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Silica Application in Improving Growth and Production of Onion (*Allium cepa* L.) Under Drought Stress

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Abstract. Climate change contributes to greater drought severity, leading to the decline of crop production. This study aims to evaluate the role of silica in onion production under water-deficient conditions. The research was conducted at the Technical Implementation Unit Benih Induk Palawija in Tanjung Selamat, Deli Serdang, North Sumatra Province. Randomized Block Design with factorial arrangement was employed in this study, comprising 4 different doses of silica (0, 0.48, 0.96 and 1.44 g per plant) at 3 different levels of drought (40, 60 and 80% water holding capacity (WHC)). The results showed that silica did not give significant results on vegetative growth and its yield, except for its root dry weight and plant wet weight. The best plant development was demonstrated by onions exposed to 80% WHC, followed by plants with 60% and 40% WHC. The application of silica 0.48 g on onions treated with 60% WHC has a greater increase in the production of onion bulbs.

Keywords: drought stress; onion; silica; yield

INTRODUCTION

Onion (*Allium cepa* L.) is one of the essential commodities with high economic value worldwide, including Indonesia (Tori *et al.*, 2023; Yusuf *et al.*, 2024) as this bulbous crop holds significant culinary importance and provides potential health benefits such as inhibiting inflammation, producing high levels of antioxidant properties, and also improving immune function (Ren & Zhou, 2021; Sagar *et al.*, 2022; Shabir *et al.*, 2022).

Indonesia is still struggling with the demand for onions as this commodity is still low in quantity and quality. In 2019, onion production reached 1,580,247 tons in 159,195 ha with a productivity of 9.93 tons.ha^{-1} (BPS, 2020). In North Sumatra, the yield of onion reached 18,072 tons in 2019 in the field 2,246 ha with a productivity of 8.05 tons.ha^{-1} (BPS, 2021). These phenomena showed that the national production of onions in Indonesia is still low. The lower production of onion could result from several factors, i.e, abiotic stress, such as climate change, or from biotic stress, i.e, pest and disease infestations. (Agale & Thaware, 2021; Jung *et al.*, 2024).

Climate change contributes to severe drought, leading to a greater negative impact on several agricultural commodities, including onion, where this plant is highly dependent on an appropriate water supply (Aku *et al.*, 2023; Sansan *et al.*, 2024). Prolonged dry season poses a distinctive challenge for farmers as onion is a short-lived plant (50-75 days of age) with short fibrous roots. Water-deficient condition has a greater effect on the growth and production of all onion cultivars (Chaudhry *et al.*, 2020; Gedam *et al.*, 2021; Polakitan *et al.*, 2022). Water shortages in onions cause production loss 30% in Indonesia (Rahmawati & Wulandari, 2024). Therefore, farmers worldwide have been looking for several methods to overcome this problem.

Hadiawati *et al.* (2017) studied that the decrease of production can reach 58.9% in 30-day-old onions exposed to drought stress, followed by 62.6% at 40 days after planting. However, when 50-day-old onions are exposed to drought, the decrease in plant wet weight reaches 32.0%. The early stage of growth contributes to onion production, which is exposed to water shortage at its early development (30 and 40-day-old), resulting in abnormal growth of onions, such as a lower number of leaves and a smaller size of bulb.

Silica is known to have beneficial effects on plants, particularly under drought stress by

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improving photosynthetic activity, plant growth, biomass production, antioxidants and osmolyte production, gene expression and nutritional uptake, facilitating plants to have better development and production (Johnson *et al*., 2022; Malik *et al*., 2021; Rehman, 2021). Several studies have discussed the roles of silica in improving crops, including potato (*Solanum tuberosum*) (Wadas & Kondraciuk, 2023). (Sayed *et al*., 2022). Nevertheless, the research on silica in onions is still scant. For this reason, we conducted a study on silica applied to onions to evaluate its effect on onion growth and production under drought stress.

METHODS

The research was conducted from August to November 2022 at the Technical Implementation Unit (Unit Pelaksana Teknis-UPT) Benih Induk Palawija in Tanjung Selamat, Deli Serdang, North Sumatra Province (3°32'08.4" latitude, 98°35'47.6" longitude), 25 m asl.

