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Effect of Different Rates and Sources of Silicate Fertilizers on Soil Fertility, Sugar Beet Productivity and Quality Grown on Saline Soil

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ABSTRACT

To study the effect of silica sources on some saline soil properties and sugar beet productivity and quality grown under saline soil conditions, a field experiment was conducted in Village El-Rowad in Sahl El-Hussinia, El-Sharkia Governorate, Egypt. Sugar beet (*Beta vulgaris* L. var. Loil) was cultivated in the winter of two successive seasons (2022/23 and 2023/24). The results showed that a slight decrease in soil pH was observed with the higher silicate application rate (6 ml L⁻¹), in the form of calcium silicate. The least value of soil EC (3.78 dS m⁻¹) was reached under the interaction of the highest silicon rate (6 ml L⁻¹) and calcium silicate form, with superior efficacy in mitigating soil salinity. Data showed that calcium silicate had significantly enhanced soil macronutrient and micronutrient contents compared to other silica sources used. The application rate (6 ml L⁻¹) resulted in the highest increases, from 9.90 to 26.09% for macronutrients N, P and from 11.18 to 20.58% for Fe, Mn, respectively, and 15.79% for Zn, compared to the control. Data also revealed that root nutrient contents, as macro and micro-nutrient concentrations, with calcium silicate source at a rate of 6 mL⁻¹, were maximized from 21.03 to 42.96%, while reduced Na⁺ was valued by 4.14%. Calcium silicate at 6 ml L⁻¹ gave more root length, dry matter, and sugar beet yield with a 2.36% increase compared to the control. Potassium silicate enhanced root weight by 17.65%. Finally, calcium silicate at the highest rate (0.6 ml L⁻¹) gave the best overall sugar beet quality parameters, the maximum sucrose yield (4.02 Mg fed⁻¹), which was a 75.5% relative increase compared with control (2.29 Mg fed⁻¹); total chlorophyll relative increase 63.92% and stress mitigation as the lowest proline contents compared with control.

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INTRODUCTION

Salinity is considered one of the major plant abiotic stresses, which negatively influences the yield production up to 70% endangering the global food security. Several plant nutrients have proven and confirmed their roles in ameliorating stress, such as nitrogen, potassium, sulfur, selenium, and silicon. The sugar production from sugar beet in 2018 was approximately 42 million metric tons in the world, providing nearly 30% of sugar world supply.

Xiaoyan *et al.* (2019) stated that by 2050, up to 30% of the world's arable land will have been destroyed by salinization. Soil salinity became one of the major environmental stresses on crop growth and productivity, causing a significant loss in profitable crops and decreased agricultural productivity. In Egypt, salt-affected soils are about 2 million faddans, approximately 35% of the total cultivated area (FAO, 2021). Millions of Egyptians suffer from the salinity issue; the northern Nile Delta, the Mediterranean coast, the Sahl El-Tina region, and a few areas from the Fayoum region are among the majorly salt-affected soils (Ibrahim *et al.*, 2017).

The processes that form the soil and, consequently, the types of soil greatly influence the quantity of silicon present in the soil and its

accessibility. Soil Si-pools can be classified as either primary minerals inherited from parent material or biogenic pools formed by the synthesis of secondary minerals such as clay minerals (Summer *et al.*, 2006). When the pH falls from 7 to 2, the concentration of silicon in the soil solution can rise dramatically (Berthelsen and Korndörfer, 2012).

Sugar beet (*Beta vulgaris* L.) is one of the salt-tolerant crops; therefore, it could be used for studying salt acclimation in crops (Xiaoyan *et al.*, 2019). Sugar beet is a root crop for sugar production. In Egypt, sugar beet is grown on recently reclaimed lands and can grow in a variety of soil types. Each incremental increase by an EC unit results in a 5.9% yield loss, and it can naturally withstand salt levels in growth conditions up to an electric conductivity of 7.0 dSm⁻¹ without experiencing a significant yield decline (Grieve *et al.*, 2012).

According to Ibrahim *et al.* (2017), adding potassium silicate to sugar beet at a rate of 8 g L⁻¹ increased the plant's vegetative parameters, yields and quality of the plant. When potassium silicate was applied, the amount of sodium in plants under salt stress was greatly reduced. The involvement of potassium and silicon in raising enzyme activity and soluble solute concentration in the xylem, which results in limited sodium adsorption by the plants,

may be the cause of the decrease in Na content in soil and roots (Enan and Alla, 2024; Ahmad, 2013).

Fertilization plays a vital role in supporting plants to tolerate salt stress (Ghoulam, *et al.*, 2002). Foliar application of silicon positively affected the yield quantity and quality of most agricultural plant species (Laane, 2018). Potassium silicate is an activator for numerous enzymes involved in protein synthesis and N-fixation, as well as its function in preserving the water balance in plants. The maximum sucrose percentage and T.S.S. values were obtained by spraying potassium silicate at a rate of 200 ppm (Nor Eldin and Abd-Allah, 2022). While silicic acid spraying enhanced development and yield and reduced biotic and abiotic stressors (Laane, 2018). Potassium silicate spraying on sugar beet plants may reduce the adverse impacts of drought stress and improve fertilizer efficiency, which could result in fertilizer savings (Ali *et al.*, 2019). Sugar beet root output was increased by spraying potassium silicate at a rate of 2000 mg L⁻¹. The presence of potassium in the potassium silicate solution, which significantly increases sugar beet roots, may be the cause of this rise. It may also be the result of lessening the adverse impacts of high soil salinity (Ali *et al.*, 2019). Applying K-silicate topically to sugar beet increased the amount of chlorophyll and the activity of photosynthetic enzymes. This outcome might be the consequence of silicon buildup in leaves, which leads to their erection and makes light penetration easier. Additionally, silicon and potassium components of K-silicate improved osmolytes and strengthened the antioxidant defense mechanisms, both enzymatic and non-enzymatic as proline and glycine betaine (Enan and Alla, 2024).

Calcium silicate, one of the most widely used silicon fertilizers, is a by-product of the steel and phosphorus industries. Despite being costly, calcium silicate is a highly soluble material that can be utilized in hydroponics (Parimala and Singh, 2022). When calcium silicate was applied, leaf area index, leaf yield, root yield, total chlorophyll and carotenoids, and sugar production all were increased (Siuda *et al.*, 2024).

One of the dissolved polymers is silica gel, which is made up of silicate ions that are polymerized into many chain series or three-dimensional chains (Majeed and Ahmed, 2015). Due to silica gel's high porosity, a small amount of silica gel can effectively adsorb a significant amount of heavy metals from soil (Omura *et al.*, 2021). By creating an inner protective layer, silica gel helps plants defend against external attacks (Sharma *et al.*, 2019). When applied to soil, silica gel improves soil properties and crop yield (Mahrous and Abd Elghany, 2020). As a silicon supply, silica gel improved the results of cultivars growing under salt stress by raising potassium and lowering sodium

concentrations in the soil salinity. Under salt stress, the application of silicone gel improves wheat's development, physiological function, and metabolic efficiency. Reduced sodium absorption and enhanced potassium absorption are the reasons for silicon-applied wheat's resistance to salinity, which contributes to better nutrition (Kousar *et al.*, 2021).

The objective of this study was to provide more information about the effects of applying different silica sources and rates on the fertility properties of saline soil, as well as on the productivity and quality of sugar beet grown under these saline conditions.

MATERIAL AND METHODS

Two field experiments were conducted on a saline clay soil in Village El-Rowad in Sahl El-Hussinia, El-Sharkia Governorate, Egypt, (located between N 31° 13' 4.76", Longitude E 30° 58' 26.94" E and elevation 2.0 m above sea level), cultivated with sugar beet (*Beta vulgaris* L.) in winter of two successive seasons (2022/23 and 2023/24), to study the effect of some silicate sources as potassium silicate, calcium silicate and silica gel, and rates on saline soil fertility properties, sugar beet productivity and quality under saline soil. The experiment layout was RCBD, which was carried out in a split-plot design with three replicates. Silicate source treatments were assigned to the main plots, whereas silicate rates were assigned to the subplots. Some physical and chemical properties of the soils shown in Table 1 were determined before sowing according to standard methods described by Cottenie *et al.* (1982), Page *et al.* (1982) and Klute (1986).

