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# Effect of Sources and Levels of Silicon on Availability of Major Nutrients and Silicon in the Experimental Field 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, yield and quality characters in garlic. Also to study the effect of sources and levels of silicon on total up take of NPK and Silicon.*

*Fifteen treatment combinations formed by three sources of silicon fertilizers (viz., diatomaceous earth, calcium silicate and bagasse ash) with five levels of silicon (viz., 0,100,150, 200 and 250 kg ha$^{-1}$) and one absolute control, were tried and each replicated three times. The basal dose of fertilizer 100 N, 50 $P_2O_5$ and 50 $K_2O$ kg ha$^{-1}$was applied before planting.*

*In case of effect of sources and levels of silicon on nutrient availability, the source $A_2$ (CS) recorded significantly highest N, P, K and Si at harvest while in case of levels ($B_5$) application of Si @ 250 kg ha$^{-1}$ recorded significantly highest N, P, K and Si.*

*The interaction effect of sources and levels of silicon on available nitrogen and potassium in soil at harvest was nonsignificant, however in phosphorus and silicon it was significant.*

*The available NPK and silicon in soil was significantly increased with treated over control.*

***Keywords:*** *Diatomaceous earth, Calcium silicate, Bagasse ash, Silicon*

## INTRODUCTION

The word Silicon is derived from the latin word 'Silex', meaning flint. 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.

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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. 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, water melon, can increase the vitamin C content in eggplant, cabbage, onion, garlic and ginger. It also increases the protein content in soybean and peanut. Si fertilizers can improve quality of tea. Silicon fertilizers improve the quality of horticultural products. (Matichenkov & Bocharnikova, 2004).

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. However, the fact that a large effect is that element must be directly involved in plant metabolism.

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 (Thompson and Kelly, 1957). 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 antiprotozoal properties.

Garlic is important crop in rabi season. By using different sources and levels of silicon through soil improves the quality and yield of different crops. 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 in 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 KrishiVidyapeet, Rahuri 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.

**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** | |

**I. Application of silicon sources and fertilizers :**

Different silicon sources as diatomaceous earth, calcium silicate and 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.

**II. Characterization of silicon sources :**

Total silicon was determined by HCL (12.1*N*) + HF (48 %) method by Korndorfer *et al.* (2004). In this method of 0.1 g sample, 1 ml of HCL and 4 ml of hydrogen fluoride taken in a 250 ml silicon free plastic conical flask. After 12 hrs, 50 ml of boric acid (70 g $l^{-1}$) and 40 ml of distilled water were added. Silicon in the extract was determined calorimetrically by using spectrophotometer at 630 ηm wavelength.

**Table: 2: Treatment combinations**

| Sr. No. | Treatments | Combinations | Sr.No. | 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 |

**III. Soil chemical properties :**

**1. Available nitrogen in soil :**

It was determined by alkaline permanganate method as described by Subbiah and Asija (1956).

**2. Available phosphorus in soil :**

The soil: extractant ratio was 1:20 and the shaking time was 5 minutes. Phosphorus in the extract of (available phosphorus) was determined calorimetrically by using spectrophotometer at 660 nm wavelengths by Watanabe and Olsen (1965).

**3. Available potassium in soil :**

It was extracted with neutral normal ammonium acetate ($NH_4OAc$, pH 7.0) the soil: extractant ratio was 1:5 and shaking time was 5 minutes. Potassium in soil was determined flame photometrically as described Jackson (1973).

**4. Available silicon in soil :**

The silicon in the extracting solution was determined by transferring 0.25 ml of filtrate into a plastic centrifuge tube and then added 10.50 ml of distilled water, plus 0.25 ml of 1:1 hydrochloric acid (HCL), and 0.50 ml of 10 % ammonium molybdate [$(NH_4)$ 6M $7O_2$] solution (pH 7-8). After 5 minutes, 0.50 ml of 20% tartaric acid solution was added and after two minutes, 0.50 ml of the reducing agent amino napthol n-sulphonic acid (ANSA) was added. Then after five minutes, addition of the reducing agent, absorbance was measured at 630 nm using spectrophotometer. Simultaneously, Si standards (0.2, 0.4, 0.8 and 1.0 mg $L^{-1}$) were prepared in the same matrix and measured using spectrophotometer (Korndorfer et al., 2004).

