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Research Article

EFFECT OF SOURCES AND LEVELS OF SILICON ON GROWTH, DEVELOPMENT AND QUALITY CHARACTERS OF GARLIC

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Abstract: The present investigation was under taken on garlic (*Allium sativum* L.) cv. Phule Nilima to study the effect of silicon, at "All India Coordinated Research Project on Vegetable Crops", Department of Horticulture, MPKV, Rahuri, Dist. Ahmednagar in *rabi* season of 2017-18, by using different sources and levels of silicon on chemical properties of soil and nutrient availability in the soil related to growth and quality characters in garlic. Fifteen treatment combinations formed by three sources of silicon fertilizers (*viz*., diatomaceous earth (DE), Calcium silicate (CS) and bagasse ash (BA)) with five levels of silicon (*viz*., 0,100,150, 200 and 250 kg ha^{-1}) and one absolute control, were tried and each replicated for three times. The source A_2 (CS) and level Si @ 250 kg ha^{-1} (B_5) was recorded significantly the maximum plant height, number of leaves per plant, polar diameter and equatorial diameter. However, the source A_3 (BA) and level Si @ 250 kg ha^{-1} (B_5) recorded maximum TSS at harvest. The interaction effect of sources and levels of silicon (A_2B_5) was non-significant for all characters except TSS (°B) and was for A_3B_5 under study. However, the treatment combinations of A_2B_5 recorded highest plant height (58.53 cm), highest number of leaves (11.67) per plant, highest polar diameter (4.68cm), highest equatorial diameter (5.03 cm) at harvest and the treatment combination of (A_3B_5) recorded highest (38.52ºB) TSS (º B) at harvest. All characters *viz*. plant height, number of leaves per plant, polar diameter, equatorial diameter, and total soluble solids (TSS°B) were shown significant increase with treated over control.

Keywords: *Diatomaceous earth, Calcium silicate, Bagasse ash, Silicon, Polar diameter, Equatorial diameter, TSS°B and yield*

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Introduction

Silica refers to a compound in which each molecule of silicon is chemically bound to two oxygen molecules (SiO_2; Silicon dioxide). Silicon (Si) is the second most abundant element (27.72 %) after oxygen (46.60 %) in the earth crust. Silicon dioxide comprises 50-70 % of the soil mass, the earth crust contains large proportion of silicon and this silicon is mostly in the form of silicates. Under field condition, Si fertilization is widely used to enhance production as well as improving resistance to lodging and increasing the erectness of leaves; these effects allow better light transmittance through plant canopies and thus indirectly improve whole plant photosynthesis. Many studies have shown that leaf transpiration of some plants is reduced considerably by Si application. Silicon fertilizers can improve calcium content, nitrogen, and ratio of sugar to nicotine in tobacco and makes the quality higher. Si fertilizer can improve the sugar content in grape, watermelon, can increase the vitamin C content in eggplant, cabbage, green Chinese onion garlic and ginger. Silicon fertilizers improve the quality of Horticultural product [2]. However, until now silicon has not been put in list of essential elements for higher plants due to lack of evidence that plant is unable to complete its life cycle in absence of silicon. Garlic contains approximately 33 sulfur compound. Garlic (*Allium sativum* L.) member of Alliaceae or Lilliaceae family is the important bulb crop next to onion. Garlic originated in central Asia where it was extended to the Mediterranean region in the prehistoric dates [6]. The cloves of garlic bulb used in flavoring of various vegetarian and non-vegetarian dishes. Garlic has higher nutritive value as compared to other bulbous crops. In Ayurveda garlic is considered as "Nectar of life." It is rich source of carbohydrates (29.0%), proteins (6.3%), minerals (0.3%), essential oils (0.1-0.4%) and also contain appreciable quantities of fats and vitamin C. It has antibacterial, antifungal, antiviral and anti-protozoal properties. Garlic is important crop in *rabi* season. By using different sources and levels of silicon through soil improves the quality and yield of garlic. Garlic bulbs supplied with N, P, K with silicon improves bulb quality and nutrient. Nitrogen showed a direct positive effect on pungency and total soluble solids (TSS) content. However due to lack of experimental evidence regarding significant effect of silicon on quality and yield, the present investigation was therefore undertaken to assess the efficiency of different sources and levels of silicon on availability of NPK as well as silicon in soil at harvest of garlic crop.