The area of each experimental plot was 5 × 10 m (50 m²), which made to rows at 60 cm apart. All farming practices were carried out before planting. Calcium super phosphate (15.5 % P₂O₅) was applied at a rate of 300 kg fed⁻¹ during soil preparation. Urea fertilizer (46 % N) was applied at a rate of 100 kg fed⁻¹ on three equal doses after 31, 50, and 65 days after planting. Potassium (48 % K₂O) was applied at a rate of 75 kg fed⁻¹ on two equal doses after 31 and 50 days from sowing. Silicate sources as silica gel, calcium, and potassium silicate applied at rates of 0, 4, and 6 ml L⁻¹ foliar spray as at rates of 0, 800, and 1.200 ml per 200 L⁻¹ water fed⁻¹ for each source used. Sugar beet (*Beta vulgaris* L.) seeds were obtained from Sugar Crops Res. Inst. Agric. Res. Cent. Egypt. Sowing was carried out on 15 October 2022 and 2023. Two seeds were sown in each hill at two cm. After 31 days from sowing, hills were thinned to one plant.

After 75 days from planting, random samples of top leaves of sugar beet were taken to determine total chlorophyll content according to the method described by Wettstein (1957).

Table 1: Some physical and chemical properties of the experiment soil before planting.

Soil characteristics	Value	Soil characteristics	Value				
Particle size distribution%:		Soluble cations (soil paste mmole_cL⁻¹):					
Clay	49.45	Ca ²⁺	14.10				
Silt	35.67	Mg ²⁺	18.00				
Sand	14.88	Na ⁺	65.20				
Textural class*		K ⁺	1.10				
Soil chemical properties:		Soluble anions (soil paste mmole_cL⁻¹):					
pH (soil paste extract)	8.41	CO ₃ ²⁻	ND				
CaCO ₃ %	10.75	HCO ₃ ⁻	5.20				
Organic carbon %	1.12	Cl ⁻	42.10				
EC (dS m ⁻¹ , soil paste extract)	9.84	SO ₄ ²⁻	51.00				
SAR	15.91	ESP	21.00				
Soil physical properties:							
Bulk density g cm ⁻³	1.48	Soil moisture at wilting point %	17.10				
Soil moisture at field capacity %	35.10	Avail. Water %	18.10				
Available Nutrients mg kg⁻¹							
N	P	K	B	Fe	Mn	Zn	
35.20	3.98	180.00	0.069	6.23	2.97	0.54	
Critical level of nutrients (mg kg ⁻¹) after Lindsay and Norvell, (1978) and Page <i>et al.</i> (1982).							
Limits	N	P	K	B	Fe	Mn	Zn
Low	< 40.0	< 5.0	< 85	< 0.08	< 4.0	< 2.0	< 1.0
Medium	40-80	5-10	85-170	0.08-0.1	4-6	2-5	1-2
High	> 80.0	> 10.0	> 170.0	> 0.1	> 6.0	> 5.0	> 2.0

Critical level of nutrients (mg kg⁻¹) after Lindsay and Norvell, (1978) and Page *et al.* (1982).

Limits	N	P	K	B	Fe	Mn	Zn
Low	< 40.0	< 5.0	< 85	< 0.08	< 4.0	< 2.0	< 1.0
Medium	40-80	5-10	85-170	0.08-0.1	4-6	2-5	1-2
High	> 80.0	> 10.0	> 170.0	> 0.1	> 6.0	> 5.0	> 2.0

*Using USAD Soil Texture Triangle, after (Issam and Sayegh, 2007). **ND- Not detected

Proline content was estimated by the ninhydrin method according to Bates *et al.* (1973) using a Spectrophotometer (JENWAY 6405 UV/Vis).

At harvest time, after 150 days from planting, random samples of sugar beet plants were taken from each plot to determine root length (cm), weight of root plant⁻¹ (Kg), dry matter plant⁻¹ (g), and root yield weight (Mg fed⁻¹). Sucrose percentage was determined using the Sacharimeter apparatus according to the method described by Le-Docte (1927). Sugar yield was also calculated by multiplying root yield (Mg fed⁻¹) × Sucrose%.

Sugar beet plant samples were oven-dried at 70 °C till a constant weight and the dry weight was recorded. The plant material was ground to a fine powder. The plant content of total nitrogen was determined according to (Bremner and Mulvaney, 1982) with micro-Kjeldahl, phosphorus was determined colorimetrically by using Vanado-Molybdate yellow color method according to AOAC (2010) using Spectrophotometer (JENWAY 6405 UV/Vis), while potassium was determined by flame photometer (JENWAY PFP7 flame). according to Jackson (1973). The plant content of Fe, Mn, Zn, and Cu was determined in plant digest using an Atomic Absorption Spectrophotometer (Perkin-Elmer 372) using methods described by Cottenie *et al.* (1982) and Page *et al.* (1982).

Data were statistically analyzed according to Snedecor and Cochran (1980), and means were

compared using the L.S.D test at 0.05 of probability.

RESULTS and DISCUSSION

Bartlett test (Bartlett, 1937) indicated the homogeneity of variance. So, data were pooled over the two seasons.

Some soil properties

Data in Table 2 indicated that the silicate source did not significantly affect soil pH. The soil pH values were between 8.14 and 8.00. Also, the rates of Si fertilizer application had no effect on soil pH. However, the decrease of soil pH as a result of calcium silicate treatment at a rate of 6 ml L⁻¹ compared with other treatments had not reached the level of significance. Soil pH tends to slightly decrease with increasing the rates of any silicate source. Regarding the interaction between sources of Si and the rates, data clearly showed that there was no effect on soil pH. These results are in agreement with the results of AbdElghany *et al.* (2019), who stated that the soil pH means ranged from 8.27 to 8.05, between slightly to moderately alkaline.

Soil salinity values (EC dSm⁻¹) presented in Table 2 and Fig. 1, data revealed that the least EC values were obtained as a result of calcium silicate foliar application compared with other treatments. However, Silica gel gave the highest mean value of 7.19 dSm⁻¹. The relative decreases of EC mean values were 34.92 & 52.69 %; 14.48 & 30.54 % and

8.13 & 22.25 % for soil treated with calcium silicate, potassium silicate, and silica gel at rates 4 and 6 mL⁻¹ foliar application, respectively, compared to the control. Also, soil EC recorded the least mean value as 3.78 dSm⁻¹ as a result of the interaction between the highest Si rate and calcium silicate. These results are in agreement with Al-Toobi *et al.* (2023), who stated that soil salinity decreased as affected by the application of silicate on saline soil. Foliar application of Ca-silicate on soil decreased Na⁺ % concentrations, which may be owing to more ions occupying the adsorbent surfaces (Eissa, 2024).

The soil electrical conductivity (EC) significantly reduced from 60 dSm⁻¹ to 17 dSm⁻¹ in

the leached sugar beet (Abd El-Rahman *et al.*, 2024). Potassium silicate treatments decreased soil salinity. The application of silicate to the soil may have reduced soil salinity values due to the soluble ions in the irrigation water, which increases the soil solution. This is because the soil retains a portion of the water up to the field capacity (Jabal and Abdulkaree, 2023). Additionally, silica gel, as a source of silicon, positively influenced ion homeostasis by increasing potassium levels and decreasing sodium concentrations in the soil. This balance in ion concentration contributed to the overall reduction in soil salinity (Kousar *et al.*, 2021).

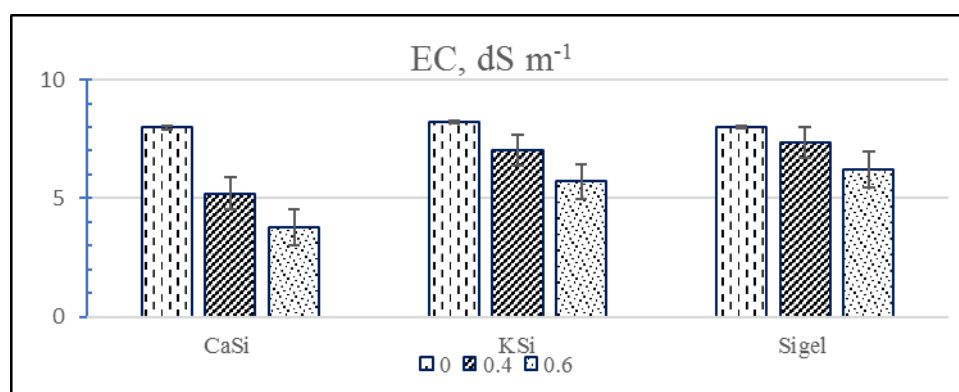


Fig. 1: Soil salinity as affected by the interaction between Si Sources and rates.