**IV. Statistical analysis :**

The data generated after observations of soil, plant and yield and quality characters etc. statistically analyzed by methods suggested by Panse and Sukhatme (1985).

## RESULTS AND DISCUSSION

The data on effect of sources and levels of silicon and their interactions on available major nutrients at harvest of garlic under field experiment are presented below.

**1. Effect of sources and levels of silicon on available nitrogen in Soil at harvest :**

The data in respect of effect of different sources and levels of silicon on available nitrogen in soil at harvest presented in Table -3.The source $A_2$ (CS) recorded significantly the highest available nitrogen in soil at harvest (175.29 kg $ha^{-1}$) than all other sources.

The levels of silicon were significantly influenced on soil available nitrogen. Application Si @ 250 kg $ha^{-1}$ ($B_5$) for all sources recorded significantly the highest available nitrogen in soil (183.07 kg $ha^{-1}$) over rest of levels of silicon.

The interaction effect of sources and levels of silicon on available nitrogen in soil at harvest was non-significant. However, the treatment combination of $A_2B_5$ (185.07 kg $ha^{-1}$) recorded highest nitrogen in soil at harvest.

The available nitrogen in soil was significantly increased with treated (171.80 kg $ha^{-1}$) over control (156.72 kg $ha^{-1}$).

**Table 3: Effect of sources and levels of silicon on available nitrogen in soil at harvest**

| Silicon sources (A) | Levels of silicon (B) kg $ha^{-1}$ | | | | | |
|---|---|---|---|---|---|---|
| | **$B_1$ 0** | **$B_2$ 100** | **$B_3$ 150** | **$B_4$ 200** | **$B_5$ 250** | **Mean** |
| $A_1$ : DE | 160.11 | 165.43 | 168.12 | 173.96 | 182.93 | 170.11 |
| $A_2$ : CS | 162.88 | 175.50 | 172.94 | 180.07 | **185.07** | **175.29** |
| $A_3$ : BA | 160.65 | 165.92 | 168.32 | 173.95 | 181.22 | 170.01 |
| **Mean** | 161.21 | 168.95 | 169.79 | 175.99 | **183.07** | **171.80** |
| **Control** | **156.72** | | | | | |
| | S.E. ± | | | CD at 5% | | |
| **A** | 1.51 | | | 4.38 | | |
| **B** | 1.96 | | | 5.66 | | |
| **(A × B)** | 3.39 | | | NS | | |
| **Treat Vs C** | 3.50 | | | 10.12 | | |
| **Initial** | 192.65 | | | | | |

With the increased levels of silicon, available nitrogen found to be increased over initial. This might be due to synergistic effect of nitrogen and silicon. The application of silicon reduces leaching losses of nitrogen also reported by Ma et al. (2001) and Munir et al. (2003).

**2. Effect of sources and levels of silicon on available phosphorous in soil at harvest :**

The available phosphorus in soil was significantly influenced due to sources of silicon (Table - 4). The source $A_2$ (CS) recorded significantly the highest available phosphorus in soil at harvest (16.48 kg $ha^{-1}$) than all other sources.

The levels of silicon significantly influenced the available phosphorus. Application of Si @ 250 kg $ha^{-1}$ ($B_5$) recorded significantly the highest available phosphorus (17.98 kg $ha^{-1}$).

The interaction effect of sources and levels of silicon on available phosphorus in soil at harvest was significant. Application of Si @ 250 kg $ha^{-1}$ ($B_5$) through CS was significantly registered the highest $A_2B_5$ (19.26 kg $ha^{-1}$) available phosphorus in soil than rest of the treatment combinations.