Material and Methods

The present investigation entitled "Response of garlic to silicon". (Cv. Phule Nilima) was carried out at, All India Coordinated Research Project on Vegetable Crop, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, 413722, in *Rabi* 2017-18. The experiment was laid out in Factorial Randomized Block Design (FRBD) with control three replications having 16 treatments including one absolute control. Treatment details regarding sources and levels are given below in [Table-1& 2].

Application of silicon sources and fertilizers

Different silicon sources as diatomaceous earth, calcium silicate, bagasse ash, were applied as basal dose 15 days before planting. A basal dose of 50:50:50; N: P_2O_5: K_2O kg ha^{-1} was applied at the time of planting through urea, single super phosphate and muriate of potash for all treatments. The second split dose of nitrogen *i.e*., 50 kg N ha^{-1} was applied in equal two split doses at 30and 45 days after planting.

Table-1 *Treatment details*

A. Factor "A"	: Sources of Silicon (three sources of silicon)
1. A_1	: Diatomaceous earth (36%)
2. A2	: Calcium Silicate (36%)
3. A3	: Bagasse ash (27.9 %)
B. Factor "B"	: Level of Si kgha^{-1} (five levels of silicon)
1. B_1	: 000 (control)
2. B_2	: 100
3. B_3	: 150
4. B_4	: 200
5. B_5	: 250
C. Absolute control	

Table-2 *Treatment combinations*

SN	Treatments	Combinations	SN	Treatments	Combinations
1	T_1	A_1B_1	9	T_9	A_2B_4
2	T_2	A_1B_2	10	T_{10}	A_2B_5
3	T_3	A_1B_3	11	T_{11}	A_3B_1
4	T_4	A_1B_4	12	T_{12}	A_3B_2
5	T_5	A_1B_5	13	T_{13}	A_3B_3
6	T_6	A_2B_1	14	T_{14}	A_3B_4
7	T_7	A_2B_2	15	T_{15}	A_3B_5
8	T_8	A_2B_3	16	T_{16}	Absolute control

Observations recorded at harvest

The observation recorded while conducting this investigation was as under.

Growth, development and quality characters

Ten plants from each treatment were selected randomly and labelled. The observations for *viz*. plant height, number of leaves per plant, polar diameter (cm), equatorial diameter (cm) and total soluble solids (TSS°B) were recorded at harvest. The selected bulbs were sliced and pressed to remove juice for placing on hand refract meter for recording TSS(°B).

Statistical analysis

The data generated after observations of soil, plant and pest and disease incidence from present experiment was statistically analyzed by methods suggested by [3]

Results and Discussion

The data in respect of plant height, number of leaves per plant, polar diameter, equatorial diameter and total soluble solids were influenced by sources and levels of silicon are presented below.

Plant height (cm)

The data regarding mean plant height is influenced by different treatments at harvest are presented in [Table-3]. The Plant height was found significantly influenced due to sources and levels of silicon. The sources A_2 (CS) was recorded significantly the highest plant height (52.95cm) over all other sources. The levels of silicon significantly influenced plant height. Application of Si @250 kg ha^{-1} (B5) recorded significant the highest plant height (56.58 cm) over all other the levels of silicon.

Table-3 *Effect of sources and levels of silicon on plant height (cm)*

Silicon sources (A)	Levels of silicon (B) kg ha^{-1}					
	B_1	B_2	B_3	B_4	B_5	Mean
	0	100	150	200	250	
A_1 : DE	46.78	46.13	49.2	52.67	56.57	50.27
A_2 : CS	47.73	49.27	54.33	54.87	58.53	52.95
A_3 : BA	48.35	49.07	48.4	50.73	54.63	50.24
Mean	47.62	48.16	50.64	52.76	56.58	51.15
Control	45.3					
	S.E. ±			CD at 5%		
A	0.73			2.12		
B	0.95			2.74		
(A × B)	1.64			NS		
Treat Vs C	1.7			4.91		