Table 2: Soil pH, EC and available macro and micronutrients in soil after harvest time as affected by different sources and rates of silicate fertilizer.

Types of fertilizers (A)	Spray Rate ml L ⁻¹	pH	EC	Available macronutrients			Available micronutrients		
				mg kg ⁻¹					
		1:2.5	dSm ⁻¹	N	P	K	Fe	Mn	Zn
Calcium silicate	0	8.12	7.99	38.4	4.77	185.00	6.64	3.12	0.58
	0.4	8.07	5.20	40.5	5.16	188.00	7.14	3.55	0.63
	0.6	8.00	3.78	43.9	5.98	191.00	7.75	3.85	0.69
Mean Ca Si		8.06	5.66	40.9	5.30	188.00	7.18	3.51	0.63
Potassium silicate	0	8.14	8.22	37.8	4.12	182.00	6.60	3.10	0.55
	0.4	8.09	7.03	38.6	4.87	184.00	6.89	3.24	0.60
	0.6	8.05	5.71	40.1	5.23	186.00	7.14	3.66	0.63
Mean KSi		8.09	6.99	38.8	4.74	184.00	6.88	3.33	0.59
Silica gel	0	8.13	8.00	37.5	4.22	181.00	6.62	3.11	0.57
	0.4	8.10	7.35	39.4	4.89	183.00	6.96	3.36	0.62
	0.6	8.06	6.22	41.2	5.33	187.00	7.20	3.75	0.65
Mean Si gel		8.10	7.19	39.4	4.81	183.67	6.93	3.41	0.61
Mean (B)	0	8.13	8.07	37.9	4.37	182.67	6.62	3.11	0.57
	0.4	8.09	6.53	39.5	4.97	185.00	7.00	3.38	0.62
	0.6	8.04	5.24	41.7	5.51	188.00	7.36	3.75	0.66
L.S.D. at 0.05									
Types of fertilizers (A)		ns	0.149	1.54	0.546	3.146	0.274	0.198	0.13
Spray rates (B)		ns	0.247	0.43	0.281	2.271	0.292	0.097	0.045
A×B		ns	0.428	0.76	0.487	3.934	0.506	0.168	0.079

The data presented in Table 2 and Figures 2 and 3 clearly demonstrate that the application of silicate sources has a significant positive effect on the availability of macro- and micronutrients in the soil. Notably, calcium silicate significantly outperformed other sources regarding the nutrient content of nitrogen (N), phosphorus (P), potassium (K), iron (Fe), manganese (Mn), and zinc (Zn). The highest application rate of silicon resulted in superior mean values of 9.90%, 26.09%, 2.92%, 11.18%, 20.58%, and 15.79% for N, P, K, Fe, Mn, and Zn, respectively, when compared to the control

treatment.

In terms of the interaction between silicon sources and application rates on soil pH values, the data indicate that there was no effect on pH. However, other soil parameters were significantly affected by the different treatments. The relative increases in mean values for soil treated with calcium silicate at rates of 4- and 6-ml L⁻¹, compared to the control, were as follows: 5.27% and 14.06% for N, 8.18% and 25.37% for P, 1.62% and 3.24% for K, 7.53% and 16.72% for Fe, 13.78% and 23.40% for Mn, and 8.62% and 18.97% for Zn.

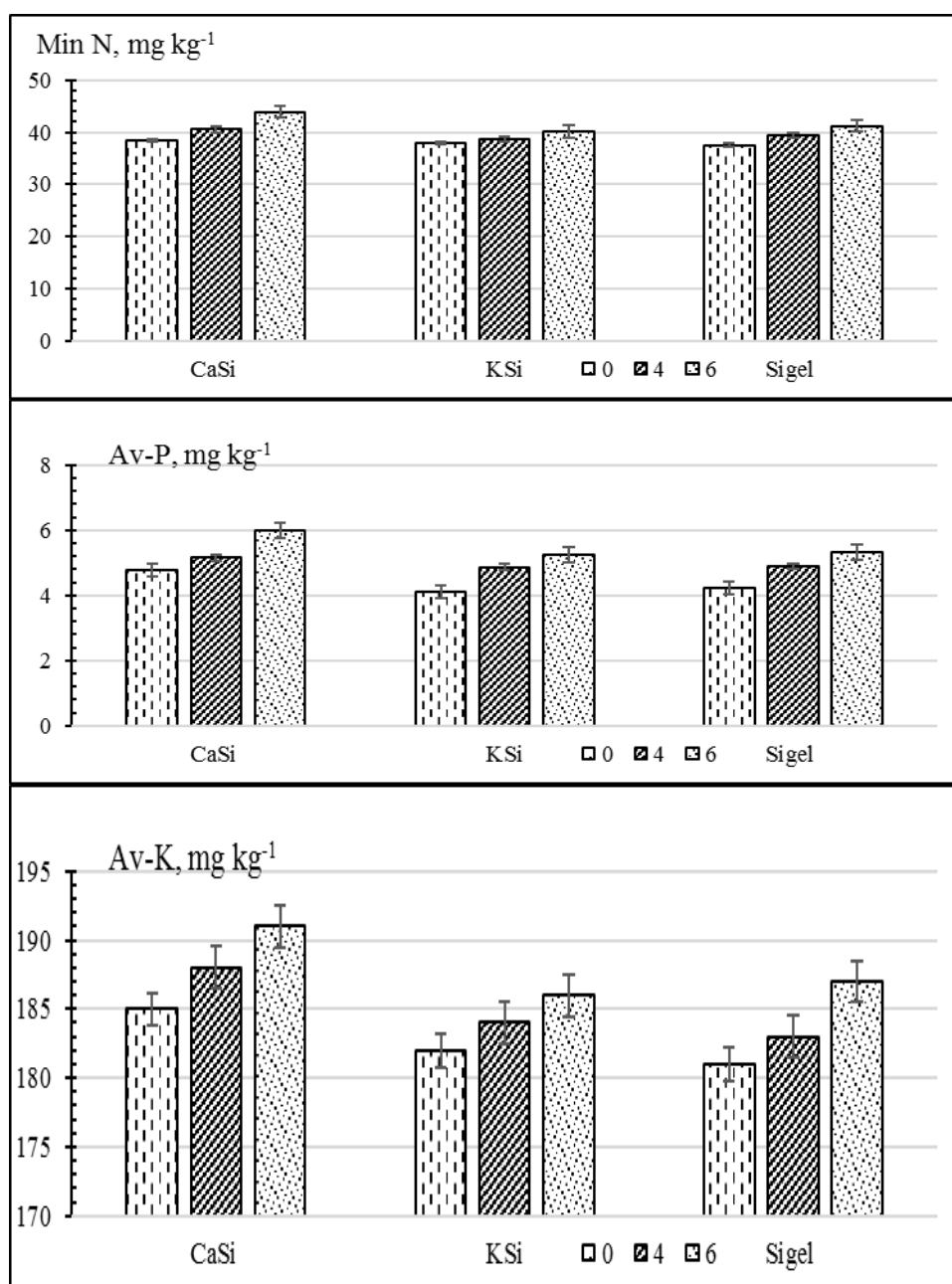


Fig. 2: Soil macro-nutrient as affected by the interaction between Si sources and rates.

Table 2 presents data showing the relative increases in the mean values of available macro- and micronutrient contents in soil treated with potassium silicate at foliar application rates of 4- and 6-ml L⁻¹ compared to the control group. The relative increases in mean values were as follows: 5.03% and 9.75% for nitrogen (N), 15.88% and 26.30% for phosphorus (P), 1.10% and 3.31% for potassium (K), 5.14% and 8.76% for iron (Fe), 8.04% and 20.58% for manganese (Mn), and 8.77% and 14.04% for zinc (Zn) with the application of silica gel at the same rates.

Additionally, the results indicated an increase in the mean percentage values of N, Fe, and Mn in soil treated with foliar application of calcium silicate at both 4- and 6-ml L⁻¹. A specific increase in K content was noted in soil treated with calcium

silicate only at the 4 ml L⁻¹ rate compared to the control. Moreover, the mean values of P and Zn showed increases in soil treated with foliar application of potassium silicate at both 4- and 6-ml L⁻¹ compared to the control.