The materials used are onion seed cv. Maja Cipanas, fertilizer Starsil (with silica 26%), fertilizers N, P, K (ratio 16:16:16), insecticide Carbofuran, fungicide Mancozeb and other necessary materials. The equipment used are polybag (30 cm x 40 cm), aluminium trays, a hoe, measuring tape, watering can, weighing scale, measuring tools, beaker glass, graduated cylinder, and hand sprayer.

Randomized Block Design with factorial arrangement in three replications was employed in this study, comprising 4 different doses of silica (0, 0.48, 0.96 and 1.44 g per plant) at 3 different levels of drought (40, 60, and 80% water holding capacity-WHC). There were 12 experimental combinations that resulted in 36 experimental units.

Top soil collected from 20-cm soil depth in 5 different spots for its chemical properties assessment (pH, organic C, total N, total P, P availability, K total, K availability and Si total). The soil was sieved and air-dried for a week. Each polybag containing 5 kg of soil was incubated for 5 days for further use.

Gravimetric analysis was carried out to determine water content in the soil. This analysis is important to ensure the accuracy of initial water content in the soil before conducting the experiments, by oven-drying 10g soil samples at 105°C for 24 hours.

Onion seeds were selectively assessed to obtain healthy and similar-sized seeds before planting them in polybags (2-cm depth). NPK fertilizers were applied, 1.5 g per plant (ratio 16:16:16) at 2 and 4 weeks after planting. NPK fertilizer helps plants get the nutrients they need and is easier to utilize. Silica was also applied at 2 and 4 weeks by creating holes around the plants (±3 cm), putting the silica in the holes and then covering the holes with soil.

Drought stress exposure was carried out 2 weeks after planting, when the plants had produced bulbs. These bulbs were not watered to maintain the water capacity 80%, 60% and 40% until harvest by using a soil moisture meter. By subtracting the percentage of air water content from the percentage of field capacity water content, one can get 100% field capacity. 80%, 60%, and 40% multiplication is done using the findings. It is added to each polybag's starting weight.

Weeding and pesticide applications were regularly done to prevent the plants from pest and disease attacks. Plant height, leaf number, bulb production at 2, 4 and 6 weeks after planting, root length, bulb wet weight, bulb dry weight, number of bulbs produced (harvesting stage), chlorophyll and proline contents were recorded in this study.

The collected data were subjected to Analysis of Variance (ANOVA) and any significant means observed were further analyzed using Tukey's HSD at 5% probability level.

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RESULTS AND DISCUSSION

The Effect of Application of Silica on Plant Height of Onion Under Drought Stress

The results in **Table 1** show that plant height indicates the development of plants influenced by the environment or the treatments applied to the plants. The results on height revealed that the application of different doses of silica did not significantly improve the plant height at 2, 4 and 6 weeks after planting.

The results in **Table 1** showed that the application of different doses of silica did not significantly improve the plant height of onion at 2, 4 and 6 weeks after planting. Different levels of drought stress also did not have a significant effect on plant height at 2 weeks after planting. However, the greatest plant height was recorded at 4 and 6 weeks after planting with onion plants exposed to 80% WHC (32.64 cm and 33.95 cm), followed by 60% WHC (32.56 cm and 32.22 cm) and the lowest were exhibited by plants exposed to lowest water content, 40% WHC (30.38 cm and 28.36 cm).

The results of ANOVA showed that in water-deficient conditions, the application of silica did not have a significant effect on plant height of onion.

The effect of the application of silica on the leaf number of onion under drought stress

Table 2 explained that there was no significant difference in the application of silica on the leaf number of onion at 2, 4 and 6 weeks after planting. Different level of water deficit exposed to plants also did not affect their leaf number at 2 and 4 weeks after planting. Nonetheless, it increased the leaf number significantly at 6 weeks after planting. Despite drought exposure, the leaf number is increasing with time until it reaches 4 weeks of age and stops when it reaches 6 weeks of age. Plants with the lowest demonstrated leaf number at 4 and 6 weeks after planting (19.97 and 13.81 g).