The available phosphorus in soil was significantly increased with treated (15.77 kg $ha^{-1}$) over control (14.12 kg $ha^{-1}$).

**Table 4: Effect of sources and levels of silicon on available phosphorus in soil at harvest**

| Silicon sources (A) | Levels of silicon (B) kg $ha^{-1}$ | | | | | |
|---|---|---|---|---|---|---|
| | **$B_1$ 0** | **$B_2$ 100** | **$B_3$ 150** | **$B_4$ 200** | **$B_5$ 250** | **Mean** |
| $A_1$ : DE | 14.90 | 14.68 | 14.60 | 14.83 | 18.16 | 15.44 |
| $A_2$ : CS | 14.87 | 14.94 | 16.32 | 17.00 | **19.26** | **16.48** |
| $A_3$ : BA | 15.80 | 14.57 | 14.18 | 14.97 | 16.53 | 15.41 |
| **Mean** | 15.19 | 15.06 | 15.04 | 15.60 | **17.98** | **15.77** |
| **Control** | **14.12** | | | | | |
| | S.E. ± | | | CD at 5% | | |
| **A** | 0.26 | | | 0.77 | | |
| **B** | 0.34 | | | 1.00 | | |
| **(A × B)** | 0.60 | | | 1.73 | | |
| **Treat Vs C** | 0.62 | | | 1.79 | | |
| **Initial** | 20.10 | | | | | |

The application of silicon significantly increased available phosphorus in soil at harvest of garlic. The silicon application decreases the phosphorus retention capacity of soil and thus increases the water soluble phosphorus in soil leading to increase efficiency of phosphatic fertilizers. The silicon in solution renders phosphorus available to plants reversing its fixation as silicon itself competes for phosphorus fixation sites in the soil. Similar findings are reported Gerroh and Gascho (2005), Prakash et al. (2010).

**3. Effect of sources and levels of silicon on available potassium in soil at harvest :**

The data in respect of effect of different sources and levels of silicon on available potassium in soil was significantly influenced by sources of silicon (Table - 5). The source $A_2$ (CS) recorded significantly the highest potassium (284.51 kg ha $^{-1}$). However, it was at par with $A_1$ (271.75 kg $ha^{-1}$).

The levels of silicon significantly influenced available potassium at harvest. The application of Si @ 250 kg $ha^{-1}$ ($B_5$) recorded significantly the highest potassium (294.09 kg $ha^{-1}$) over all the levels of silicon. However it was at par with $B_3$ (274.50 kg $ha^{-1}$)

The interaction effect of sources and levels of silicon was non-significant. However, the treatment combination of $A_2B_5$ (297.33 kg $ha^{-1}$) recorded highest potassium.

The available potassium was significantly increased with treated (273 kg $ha^{-1}$) over control (254.56 kg $ha^{-1}$).

**Table 5: Effect of sources and levels of silicon on available potassium in soil (kg $ha^{-1}$)**

| Silicon sources (A) | Levels of silicon (B) kg $ha^{-1}$ | | | | | |
|---|---|---|---|---|---|---|
| | **$B_1$ 0** | **$B_2$ 100** | **$B_3$ 150** | **$B_4$ 200** | **$B_5$ 250** | **Mean** |
| $A_1$ : DE | 277.99 | 250.07 | 286.29 | 247.79 | 296.61 | 271.75 |
| $A_2$ : CS | 258.41 | 289.06 | 282.87 | 294.86 | **297.33** | **284.51** |
| $A_3$ : BA | 280.07 | 251.33 | 254.32 | 251.57 | 288.32 | 265.12 |
| **Mean** | 272.16 | 263.48 | 274.50 | 264.74 | **294.09** | **273.79** |
| **Control** | **254.56** | | | | | |
| | S.E. ± | | | CD at 5% | | |
| **A** | 5.30 | | | 15.32 | | |
| **B** | 6.84 | | | 19.77 | | |
| **(A × B)** | 11.86 | | | NS | | |
| **Treat Vs C** | 12.25 | | | 35.38 | | |
| **Initial** | 298.12 | | | | | |

Increase in soil available potassium may be due to optimum nitrogen and potassium rates and more availability of silicon in soil due to application of Si and this might be due to positive interaction of silicon with potassium and reduction in its leaching.Similar results reporded by Durgude et al. (2014).