These findings align with the research conducted by Al-Toobi et al. (2023), which indicated that silica application enhances soil organic matter as well as the availability of N, P, and K concentrations, in addition to increasing the soil Si level. The use of Si-rich organic materials likely contributed to this outcome. The improved availability of nutrients can be attributed to an increase in soil cation exchange capacity (CEC), improved water and air regimes, and changes in soil mineral composition, as noted by Jabal and Abdulkaree (2013).

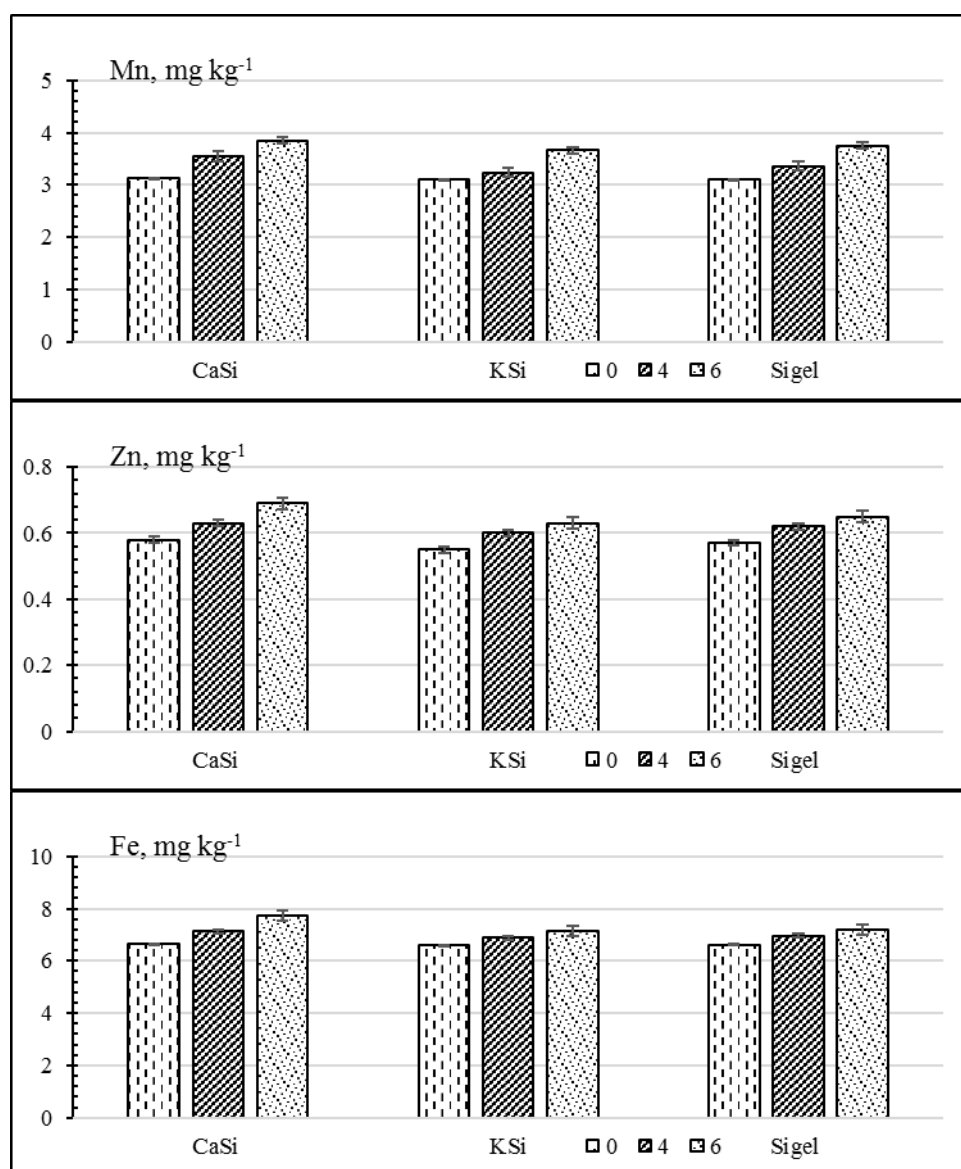


Fig. 3: Soil micro-nutrient as affected by the interaction between Si sources and rates.

Effect of silicate fertilizer on sugar beet productivity

The data presented in Table 3 indicate that the parameters of sugar beet, including root length, weight, dry matter, and yield, increased with the application of higher rates of silicate from all sources used. The highest values for root length, root weight, root dry matter, and root yield were achieved with calcium silicate applied at a rate of 6 ml L⁻¹. The relative increases in mean values compared to the control were as follows: for root length, 14.74%; for root weight, 13.59% and 13.90%; for dry matter weight, 36.57% and 18.92% and 34.42%; and for root yield, 22.36%, 19.35%, and 22.59% for plants treated with calcium silicate, potassium silicate, and silica gel, respectively.

Additionally, Table 3 shows that the type of silicate source had an insignificant effect on root weight, whereas calcium silicate fertilizer significantly affected root and sucrose yield, achieving values of 20.51 and 3.05 Mg fed⁻¹, respectively.

In summary, the positive effects of the various silicate sources on sugar beet growth parameters can be ranked as follows:

-For root length: calcium silicate > silica gel > potassium silicate > control

-For weight of dry matter: potassium silicate > silica gel > calcium silicate > control

-For root weight per plant: silica gel > calcium silicate > potassium silicate > control

- For root yield per fed: potassium silicate > silica gel > calcium silicate > control.

The foliar application of silica gel on sugar beet has been found to be beneficial for the growth, development, and yield of sugar beet plants. This may be due to its ability to improve organogenesis, growth traits, and the morphological, anatomical, and physiological characteristics of the plants under conditions of soil salinity. These findings align with those of Elsokkary (2018), who noted that silica gel accumulates in the epidermal plant tissues and enhances plant growth. Consequently, silica is now recognized as an essential element for plant health.

In addition, the effects of potassium silicate on plant growth indicate improvements in growth and yield; this may be due to the alleviating roles of both potassium and silicon in mitigating drought stress (Abu El-Azm and Youssef, 2015). A foliar application of potassium silicate at 2000 ppm led to increases in vegetative parameters. This enhancement of vegetative growth in potato plants can be attributed to potassium's role in plant nutrition and its ability to promote the translocation of assimilates and protein synthesis (Abd El-Gawad *et al.*, 2017).

Table 3: Sugar beet productivity as affected by different silicate sources and rates.

Types of fertilizers (A)	Spray Rate ml L ⁻¹	Root length	Root weight	Root dry matter	Root yield
		cm	Kg plant ⁻¹	g	Mg fed ⁻¹
Calcium silicate	0	23.14	0.99	385.52	17.85
	0.4	25.88	1.08	494.63	19.35
	0.6	27.21	1.15	558.34	24.33
Mean Ca Si		25.41	1.07	479.50	20.51
Potassium silicate	0	21.63	0.85	380.22	17.52
	0.4	23.48	0.97	419.00	18.96
	0.6	25.66	1.03	485.27	22.85
Mean K Si		23.59	0.95	428.16	19.78
Silica gel	0	22.52	0.93	385.24	17.66
	0.4	25.31	1.06	490.00	19.10
	0.6	25.99	1.12	545.66	23.65
Mean Si gel		24.61	1.04	473.63	20.14
Mean (B)		22.43	0.92	383.66	17.68
		24.89	1.04	467.88	19.14
		26.29	1.10	529.76	23.61
L.S.D. at 0.05					
Types of fertilizers (A)		1.443	ns	2.817	0.401
Spray rates (B)		0.986	0.065	3.374	0.889
A×B		0.922	0.112	5.844	1.54

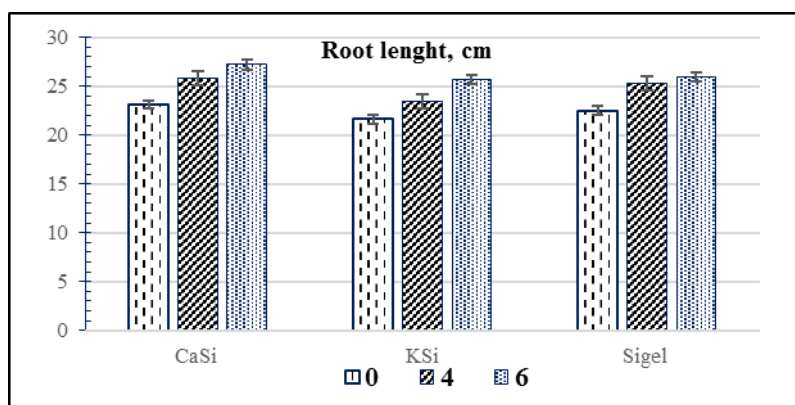


Fig. 4: Root length, cm as affected by the interaction between Si sources and rates.

