatments	Silicon (mg/kg D.W)		Chl. a (mg/g F.W)		Chl. b (mg/g F.W)		Carotenoids (mg/g F.W)	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012 2013
Control	19.75	20.35	0.43	0.45	0.22	0.23	0.46	0.48
1 g Si (F. spray)	27.48	29.13	0.56	0.57	0.33	0.34	0.57	0.59
1 g Si (S. drench)	58.18	59.23	0.61	0.63	0.37	0.39	0.61	0.64
2 g Si (F. spray)	30.44	32.34	0.58	0.59	0.35	0.36	0.58	0.60
2 g Si (S. drench)	66.09	68.03	0.65	0.67	0.42	0.43	0.66	0.69
4 g Si (F. spray)	54.12	55.19	0.66	0.69	0.40	0.41	0.65	0.65
4 g Si (S. drench)	82.75	83.51	0.87	0.90	0.48	0.51	0.71	0.73
1 g Si + 2 g NPK (S. drench)	85.00	86.10	0.96	0.99	0.50	0.51	0.74	0.75
2 g Si + 2 g NPK (S. drench)	87.15	88.10	1.35	1.40	0.54	0.56	0.77	0.79
4 g Si + 2 g NPK (S. drench)	107.00	107.50	2.10	2.22	0.56	0.58	0.81	0.82
2 g NPK (S. drench)	22.21	23.45	1.33	1.36	0.41	0.43	0.68	0.69

F. spray = Foliar spray, and S. drench = Soil drench.

TABLE 8. Effect of fertilization treatments on N, P and K content in the leaves of *Gladiolus grandiflorus* Andrews cv. Flora Red plants during 2011/2012 and 2012/2013 seasons.

Treatments	N (mg/g d.w)		P (mg/g d.w)		K (mg/g d.w)	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Control	1.13	1.14	0.14	0.15	11.32	12.1
1 g Si (F. spray)	1.37	1.40	0.16	0.18	14.21	14.52
1 g Si (S. drench)	2.50	2.61	0.22	0.22	14.60	14.75
2 g Si (F. spray)	4.81	4.85	0.19	0.20	14.67	14.80
2 g Si (S. drench)	5.75	5.80	0.22	0.25	15.24	15.30
4 g Si (F. spray)	5.13	5.63	0.27	0.27	14.92	14.97
4 g Si (S. drench)	6.11	6.15	0.29	0.31	16.22	16.31
1 g Si + 2 g NPK (S. drench)	6.70	6.77	0.32	0.34	18.91	19.22
2 g Si + 2 g NPK (S. drench)	6.80	6.81	0.35	0.36	23.58	23.67
4 g Si + 2 g NPK (S. drench)	7.20	7.24	0.37	0.38	24.53	24.71
2 g NPK (S. drench)	5.11	5.20	0.29	0.32	21.56	22.31

F. spray = Foliar spray, and S. drench = Soil drench.

Recommendations

From the previous results, it is recommended to treat *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.

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تأثير السيليكون و/ أو مخلوط ال NPK على النمو و الإزهار و إنتاج الكورمات فى الجلاديولس

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أجريت تجربة أصص تحت الشمس بالمزرعة التجريبية لمعهد بحوث البساتين، مركز البحوث الزراعية، الجيزة مصر خلال موسمى ٢٠١٢/٢٠١١ ، ٢٠١٣/٢٠١٢ لدراسة تأثير المعاملة بالسيليكون فى صورة مسحوق الدياتومات، عند إضافته رشاً على الأوراق أو تكبيشاً للتربة بمعدلات ١ ، ٢ ، ٤ جم/اللتر ومخلوط ال NPK كإضافة أرضية بمعدل ٢ جم/الإصيص على إنتاج نباتات الجلاديولس (صنف "Flora Red" الأحمر). وقد تم دراسة تأثير المعاملات المشتركة بين السيليكون بمعدلات ١ ، ٢ ، ٤ جم/لتر و مخلوط ال NPK بمعدل ٢ جم/ الإصيص و لم تستقبل نباتات المقارنة أى معاملة.

أوضحت نتائج هذه التجربة أن جميع المعاملات الفردية و المشتركة المستخدمة بهذه الدراسة قد أحدثت زيادة معنوية فى متوسطات جميع قياسات النمو الخضرى، طول الحامل الزهرى و عدد الزهيرات/ نورة سنبلية ، كما أنها قللت عدد الأيام حتى الإزهار. و تم الحصول على إتجاه مشابه فيما يتعلق بمتوسط عدد الكورمات و الكريمات/نبات، متوسط قطر الكورمة و الكريمات، الوزن الطازج والجاف للكورمة و الكريمات و كذلك محتوى الأوراق من السيليكون كلوروفيل أ ، ب ، الكاروتينويدات ، النيتروجين ، الفوسفور و البوتاسيوم. أوضحت النتائج أيضاً أن متوسطات جميع القياسات السابقة تزداد تدريجيا كلما زاد مستوى إضافة السيليكون بصرف النظر عن طريقة الإضافة ، إلا أن طريقة الإضافة الأرضية أعطت نتائج أفضل من طريقة الرش على الأوراق. علاوة على ذلك ، فإن الجمع بين إضافة السيليكون و مخلوط ال NPK أحدثت تحسناً إضافياً فى متوسطات جميع الصفات المذكورة سابقاً ، لكن السيادة فى كلا الموسمين كانت للمعاملة التى تجمع بين السيليكون بمعدل ٤ جم / لتر ومخلوط ال NPK بمعدل ٢ جم / الإصيص و التى أعطت أعلى القيم على الإطلاق مقارنة بجميع المعاملات الفردية و المشتركة الأخرى .

وعليه ، يمكن النصح بتسميد نباتات الجلاديولس (صنف "Flora Red" الأحمر) المنزرعة فى أصص بالسيليكون (فى صورة مسحوق الدياتومات) بمعدل ٤ جم/لتر و مخلوط ال NPK بمعدل ٢ جم/ الإصيص بشرط إضافتها أرضياً.