The interaction effect of sources and levels of silicon was non-significant. However, the treatment combination of A_2B_5 (58.53 cm) recorded highest plant height at harvest. The plant height was significantly increased with treated (51.15) over control (45.30). Increase in plant height with increased levels of silicon. This might be due to dissolution of silicon from sources of silicon as well as from soil and become available to plant. The silicon gets deposition in the plant tissues causing erectness of leaves and stem. These results corroborate those obtained by [5]

Number of leaves per plant

The number of leaves per plant was found significantly influenced due to sources and different levels of silicon presented in [Table-4]. The source A_2 (CS) was recorded significantly the highest number of leaves per plant (10.47) over all other sources. The levels of silicon significantly influenced number of leaves per plant. Application of Si @ 250 kg ha^{-1} (B5) recorded significant the highest number of leaves per plant (10.89) over all other levels of silicon. However, it was at par with B_4 (10.67).

Table-4 *Effect of sources and levels of silicon on number of leaves per plant*

Silicon sources (A)	Levels of silicon (B) kg ha^{-1}					
	B_1	B_2	B_3	B_4	B_5	Mean
	0	100	150	200	250	
A_1 : DE	8.33	9.33	9	10.67	10.67	9.6
A_2 : CS	9.67	9.67	10	11.33	11.67	10.47
A_3 : BA	9.67	9.33	8.67	10	10.33	9.6
Mean	9.22	9.44	9.22	10.67	10.89	9.89
Control	7.67					
	S.E. ±			CD at 5%		
A	0.25			0.74		
B	0.33			0.96		
(A × B)	0.57			NS		
Treat Vs C	0.59			1.72		

The interaction effect of sources and levels of silicon was non-significant. However, the treatment combination of A_2B_5 (11.67) recorded highest number of leaves at harvest. The number of leaves per plant was significantly increased with treated (9.89) over control (7.67).

Polar diameter of bulb (cm)

The polar diameter of bulb was found significantly influenced due to sources and levels of silicon presented in [Table-5]. The source A_2 (CS) was recorded significantly the highest polar diameter (4.07 cm) over all other sources. However, it was at par with A1 (3.95). The levels of silicon significantly influenced the polar diameter. Application of Si @ 250 kg ha^{-1} (B5) recorded significantly highest polar diameter (4.12 cm) over all other the levels of silicon. However, it was at par with B_3 (3.88cm) and B_4 (4.00cm). The interaction effect of sources and levels of silicon was nonsignificant. However, the treatment combination of A_2B_5 (4.68cm) recorded highest polar diameter at harvest. The polar diameter was significantly increased with treated (3.94 cm) over control (3.13 cm).

Table-5 *Effect of sources and levels of silicon on Polar diameter (cm)*

Silicon sources (A)	Levels of silicon (B) kg ha^{-1}					
	B_1	B_2	B_3	B_4	B_5	Mean
	0	100	150	200	250	
A_1 : DE	3.82	3.64	3.96	3.91	4.42	3.95
A_2 : CS	3.75	3.89	3.9	4.14	4.68	4.07
A_3 : BA	3.56	3.46	3.8	3.96	4.15	3.79
Mean	3.71	3.66	3.88	4	4.12	3.94
Control	3.13					
	S.E. ±			CD at 5%		
A	0.077			0.22		
B	0.099			0.28		
(A × B)	0.17			NS		
Treat Vs C	0.17			0.51		

Increase in polar diameter due to supply of nutrients from soil and beneficial effect of added silicon. The role of silicon for increase in cell division, elongation, expansion and deposition of silicon at cellular level make at more size. This effect of other factors responsible for increase in polar diameter. Similar finding was also reported by Durgude *et al*. (2014).