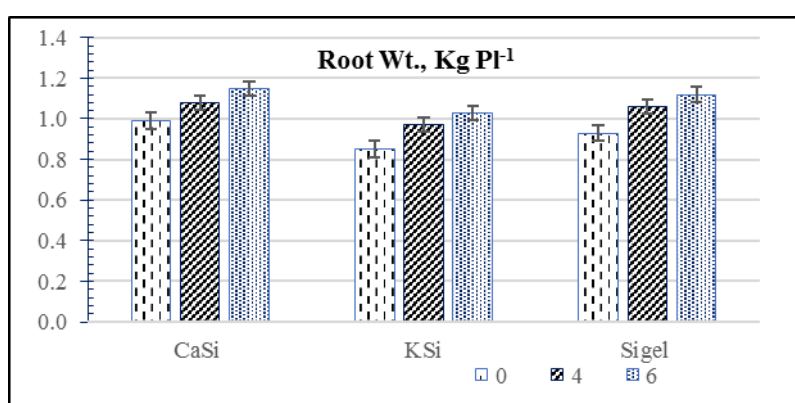


Fig. 5: Root weight, kg Pl⁻¹ as affected by the interaction between Si sources and rates.

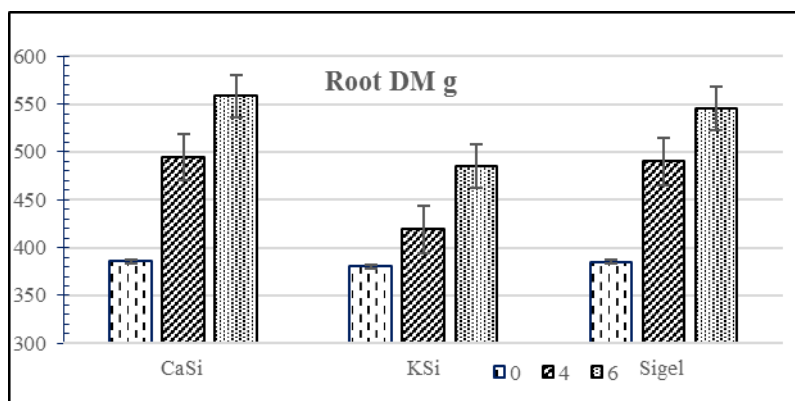


Fig. 6: Root dry matter, g as affected by the interaction between Si sources and rates.

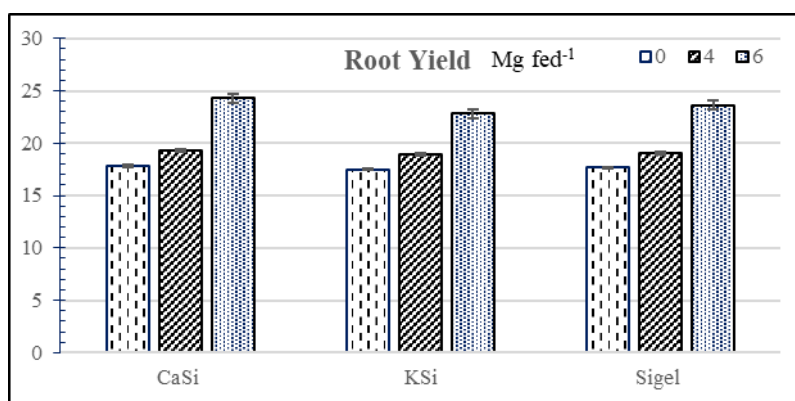


Fig. 7: Root yield, Mg fed⁻¹ as affected by the interaction between Si sources and rates.

Furthermore, the addition of calcium silicate under saline soil conditions has been shown to enhance plant growth (Nizar *et al.*, 2024). Silica gel, as a source of silicon, significantly improves wheat characteristics by mitigating the adverse effects of salt stress (Kousar *et al.*, 2021). Eneji *et al.* (2008) indicated that applying 1000 mg kg⁻¹ of potassium silicate to the soil at the time of transplanting resulted in the greatest biomass yield responses across various species when compared to calcium silicate or silica gel.

Effect of silicate fertilizer sources on nutritional status in sugar beet root

The nutritional status of sugar beet roots is presented in Table 4 and Figures 8, 9, and 10. The data indicate that the mean values of nutrient concentrations increased as follows: nitrogen (N) by 21.03%, phosphorus (P) by 35.71%, potassium (K) by 4.15%, iron (Fe) by 15.04%, manganese (Mn) by 18.45%, and zinc (Zn) by 42.96%. In contrast, the concentration of sodium (Na⁺) decreased by 4.14% in sugar beets treated with calcium silicate compared to the control group.

Additionally, when sugar beets were treated with potassium silicate at various rates, the relative increases in mean values for nutrient concentrations were as follows: 17.55% for N, 17.07% for P,

2.46% for K, 11.98% for Fe, 13.74% for Mn, and 28.43% for Zn, while the Na⁺ concentration decreased by 5.06% compared to the control.

The application of foliar silicate sources significantly affected the sodium concentration. With silica gel treatments, the relative increases in mean values were 20.11% for N, 24.39% for P, 4.53% for K, 10.00% for Fe, 13.22% for Mn, and 18.16% for Zn. There was also a decrease of 6.41% in Na⁺ concentrations in the roots of sugar beets compared to the control.

The highest concentrations of N, P, K, Fe, Mn, and Zn in the roots were achieved with a calcium silicate application rate of 6 ml L⁻¹, accompanied by a decrease in Na⁺ concentration compared to the other treatments.

The interaction between different silicate sources and application rates showed an increase in effectiveness when various silicate sources were applied at high rates under saline soil conditions. However, the effect was insignificant on nitrogen (N), phosphorus (P), and potassium (K) levels in sugar beet. In contrast, there were significant effects observed on micronutrient and sodium (Na) content.

Table 4: Macro-micro nutrients and non-nutrient content in root of sugar beet as affected by different silicate sources and rates.

Types of fertilizers (A)	Spray Rate ml L ⁻¹	Macronutrients content (%)				Micronutrients content (Mg kg ⁻¹)		
		N	P	K	Na	Fe	Mn	Zn
Calcium silicate	0	1.95	0.42	2.89	1.45	123.00	76.65	28.96
	0.4	2.23	0.55	2.96	1.42	138.00	85.95	36.58
	0.6	2.48	0.58	3.05	1.35	145.00	95.63	46.21
Mean Ca Si		2.22 A	0.52	2.97	1.41	135.33	86.08	37.25
Potassium silicate	0	1.88	0.41	2.85	1.58	115.30	72.66	27.96
	0.4	2.14	0.47	2.88	1.52	125.21	79.65	33.28
	0.6	2.28	0.49	2.96	1.48	133.00	85.63	38.54
Mean K Si		2.10	0.46	2.90	1.53	124.50	79.31	33.26
Silica gel	0	1.89	0.41	2.87	1.56	120.85	75.96	27.96
	0.4	2.18	0.49	2.97	1.49	126.34	82.65	35.10
	0.6	2.35	0.53	3.02	1.42	139.52	89.34	42.15
Mean Si gel		2.14	0.48	2.95	1.49	128.90	82.65	35.07
Mean (B)		1.91	0.41	2.87	1.53	119.72	75.09	28.29
		2.18	0.50	2.94	1.48	129.85	82.75	34.99
		2.37	0.53	3.01	1.42	139.17	90.20	42.30
L.S.D. at 0.05								
Types of fertilizers		ns	ns	ns	0.083	2.901	0.964	0.95
Spray rates (B)		0.229	0.046	0.129	0.108	2.449	1.439	1.85
A×B		0.398	0.079	ns	0.056	4.241	2.493	3.204

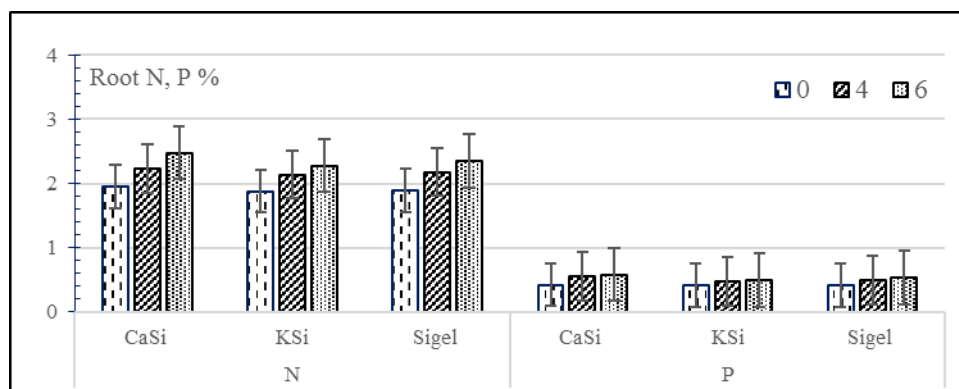


Fig. 8: N and P (%) as affected by the interaction between Si sources and rates.