The results of ANOVA also revealed that there were no significant correlations between the application of silica and drought stress with the number of onion leaves.

Table 1. The application of silica on the plant height of onion

Time of application	Drought stress level (% WHC)	Silica dose (g) 0	0.48	0.96	1.44	Mean
		.... cm				
2 weeks after planting	80	27.33	26.17	15.15	25.99	16.16
	60	28.37	26.95	27.73	25.54	27.15
	40	26.15	27.65	26.73	27.22	26.94
	Mean	27.28	26.92	26.53	26.25	
4 weeks after planting	80	33.74	33.33	31.26	32.25	32.64 a
	60	32.22	32.01	32.99	33.00	32.56 ab
	40	28.55	31.60	29.82	31.55	30.38 b
	Mean	31.50	32.31	31.36	32.26	
6 weeks after planting	80	33.00	34.75	35.09	32.95	33.95 a
	60	31.80	32.20	33.13	32.75	32.22 ab
	40	26.87	30.50	28.64	27.45	28.36 b
	Mean	30.56	32.15	32.28	31.05	

Note: Values followed by the same letters on the same columns are not significantly different according to the Least Significant Difference (LSD) Test at 5% probability level

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Table 2. The effect of the application of silica on leaf number of onion

Time of application	Drought stress level (% WHC)	Silica dose (g) 0	0.48	0.96	1.44	Mean
2 weeks after planting	80	19.33	18.41	18.50	21.00	19.31
	60	20.75	20.50	19.00	17.25	19.37
	40	18.00	19.91	17.25	17.50	17.66
	Mean	19.36	18.94	18.25	18.58	
4 weeks after planting	80	27.00	24.50	25.33	27.41	26.06 a
	60	23.00	24.66	24.50	24.41	24.14 a
	40	17.83	20.00	19.66	22.41	22.41
	Mean	22.61	23.05	23.16	24.73	
6 weeks after planting	80	22.83	19.58	21.00	25.08	22.12 a
	60	17.75	22.33	20.00	19.66	19.93 a
	40	14.33	12.75	13.91	14.25	13.81b
	Mean	18.30	18.22	18.30	19.66	

Note: Values followed by the same letters on the same columns are not significantly different according to the Least Significant Difference (LSD) Test at 5% probability level

The effect of silica application on the number of onion bulbs under drought stress

The results of ANOVA indicated there were no significant effects of silica application and water stress on the wet and dry weights of onion bulblets. Different doses of silica and different levels of drought stress exhibited non-significant results on bulblet number at 2, 4 and 6 weeks after planting. The results of ANOVA showed there were no significant correlations between silica application and drought stress on the number of onion bulblets. Table 3 shows that the number of onion bulblets at 2 weeks after planting produced more than 5 bulblets. There was no significant increase in onion bulblets at 4 weeks after planting; only one bulblet was produced during its development until 6 weeks after planting. This result indicated there was no significant effect of silica application on the number of onion bulblets under drought stress.

Table 3. The effect of silica application on the number of onion bulblets

Time of application	Drought stress level (% WHC)	Silica dose (g) 0	0.48	0.96	1.44	Mean
2 weeks after planting	80	5.16	5.16	5.33	5.66	5.33
	60	5.16	5.5	5.08	5.24	5.25
	40	5.00	5.0	4.91	5.00	4.97
	Mean	5.11	5.22	5.11	5.30	
4 weeks after planting	80	7.08	6.41	6.25	6.66	6.60
	60	5.75	6.91	6.33	6.25	6.31
	40	5.91	5.58	5.83	5.91	5.8
	Mean	6.25	6.30	6.13	6.27	
6 weeks after planting	80	7.83	6.66	6.50	7.91	7.22
	60	6.08	7.66	7.25	6.75	6.93
	40	6.25	6.25	6.25	6.41	6.37
	Mean	6.83	6.86	6.66	7.07	

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The effect of silica application on root length, fresh and dry weights of onion roots under drought stress.