Equatorial diameter of bulb (cm)

The data related to equatorial diameter of bulb was significantly influenced due to sources and different levels of silicon presented in [Table-6]. The source A_2 (CS) recoded significantly the highest equatorial diameter (4.43cm). The levels of silicon significantly influenced by application of Si @ 250 kg ha^{-1} (B_5) and recorded significantly the highest equatorial diameter (4.92 cm). The interaction effect of sources and levels of silicon was non-significant in respect of equatorial diameter. However, the treatment combination of A_2B_5 (5.03 cm) recorded the highest equatorial diameter at harvest. The equatorial diameter was significantly increased with treated (4.17cm) over control (3.01cm). The equatorial diameter was significantly increased by application of silicon. It might be due to supply of nutrients from soil and beneficial effect of added silicon. The role of Si for increase in cell division, elongation, expansion and deposition of silicon at cellular level to make more size. This might be due to other factors responsible for increase in equatorial diameter. Similar results were also reported by [1]

Table-6 *Effect of sources and level of silicon on equatorial diameter (cm)*

Silicon sources (A)	Levels of silicon (B) kg ha^{-1}					
	B_1	B_2	B_3	B_4	B_5	Mean
	0	100	150	200	250	
A_1 : DE	3.53	3.91	3.79	4.16	5.01	4.08
A_2 : CS	4.13	4.21	4.49	4.27	5.03	4.43
A_3 : BA	3.48	3.89	3.97	4.03	4.71	4.02
Mean	3.71	4	4.08	4.15	4.92	4.17
Control	3.01					
	S.E. ±			CD at 5%		
A	0.11			0.34		
B	0.15			0.44		
(A × B)	0.26			NS		
Treat Vs C	0.27			0.79		

Total soluble solids. (TSS °B)

The data in respect of effect of different sources and levels of silicon on TSS (°B) of garlic are presented in [Table-7]. The TSS (°B) of garlic found significantly influenced due to application of Si through different sources, levels and their interactions. The source A_3 (BA) recorded significantly the highest TSS (37.35°B). However, it was at par with A_2 (37.31°B). The levels of silicon significantly influenced due to TSS of garlic bulb. The application of Si @ 250 kg ha^{-1} (B_5) recorded significantly the highest TSS (38.17°B), However, it was at par with B_4 (37.63 °B) and B3 (37.22 °B).

Table-7 *Effect of sources and level of silicon on TSS (°B)*

Silicon sources (A)	Levels of silicon (B) kg ha^{-1}					
	B_1	B_2	B_3	B_4	B_5	Mean
	0	100	150	200	250	
A_1 : DE	32.47	33.8	37.27	37.74	37.93	35.84
A_2 : CS	36.16	37.46	37.4	37.51	38.04	37.31
A_3 : BA	36.2	37.4	37	37.64	38.52	37.35
Mean	34.94	36.22	37.22	37.63	38.17	36.84
Control	32.33					
	S.E. ±			CD at 5%		
A	0.4			1.16		
B	0.52			1.5		
(A × B)	0.9			NS		
Treat Vs C	0.91			2.64		

The interaction effect of sources and levels of silicon were non-significant. However, the treatment combination of A_3B_5 (38.52ºB) recorded highest TSS at harvest. The TSS was significantly increased with treated (36.84 0B) over control (32.330B). The similar findings were also reported by [4]

Conclusion

Application of silicon through Calcium silicate @ 250 kg ha^{-1} alongwith recommended dose of fertilizer (100:50:50 kg ha^{-1} and FYM) was found beneficial for increase in the growth and quality contributing characters of garlic *viz*. plant height, number of leaves per plant, polar diameter, equatorial diameter and neck thickness of garlic. In case of source, A_2 (CS) recorded significantly highest plant height, number of leaves per plant, polar diameter and equatorial diameter however source A_3 (BA) recorded significantly highest total soluble solids (TSS (°B). The plant height (cm), number of leaves per plant, polar diameter (cm), equatorial diameter (cm) and total soluble solids of garlic was significantly influenced due to application of different levels of silicon. The level (B_5) Si @ 250 kg ha^{-1} was significantly highest in this respect. The interaction effect of sources and levels of silicon was non-significant for all characters under study.

Application of research: The treatment combination of A_2B_5 recorded maximum figures for all character except total soluble solids and was maximum for A_3B_5. The plant height, number of leaves per plant, polar diameter, equatorial diameter and total soluble solids (TSS °B) was shown significant increase with treated (51.15) over control (45.30).

Research Category: Horticulture

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Cultivar / Variety / Breed name: Garlic Cv. Phule Nilima

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Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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