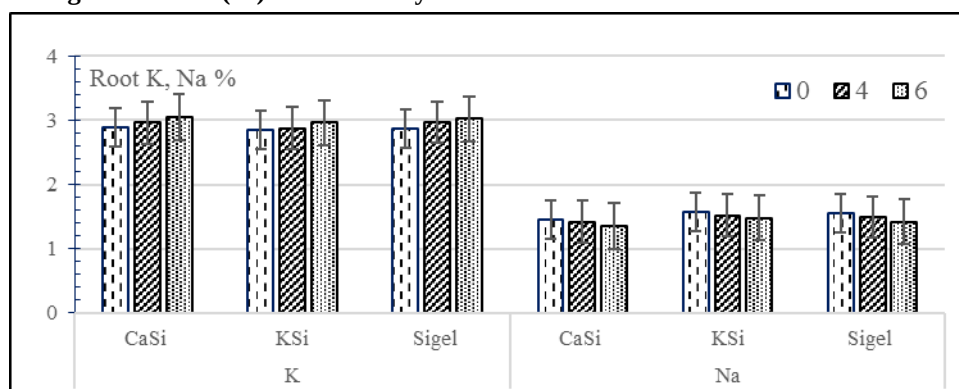


Fig. 9: K and Na (%) as affected by the interaction between Si sources and rates.

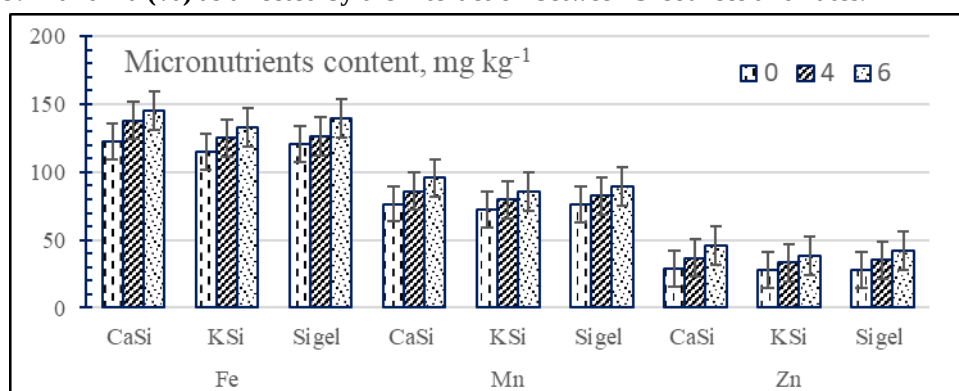


Fig. 10: Micronutrients concentrations (mg kg⁻¹) as affected by the interaction between Si sources and rates.

The use of potassium silicate, calcium silicate, and silica gel as foliar applications at different rates resulted in increased concentrations of both macro- and micronutrients in sugar beet roots grown in saline soil. Specifically, the foliar application of calcium silicate at the highest rate achieved the greatest mean values for N, P, and K content.

Additionally, the interaction between calcium silicate and the higher fertilizer rate resulted in mean values of 145.00, 95.63, and 46.21 mg kg⁻¹ for iron (Fe), manganese (Mn), and zinc (Zn), respectively, indicating a significant increase in micronutrient

concentrations.

It is evident from the distribution patterns of N, P, K, Fe, Mn and Zn concentrations in root sugar beet that it could be arranged according to the following orders:

for N, P, Fe, Mn and Zn as calcium silicate > potassium silicate > silica gel > control, for K. as silica gel > calcium silicate > potassium silicate > control and

decrease of Na⁺ as silica gel > Potassium silicate > calcium silicate > control

These results are in agreement with Abo-Basha

et al., (2024) who found that the application of potassium silicate and silica gel to sugar beet improved nutrient contents in the root and shoot of sugar beet and gave the highest values on N (0.58%, 2.54%), P (0.132%, 0.318%), K (0.42%, 1.05%), Fe (67.18, 83.28 mg kg⁻¹), and Zn (11.29, 12.73 mg kg⁻¹) content, respectively, under deficit irrigation conditions. Kousar *et al.* (2021) reveal that the silica gel foliar application on plants decreased sodium concentration (16 mg kg⁻¹) while increasing potassium concentration (114.73 mg kg⁻¹). Also, the foliar application of silicon on sugar beet had increased P concentration in leaves, while N and K concentrations increased in sugar beet roots (Artyszak *et al.*, 2019). The application of silicon to sugar beet increased the content of nitrogen, phosphorus, and potassium, which may be due to the intensification of the microbiological activity of the soil (Kulikova *et al.*, 2019). The application of silicon to plants improved the living status of plants by reducing the uptake and translocation of heavy metals from root to shoot (Etesami and Jeong, 2018). Silicon application increased of heavy metals in plants (Khan *et al.*, 2021).

Effect of silicate fertilizer on Sugar beet quality

Data presented in Table 5 showed that potassium silicate gave the highest proline value (4.86 mg g⁻¹ FW), and Ca silicate showed the lowest mean value. Regarding chlorophyll and sucrose content, both Ca silicate and Silica gel did not significantly differ and had the highest mean value. So, the relative increases of mean values were 45.82 % for chlorophyll content in leaves, 12.68 % for sucrose,

and 32.30 % for sucrose yield, respectively, for sugar beet treated with potassium silicate at different rates than the control. Also, data showed that the highest fertilizer rate, which has the maximum mean value for all tested parameters except proline content, the control treatment exceeds the other rates by 48.83 % over the highest rate. The highest rate showed the highest mean value for chlorophyll, sucrose content, at (63.64, 22.72 %). The maximum values of total chlorophyll, sucrose parentage, and sucrose yield were foliar application of calcium silicate at a rate of 6 ml L⁻¹ compared with other treatments. The decrease in proline content was affected by all silicate high rates, especially calcium silicate at a rate of 6 ml L⁻¹ foliar application. However, the relative increases of mean values were 59.61 % for chlorophyll content in leaves, 21.32 % for sucrose, and 49.78 % for sucrose yield contents in sugar beet treated with calcium silicate at different rates compared control.

As well as the relative increases of mean values for chlorophyll content level, sucrose, and sucrose yield contents in sugar beet treated with silica gel were 56.13 %, 16.63% and 42.17 % respectively, compared with the control. The effect of foliar application on proline content in sugar beet, as affected by silicate sources at different rates, was decreased with increasing rates under saline soil conditions. The relative decreases of mean values were 52.42 %, 57.43 % and 62.68 % for proline content in sugar beet treated with calcium silicate, potassium silicate, and silica gel at different rates, respectively, compared with the control.

Table 5: Effect of silicate sources and rates on sugar beet quality.