Silica also had no significant effect on root length and root fresh weight, but significantly enhanced the root dry weight. Nevertheless, these variables were significantly different when exposed to different levels of drought stress. Onion plants with 80% possessed the highest results of root length and root fresh weight, 31.50 cm and 1.46 g, followed by the results of onion exposed to 60% HWC, with root length 28.33 cm and root fresh weight 1.14 g. Based on **Table 4**, the lowest results were exhibited by the onion plants exposed to the lowest water content, 40%, with root length 24.35 cm and root fresh weight 0.94 g.

Table 4. The effect of silica application on root length, and fresh and dry weights of onion.

Variables	Drought stress level (% WHC)	Dose of silica (g) 0	0.48	0.96	1.44	Mean
Root length (cm)	80	29.66	31.06	32.66	32.50	31.50 a
	60	27.00	26.00	26.66	33.66	28.33 b
	40	24.00	25.33	23.66	24.00	24.35 c
	Mean	27.02	27.50	27.66	30.05	
Root fresh weight (g)	80	1.27	1.77	1.38	1.43	1.46 a
	60	1.00	1.31	1.17	1.07	1.14 b
	40	1.00	0.95	0.92	0.91	0.94 c
	Mean	1.09	1.34	1.16	1.14	
Root dry weight (g)	80	0.24	0.32	0.39	0.36	0.32 a
	60	0.18	0.30	0.32	0.23	0.26 b
	40	0.22	0.21	0.25	0.20	0.22 b
	Mean	0.21 b	0.28 ab	0.32 a	0.26 ab	

Note: Values followed by the same letters on the same columns are not significantly different according to the Least Significant Difference (LSD) Test at 5% probability level

The effect of silica application on fresh and dry weights of onion bulbs and the number of onion bulbs

The results of ANOVA also indicated that there was no significant effect of silica application on bulb number under different levels of drought stress. However, the different levels of drought stress applied to the onion resulted in a significant effect on the fresh and dry weights of the onion bulb. The lowest weights were demonstrated by onion plants exposed to the lowest water content, 40% WHC (7.17 g and 0.99 g) (**Table 5**). From these results, it indicated that there was a significant correlation between silica supplementation and water supply on bulb weight, but not on bulb number.

Onion plants exposed to 80% WHC without silica showed significant results compared to silica-treated plants under drought stress at 40% WHC and 60% WHC. However, all silica-treated plants showed no significant yield. Plants treated with different doses of silica, given 40% water capacity, displayed a non-significant production of onion bulbs. Nonetheless, when the water content increased to 60% with the application of silica 0.48 g, it facilitated the plants to produce a higher number of bulbs (8 bulbs), which differed significantly from plants with no silica (6.25 bulbs). These plants with no silica did not show any significant result compared to plants treated with higher doses of silica, where plants treated with silica 0.96 g produced 7.66 bulbs and plants treated with silica 1.44 g produced 7.33 bulbs. Plants treated with different doses of silica exhibited

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insignificant yield under drought 80% WHC.

Table 5. The effect of silica application on fresh and dry weights of onion clumps and the number of onion bulbs

Variables	Drought stress level (% WHC)	Silica dose (g)				Mean
		0	0.48	0.96	1.44	
Bulb fresh weight (g)	80	18.30	20.74	21.13	20.57	20.18 a
	60	14.04	16.01	14.96	14.95	14.99 b
	40	6.02	9.26	7.44	5.98	7.17 c
	Mean	12.78	15.33	14.51	13.83	
Bulb dry weight (g)	80	3.14	3.42	3.55	3.55	3.32 a
	60	1.01	2.49	2.23	2.23	2.22 b
	40	0.89	1.25	0.93	0.93	0.99 c
	Mean	1.98	2.39	2.24	2.24	
Bulb number	80	8.08	6.91	6.50	8.08	7.39 a
	60	6.25	8.06	7.66	7.33	7.31 ab
	40	6.91	6.58	6.25	6.25	6.50 b
	Mean	7.08	7.16	6.80	7.22	

Note: Values followed by the same letters on the same columns are not significantly different according to the Least Significant Difference (LSD) Test at 5% probability level.