**4. Available silicon in soil at harvest :**

The soil available silicon in soil found significantly influenced due to sources and levels and their interactions (Table - 6).

The source $A_2$( CS ) significantly recorded the highest available Si (53.59 mg $kg^{-1}$) over all other sources of silicon, however it was at par with $A_3$ (53.27 mg $kg^{-1}$).

The levels of silicon were significantly influenced on soil available silicon. Application of Si @ 250 kg $ha^{-1}$ ($B_5$) recorded significantly the highest available silicon in soil (62.31mg $kg^{-1}$) over rest of the levels of silicon.

The interaction effect of sources and levels of silicon on available silicon in soil at harvest was significant. Application of Si @ 250 kg $ha^{-1}$ ($B_5$) through $A_2$ (CS) was significantly registered the highest $A_2B_5$ (64.03 mg $kg^{-1}$) available silicon in soil than rest of treatment combinations. However, it was at par with $A_3B_5$ (62.90 mg $kg^{-1}$)

The available silicon at harvest was significantly increased with treated (52.63mg $kg^{-1}$) over control (32.73 mg $kg^{-1}$).

The available silicon increased with increase in levels of silicon in soil, but Si decreased with increase in duration of crop due to uptake of crop. Similar results reporded by Dhammapurkar et al.(2011) and Durgude et al. (2014) in different crop.

**Table 6: Effect of sources and levels of silicon on available silicon in soil (mg $kg^{-1}$) :**

| **Silicon sources (A)** | **Levels of silicon (B) kg $ha^{-1}$** | | | | | |
|---|---|---|---|---|---|---|
| | **$B_1$ 0** | **$B_2$ 100** | **$B_3$ 150** | **$B_4$ 200** | **$B_5$ 250** | **Mean** |
| $A_1$ : DE | 37.00 | 45.97 | 55.00 | 57.17 | 60.00 | 51.03 |
| $A_2$ : CS | 36.03 | 51.63 | 56.23 | 60.00 | **64.03** | **53.59** |
| $A_3$ : BA | 34.80 | 51.43 | 55.83 | 61.37 | 62.90 | 53.27 |
| **Mean** | 35.94 | 49.68 | 55.69 | 59.51 | **62.31** | **52.63** |
| **Control** | **32.73** | | | | | |
| | S.E. $\pm$ | | | CD at 5% | | |
| **A** | 0.41 | | | 1.19 | | |
| **B** | 0.53 | | | 1.54 | | |
| **(A × B)** | 0.92 | | | 2.67 | | |
| **Treat Vs C** | 0.95 | | | 2.76 | | |
| **Initial** | 55.47 | | | | | |

The available silicon increased with increase in levels of silicon on soil, but average Si content was decreased slightly as increase of crop duration.

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## CONCLUSION

The application of silicon through Calcium silicate @ 250 kg $ha^{-1}$ along with recommended dose of fertilizer (100:50:50 kg $ha^{-1}$ and FYM) was found beneficial for increase in quality as well as yield of garlic.

The available nutrient viz. N, P, K and Si at harvest of garlic were significantly influenced due to application of different sources and levels of silicon.

The source $A_2$ (CS) recorded significantly highest N, P, K and Si at harvest while in case of levels ($B_5$) application of Si @ 250 kg $ha^{-1}$ recorded significantly highest N, P, K and Si.

The interaction effect of sources and levels of silicon on available nitrogen and potassium in soil at harvest was non-significant, however in phosphorus and silicon it was significant.

The available NPK and silicon in soil was significantly increased with treated over control.

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