Types of fertilizers (A)	Spray Rate ml L ⁻¹	Proline mg g ⁻¹ FW	Total Chlorophyll mg g ⁻¹ FW	Sucrose %	Sucrose yield Mg fed ⁻¹
Calcium silicate	0	4.69	2.55	12.85	2.29
	0.4	2.85	3.96	14.63	2.83
	0.6	2.18	4.18	16.55	4.02
Mean Ca Si		3.24	3.56	14.68	3.05
Potassium silicate	0	5.69	2.51	12.93	2.26
	0.4	4.68	3.22	13.66	2.58
	0.6	4.22	4.10	14.89	3.40
Mean K Si		4.86	3.28	13.83	2.75
Silica gel	0	4.88	2.53	13.05	2.30
	0.4	4.36	3.75	14.22	2.71
	0.6	3.85	4.15	16.21	3.83
Mean gel Si		4.36	3.48	14.49	2.95
Mean (B)		5.09	2.53	12.94	2.28
		3.96	3.64	14.17	2.71
		3.42	4.14	15.88	3.75
L.S.D. at 0.05					
Types of fertilizers (A)		0.379	0.155	0.608	0.041
Application rates (B)		0.383	0.184	0.287	0.473
A×B		0.663	0.318	0.497	0.819

These results are in agreement with Abd El-Hady and Bondok (2017) indicate that increasing potassium silicate at rates 4, 8, and 16 cm³ L⁻¹ continuously led to significantly increased values of the sucrose and purity % contents in sugar beet. Potassium silicate application to plants increases of chlorophyll. Abd El Gawad *et al.* (2017) found that the application of 125 mgL⁻¹ silicate improved the total soluble sugars and total chlorophylls in leaves. The application of silicate to plants at a rate of 60 mgL⁻¹ led to an increase in the chlorophyll content in leaves and sugar percentage in pepper plants (Trejo-Tellez *et al.*, 2020). Adding calcium silicate to plant growth under saline soil maintains membrane permeability, chlorophyll content, and net photosynthesis by diluting salts accumulated in a saline environment. This may be attributed to the fact that silicon helps in increasing the erectness of leaves, thereby enhancing photosynthetic capacity (Nizar *et al.*, 2024). Enan and Neneat Alla (2024) found that the effect of the foliar application of K-silicate might be associated with the role of silicon in increasing the activities of photosynthetic enzymes and chlorophyll content, and the accumulation of silicon in leaves causes their erection, which facilitates light penetration. Potassium silicate application to sugar beet led to an increase in stomata conductance, transpiration rate, and total sugar, while proline content was decreased under soil salinity conditions (Ibrahim *et al.*, 2017). Potassium silicate foliar application at a rate of 16 cm³ L⁻¹ continuously significantly increased the values of sucrose and purity % (Abd El-Hady and Bondok 2017).

CONCLUSION

Silicon foliar fertilization is an effective agronomic technique for alleviating stress on sugar beet plants, which can hinder the growth of their photosynthetic machinery and ultimately reduce yields. This study's findings suggest that applying silicate sources at a rate of 6 ml per liter to sugar beet plants grown in saline soils is beneficial. Silicon positively enhances homeostasis by increasing potassium levels and decreasing sodium levels in these conditions.

REFERENCES

- A.O.A.C., (1995). *Official methods of Analysis*. Association of official analytical chemist. 16th edition, Washington DC.
- Abd El-Gawad, H.G., Abu El-Azm, N.A.I. and Hikal, M.S. (2017). Effect of potassium silicate on tuber yield and biochemical constituents of potato plants grown under drought stress conditions. *Middle East J. of Agric.* **6** (3): 718-731.
- Abd El-Hady, M.A. and Bondok, A.M. (2017). Impact of Potassium Silicate on Growth, Productivity and Powdery Mildew Disease of Sugar Beet under Newly Reclaimed Soil Conditions. *Middle East J. of Agriculture Research*. **6** (4): 1232 – 1242.
- Abd El-Rahman, Z.M., Shaban, Kh.A., Mohaseb, M.I. and Dshesh, T.H.M. (2024). Effect of Boron, potassium sources and rates on soil fertility, sugar beet yield and quality cultivated in saline clay soil in Egypt. *Egypt. J. Soil Sci.* **36** (12): 402-416.
- AbdElghany, S.H., Saad, S.A., Arafat, A.A., and Shaban, Kh. (2019). Effect of different irrigation periods and potassium humate on some soil properties and carrot productivity under saline soil conditions. *Middle East J. of Applied Sciences*, **9**, 1117–1127.
- Abo-Basha, D.M., Abdel-Kader, H.H., ElSayed, S.A.A. and Hellal, F.A. (2024). Silicon as stimulant to mitigate water stress in sugar beet productivity and quality under deficit irrigated conditions in Egypt. *SABRAO J. of Breeding and Genetics* **56** (2): 739-750.
- Abu El-Azm, N. A. I. and Youssef, S. M. S. (2015). Spraying potassium silicate and sugar beet molasses on tomato plants minimizes transpiration, relieves drought stress and rationalizes water use. *Middle East J. Agric. Res.*, **4**(4): 1047-1064.
- Ahmad, B. (2013). Interactive effects of silicon and potassium nitrate in improving salt tolerance of wheat. *J. Integrative Agric.*, **13** (9): 1889-1899.
- Ali, A. M.; Ibrahim, S. M. and Abou-Amer, I. A. (2019). Water deficit stress mitigation by foliar application of potassium silicate for sugar beet grown in a saline calcareous soil. *Egypt. J. Soil. Sci.* **59** (1):15-23.
- Al-Toobi, M.; Janke, R.; Khan, M. M.; Ahmed, M.; Busaidi, W. M. and Abdul Rehman, A. (2023). Silica and Biochar Amendments Improve Cucumber Growth under Saline Conditions. *Soil Systems*. **7** (26): 1-12.
- Artyszak, A., Gozdowski, D. and Kucinska, K. (2019). Impact of foliar fertilization on the content of silicon and macronutrients in sugar beet. *J. Plants*. **8** (136): 1-12.
- Bartlett, M.S. (1937). Properties of sufficiency and statistical tests. Proceedings of the Royal Society of London. Series A-Mathematical and Physical Sciences, **160** (901):268-282.
- Bates, L.S., R.P. Waldran, and I.D. Teare, (1973). Rapid determination of free proline for water studies. *Plant and Soil* **39**, 205 -208.

- Berthelsen, S. and Korndörfer, G.H. (2012). Methods for Silicon Analysis in Soil, Plant and Fertilizers. 2003. Available from [Accessed: 03-07].
- Bremner, J.M. and Mulvaney, C.S. (1982). Total nitrogen. In A.L. Page (eds.). Methods of soil Analysis, Part2. Chemical and Microbiological properties. Agronomy Monograph no. 9 (2nd Edition).
- Cottenie, A. Verloo, M. Kikens, L. Velghe, G. and Camerlynck, R. (1982). Analytical Problems and Method in Chemical Plant and Soil Analysis. Hand book Ed. A. Cottenie, Gent, Belgium.
- Eissa, D.T. (2024). Effect of calcium silicate nanoparticles applications on salt affected soils environmental conditions. *Egypt. J. Soil Sci.* **64** (1): 335-354.
- Elsoikkary I.H. (2018). Silicon as a beneficial element and as an essential plant nutrient: An outlook. *Alex. Sci. Exch. J.* **39**:534–550.
- Enan, S.A.A.M. and Nemeat Alla, H.E.A. (2024). Alleviation of salt stress on sugar beet by nitrogen, *spirulina* algae extract and potassium silicate. *Menoufia J. Plant Prod.*, **9** (4): 211–228.
- Eneji, A.E., Inanaga, S.; Muranaka, S., Li, J., Hattori, T., An, P. and Tsuji, W. (2008). Growth and nutrient use in four grasses under drought stress as mediated by silicon fertilisers. *J. of Plant Nut.*, **31**, 355-365.
- Etesami, H. and Jeong, B. R. (2018). Silicon (Si): review and future prospects on the action mechanisms in alleviating biotic and abiotic stresses in plants. *Ecotoxicol Environ Saf.*, **147**: 881-896.
- FAO (Food and Agriculture Organization of the United Nations). (2021). The State of the World's Land and Water Resources for Food and Agriculture
- Ghoulam, C., A. Foursy, and Fares, A. (2002). Effect of salt stress on growth, inorganic ions and proline accumulation in relation to osmotic adjustment in five sugar beet cultivars. *Environmental and Experimental Botany* **47** (39): 23-45. doi:10.1016/S0098-8472(01)00109-5.
- Grieve, C.M.S.R. and Grattan and Maas, E.V. (2012). Plant salt tolerance. In: Wal-lender WW, Tanji KK (eds) Agricultural salinity assessment and management. ASCE Manual and Reports on Engineering Prac-tice 71 (2nd Ed.) Reston, VA, US: ASCE, 405–459.
- Ibrahim, A.M., Khafaga, H.S., Abd El-Nabi, A.S., Eisa, S.S. and Shehata, S.A. (2017). Transplanting of sugar beet with soil drench by potassium humate or potassium silicate enhanced plant growth and productivity under saline soil conditions. *Current Sci. Inter.* **6** (2): 303- 313.
- Issam, I. B. and Sayegh A.H. (2007). *Methods of Analysis for Soils of Arid and Semi-arid Regions*. F.A.O. Rome, Italy.
- Jabal, A.H. and Abdulkaree, M.A. (2013). Soil salinity and nutrient availability influenced by silicon application to tomato irrigation with different saline water. *Latin American J. of biotechnology and Life Sci.* **8** (1): 1- 12.
- Jackson, M.L. (1973). *Soil Chemical Analysis*. Prentice Hall, Inc., Engle wood cliff, N.J.
- Khan, I., Awan, S.A., Rizwan, M., Ali, Sh., Hassan, M.J., Brestic, M. Zhang, X. and Huang, L. (2021). Effects of silicon on heavy metal uptake at the soil –plant interphase: a review. *Ecotoxicology and Environmental Safety*. **222** (1): 1-12.
- Klute, A. (1986). Methods of Analysis. Part 1, *Soil Physical Properties*. ASA and SSSA, Madison, WI.
- Kousar, T, Sabir, N., Mushtaq, A., Rizwan, S., Jabeen, U., Bafhir, F., Ismail, T., Jakhro, M. I. and Shahwani, M. N. (2021). Influence of Silica Gel on Ion Homeostasis in Salt Stressed Wheat Varieties of Balochistan. *Springer Nature J.* **13** (5): 1- 7.
- Kulikova, A.; Isaichev, V.; Yashin, E. and Saidyasheva, G. (2019). The effectiveness of silicon –containing preparations as fertilizers for sugar beet. *E3S Web of Conferences* **224**, **04041**: 1-7.
- Laane, H. (2018). The effects of foliar sprays with different silicon compounds. *J. Plants*, **7**(45): 210- 220.
- Le-Docte, A. (1927). Commercial determination of sugar beet in the beet roots using Sachs Le-Docte process. *International Sugar J.* **29**, 488-492.
- Lindsay, W. L. and Norvell, W. A. (1969). Equilibrium relationships of Zn^{2+} , Fe^{2+} , Ca^{2+} and H^{+2} with EDTA and DTPA in soils. *Soil Sci., Am. Proc.*, **33**: 62 - 68.
- Mahrous, F. N. and Abd Elghany, S. H. (2020). Impact of silica gel application under different irrigation levels on water retention characteristics and some physical properties of clay soil. *Middle East J. of Agric. Res.*, **9** (1): 61 -74.
- Majeed, M. R. And Ahmed, A. J. (2015). Sand Dunes Stabilization Using Silica Gel and Cement Kiln Dust. *Al-Nahrain University, College of Engineering Journal (NUCEJ)*. **18** (2): 179 -191.
- Nizar, S., Mini, A., Rani, B., Aparna, B. and Lekshmi, S. L. (2024). Calcium silicate application as a salt stress mitigation strategy for vegetables in the salt-affected soils of sandy plains of Kerala, India. *J. of Experimental Agric. Inter*, **46** (11): 112 – 120.