Table 6. The effect of silica application on proline accumulation, chlorophyll content, P and N uptake

Variables	Drought stress level (% WHC)	Dose of silica (g)				Mean
		0	0.48	0.96	1.44	
Proline accumu-lation (ppm)	80	2.78	4.48	0.95	2.31	2.73
	60	1.98	3.92	4.01	2.95	3.24
	40	4.06	7.41	5.61	1.20	4.57
	Mean	2.94	5.40	3.56	2.15	
Chlorophyll a content (mg/mL)	80	32.85	32.49	33.21	32.41	32.74
	60	32.88	32.17	32.73	31.41	32.29
	40	31.56	28.94	31.50	32.17	31.04
	Mean	32.43	31.20	32.48	31.99	
Chlorophyll b content (mg/mL)	80	56.14	58.16	59.73	56.56	57.67
	60	55.47	57.52	57.24	55.87	56.62
	40	55.17	48.58	55.63	57.56	54.22
	Mean	55.59	54.75	57.63	56.68	
Total chloro-phyll	80	88.97	90.67	92.92	89.05	90.39
	60	88.33	89.67	89.94	87.26	88.80
	40	86.71	77.49	87.26	89.64	85.24
	Mean	88.00	85.93	89.99		

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The effect of silica application on proline accumulation, chlorophyll content and total chlorophyll

The application of silica 0.48 g allowed the plants to have higher proline accumulation (5.40 ppm). The highest production of chlorophyll *a*, chlorophyll *b*, total chlorophyll, N and P uptake was found in plants treated with silica 0.96 g (32.48 $mg.mL^{-1}$, 57.63 $mg.mL^{-1}$, 89.99 $mg.mL^{-1}$). Based on **Table 6,** the results of ANOVA revealed that there were no significant effect of the application of different doses of silica to the production of proline accumulation, chlorophyll contents and total chlorophyll at different levels of water-deficit condition, which means there were no significant correlations between silica application and water supply to the production of proline accumulation and chlorophyll contents.

Silica has been known to have the ability to enhance plant vegetative growth and also to improve plant resistance to drought stress by increasing plant water usage efficiency in plant tissue, enhancing plant photosynthesis and promoting cell wall fortification (Irfan *et al*., 2023; Singh *et al*., 2023; Wang *et al*., 2021; Yang *et al*., 2022). In addition, silica deposition helps minimize water loss by limiting transpiration rate and regulating stomatal movement and conductance and increasing CO_2 assimilation (Lawson & Matthews, 2020).

In this study, silica supplementation in plants did not differ between treatments. Nevertheless, it promotes better development compared to plants with no silica, where the silica enables plants to grow appropriately, leading to higher plant height, and the height slightly increased with treatment (**Table 1**). The study of Juliani *et al*., (2023) aligns with our findings. They also documented insignificant results of silica on plant height (34.73 cm, 35.63 cm and 36.42 cm) of onion for each treatment (0, 20 $ml.L^{-1}$ and 40 $ml.L^{-1}$). Conversely, Sianturi *et al*., (2020) found that the application of volcanic silica 4.5 $kg.plot^{-1}$ influenced the onion height significantly at 5 weeks after planting compared to lower silica concentrations (1.5 $kg.plot^{-1}$ and 3.0 $kg.plot^{-1}$).

Several literatures documented the ability of silica to induce physiological and biochemical changes in plants, accelerating the growth and development. Silica also helps strengthen the cell wall of the stems and leaves, resulting in more erect plants and increasing the area exposed to the sunlight, which generates better plant photosynthesis, leading to enhanced plant development (Fitriani & Haryanti, 2016; Guerriero *et al*., 2016; Singh *et al*., 2023). Silica is not only beneficial for the onion crop, but it also improves the development of other plants. Early studies have documented the application of silica in improving the plant height of different species of plants (Boora *et al*., 2023; Goyal *et al*., 2022; Sah *et al*., 2022).

Leaf number increased with treatments, but insignificant difference between treatments (**Table 2**). Nurfuad *et al*. (2024) reported that there is no significant increase in onion leaf due to foliar application of rice husk silica. Similarly, Ishlah *et al*. (2022) suggested that there is no significant difference in onion leaf between treatments of nanosilica + *Trichoderma*, but there is an increasing trend in the results. A study of Alharbi *et al*. (2024) also showed that there was no significant difference between the 3.6 and 7.2 mM levels of potassium nanosilica application on the number of sorghum leaves. Nonetheless, Timotiwu *et al*. (2018) recorded that only the highest foliar application of silica (125 ppm) improved the leaf number of soybean. Indarwati *et al*. (2021) revealed that the combination of salicylic acid + biosilica produced a better number of leaves compared to the control on shallot under water deficiency.