- Nor Eldin, T. and Abo-Allah, A. M. M. (2022). Potassium silicate for mitigation of irrigation water deficiency for Faba bean intercropped with sugar beet in a sandy soil. *Mor. J. Agri. Sci.* **3** (3): 139-147.
- Omura, T.; Fujii, Y., Suzuki, T. and Minami, H. (2021). In situ preparation of inorganic nanoparticles in amino-functionalized porous cellulose particles. *J. Appl. Polym. Sci.* **138** (19) : 50397- 50410.
- Page, A.L., Miller, R.H. and Keney, D.R. (1982). *Methods of Soil Analysis, part2*. Amer. Soc. Agron. Madison, Wisconsin, USA.
- Parimala, M. and Singh, J. (2022). Soil and foliar application of silicon on quality parameters and yield of horticultural crops. *The Pharma Innovation J.* **11** (5): 427- 433.
- Sharma, R., Kumar, V., and Kumar, R. (2019). Distribution of phytoliths in plants: a review. *Geol. Ecol. Landscapes* **3**, 123–148.
- Siuda, A., Artyszak, A., Gozdowski, D. and Ahmad, Z. (2024). Effect of form of silicon and the timing of a single foliar application on sugar beet yield. *Agriculture J.* **14** (86): 1- 17.
- Snedecor, G.W. and Cochran, W.G. (1980). *Statistical Methods* 7th Ed. The Iowa State Univ. Press Amer. Iowa, USA.
- Sommer M.; Kaczorek, D., Kuzyakov, Y. and Breuer, J. (2006). Silicon pools and fluxes in soils and landscapes—a review. *J. Plant Nutr. Soil Sci.* **169**, 310–329.
- Trejo-Tellez, L. I., Atonaltzin, G. J., Hugo, F. E., Olvera, S. M. R., Jerico, J. B., Fernando, C. G. M. (2020). Silicon induces hormetic dose-response effects on growth and concentrations of chlorophylls, amino acids and sugars in pepper plants during the early developmental stage. *Peer J.*, **8**, 1- 28.
- Wettstein, D. (1957). Chlorophyll, Letal under submikro svopische formmech, sall-plastiden-Exptl Cell Ser., **12**: 427-433.
- Xiaoyan Lv, Chen S and Wang Y. (2019). Advances in Understanding the Physiological and Molecular Responses of Sugar Beet to Salt Stress. *Front. Plant Sci.*, **10** (1431) :1-11. <https://doi.org/10.3389/fpls.2019.01431>

الملخص العربي

تأثير معدلات ومصادر مختلفة من الأسمدة السيليكاية على خصوبة التربة وإنتاجية وجودة محصول بنجر السكر تحت ظروف الأرض الملحية

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أُجريت تجربة حقلية في قرية الرواد بسهل الحسينية محافظة الشرقية على محصول بنجر السكر (*Beta vulgaris* L.) خلال الموسمين الشتويين ٢٠٢٢/٢٠٢٣ و ٢٠٢٣/٢٠٢٤. أظهرت النتائج انخفاضاً طفيفاً في درجة حموضة التربة (pH) مع زيادة معدلات إضافة السيليكا إلى ٦ ملليتر/لتر، خاصة عند استخدام سيليكا الكالسيوم. كما سجلت أقل قيمة لتوصيل الكهرباء (EC = 3.78) ديسيمنز/متر نتيجة التفاعل بين أعلى معدل للسيليكا (٦ ملليتر/لتر) مع استخدام سيليكا الكالسيوم، مما يشير إلى فعاليتها في تقليل ملوحة التربة.

تأثير السيليكا على خصوبة التربة ومحتواها من العناصر الغذائية: تفوقت سيليكا الكالسيوم بشكل ملحوظ في تعزيز محتوى التربة من المغذيات الكبرى والصغرى مقارنة بمصادر السيليكا الأخرى عند معدل ٦

ملليتر/لتر، حيث سجلت زيادة تراوحت بين ٩,٩٠ إلى ٢٦,٠٩٪ للمغذيات الكبرى النيتروجين والفوسفور، ومن ١١,١٨ إلى ٢٠,٥٨٪ للحديد والمنجنيز علي التوالي، و ١٥,٧٩٪ للزنك مقارنة بالكنترول
تحسين جودة وإنتاجية بنجر السكر -زادت تركيزات المغذيات الكبرى والصغرى في جذور البنجر عند استخدام
سيليكات الكالسيوم بمعدل (٦ ملليتر/لتر) بنسبة ٢١,٠٣ إلى ٤٢,٩٦ ٪، بينما انخفضت نسبة الصوديوم (Na^+) بمقدار
٤,١٤ ٪

حققت سيليكات الكالسيوم بمعدل (٦ ملليتر/لتر) أعلى قيم في طول الجذر والمادة الجافة وكذلك محصول بنجر
السكر بزيادة مقدارها ٢.٣٦٪ مقارنة بالكنترول. كما أثرت علي جودة المحصول حيث أعطت أعلى إنتاج للسكر
(٤.٠٢ طن للفدان) بزيادة مقدارها ٧٥.٥٪ مقارنة بالكنترول (٢.٢٩ طن للفدان) ، واعي قيمة الكلوروفيل الكلي
بزيادة ٦٣.٩٢٪ مقارنة بالكنترول ، وأقل محتوى من البرولين.
لذا يوصى باستخدام سيليكات الكالسيوم بمعدل (٦ ملليتر/لتر) لتحسين خصائص الارض الملحية وزيادة إنتاجية
وجودة محصول بنجر السكر خاصة تحت ظروف الإجهاد الملحي.