There are no significant effects of silica application and water supply on the number of onion bublets in our experiments (**Table 3**). Barus *et al*. (2021) also mentioned, there is no significant difference in volcanic silica provision on onion bulblets. Moeljani *et al*. (2021) suggested that the number of onion

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bulbs was not affected by silica addition. In contrast, there are disagreements with our results by Tarigan & Hasanah, (2015) and Purba *et al*. (2015) who found that nanosilica obtained from volcanic ash, rice husk, and husk charcoal significantly affected the number of onion bulblets at 3 and 4 weeks after planting.

Silica application did not differ between treatments on root length, but there was an increasing trend of root length with treatments (**Table 4**). Sari *et al*. (2021) are in line with this study. They investigated that the silica applied in sugarcane did not have a significant improvement in the roots under drought stress. However, in wheat, silica application significantly improved the primary root length and lateral root length by 44% and 28% (Ashfaq *et al*., 2023) and root hair length by 45-107% (Cheraghi *et al*., 2024). Silica helps plants absorb important nutrients from the soil. Luyckx *et al*. (2017) and Chen *et al*. (2018) agreed that silica is responsible for improved root elongation, and it has an impact on nutrient and water uptake for increasing photosynthesis rate and plant protection against water scarcity.

Our findings on root fresh weight of silica-treated plants had no significant results, but it showed a slight difference compared to the control (**Table 4**). Despite insignificant results, the increased fresh weight of the treated root is proof of better plant requirement of nutrient uptake due to silica treatment. Silica addition contributes to a stronger root system, optimizing the nutrient uptake by plants and stimulating the plant defense system against pests and diseases through tissue hardness and thick cell walls (Saja-Garbarz *et al*., 2024; Verma *et al*., 2021; Yang *et al*., 2022). On the other hand, the silica had a significant influence on root dry weight compared to the control (**Table 4**). This aligns with the findings of Pascual *et al*. (2016) and Kurdali (2024) of silica increased in soybean and lentil roots, as proven by the increase in root dry weight. The application of silica improves the root system, leading to an increase in root dry weight.

Table 6 shows that the addition of silica did not affect the number of onion bulbs, only the weights of bulbs. This result is supported by Ishlah *et al*. (2022), that the number of onion bulbs was not affected by silica application. Srivastava *et al*. (2022) confirmed that the fresh weight of *Brassica juncea* did not differ between control and Si-treated plants under water deficit conditions (22.33g and 24.42 g). Rahmawati & Wulandari (2024) found that 12 g.L^{-1} silica applied to onion plants with 80% WHC significantly increased the fresh and dry weights of onion. *Sianturi et al*. (2020) investigated that the fresh weight of onion applied with a higher concentration of silica (4.5 kg/plot) differs significantly compared to lower concentrations (1.5 and 3 kg.plot^{-1}) at 5 weeks after planting. El-All *et al*. (2017) and Sharma *et al*. (2024) also studied that onions supplied with potassium-silicate exhibited greater weight of onion bulbs.

In these experiments, proline accumulation, chlorophyll content and total chlorophyll were not affected by silica application (**Table 6**). Some studies reported that proline is enhanced and accumulated in plants under water stress (Kordi *et al*., 2013; Lum *et al*., 2014). These findings strengthen our assumption that the supplementation of silica in our experiments has maintained the plant activity related to photosynthesis, disallowing the proline to increase, or in other words, the plant no longer needs the proline due to silica treatment under water deficit conditions. This phenomenon resulted in a non-significant result in proline accumulation in this study (**Table 6**). Interestingly, in the study of Dehghanipoodeh et al. (2018), there is an increase in proline in strawberry plants due to silica application under water stress. It could have happened due to the different amount of proline required by vegetable and fruit crops.

Chlorophyll is an essential pigment molecule for photosynthesis. The pigment harvests the energy of sunlight and converts the energy into chemical energy during photosynthesis. However, there is no significant effect of silica on chlorophyll in this recent study. There are many investigations on the

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contributions of silica in plants, which have exhibited dissimilar results to our study related to chlorophyll content. Barbosa *et al*. (2015) confirmed that the silica application 2 mM on maize stimulated the concentration of chlorophyll *a*, *b* and total chlorophyll, respectively (22%, 43% and 26%) in comparison with the control. Ramírez-Olvera *et al*. (2021) investigated that the supplementation of mM silica from SiO2 to rice plants significantly increased the chlorophyll *a/b* ratio. Trejo-Téllez *et al*. (2020) also confirmed that the highest *a, b,* and total chlorophyll were found in pepper plants treated with 125 mg.L^{-1} silica, but did not differ between silica applications 60 and 250 mg.L^{-1}.

Waterlogging-sensitive plants can experience a decrease in their nutritional absorption, causing sub-optimum nutrient supply (N, P, K) (Azhar *et al*., 2022). Nitrogen shortage increases chlorosis, restricting plants from conducting photosynthesis (Sakuraba, 2022) With the application of silica, it can improve chlorophyll content, helping plants in osmoregulation. Well-maintained osmoregulation exhibits better nutrient transfer in plants. Osmotic pressure improves water and nutrient transport, enabling plants to have adequate water and important nutrients for their growth and development.

CONCLUSION

The application of silica did not have a significant effect on vegetative growth and production of onion, except for root dry weight and plant wet weight. The application of 80% WHC exhibits the best growth of onion, and it decreased as the water supply decreased (60% and 40% WHC). Silica supplementation 0.48 g improves the number of onion bulbs under drought conditions 60% WHC. Proline accumulation, chlorophyll *a/b* and total chlorophyll were not affected by silica treatments.

Plant development and growth still benefit greatly from silica, particularly when it comes to boosting resilience to disease and stress. However, under certain environmental conditions, its effects may not be immediately apparent or require examination. These conditions may include factors such as soil type, moisture levels, and the presence of specific pathogens. Therefore, understanding the context in which silica is applied can be crucial for maximizing its benefits for plant health. Further research is needed to find the best conditions for silica use in onion plants, including the correct dosage, concentration, and duration of treatment.

REFERENCES

Agale, N. K., & Thaware, B. B. (2021). Impact of Climate Change on Life. *Environmental Issues and Sustainable Development*, *3*(8), 236–239. https://doi.org/10.5772/intechopen.94538

Aku, R., Kristiansen, P., & Coleman, M. (2023). Water management and irrigation for bulb onion (Allium cepa L.) growth and development in the Papua New Guinea Highlands. *Asia Pacific Journal of Sustainable Agriculture, Food and Energy*, *11*(2), 47–58. https://doi.org/10.36782/apjsafe.v11i2.251

Alharbi, K., Alnusairi, G. S. H., Alnusaire, T. S., Alghanem, S. M. S., Alsudays, I. M., Alaklabi, A., & Soliman, M. H. (2024). Potassium silica nanostructure improved growth and nutrient uptake of sorghum plants subjected to drought stress. *Frontiers in Plant Science*, *15*(July), 1–12. https://doi.org/10.3389/fpls.2024.1425834

Ashfaq, W., Brodie, G., Fuentes, S., Pang, A., & Gupta, D. (2023). Silicon improves root system and canopy physiology in wheat under drought stress. *Plant and Soil*, 279–296. https://doi.org/10.1007/s11104-023-06202-4

Azhar, A., Asano, K., Sugiura, D., Kano-Nakata, M., & Ehara, H. (2022). Waterlogged Conditions Influence the Nitrogen, Phosphorus, Potassium, and Sugar Distribution in Sago Palm (Metroxylon

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2168

sagu Rottb.) at Seedling Stages. *Plants*, *11*(5). https://doi.org/10.3390/plants11050710

Barbosa, M. A. M., da Silva, M. H. L., Viana, G. D. M., Ferreira, T. R., Souza, C. L. F. de C., Lobato, E. M. S. G., & Lobato, A. K. da S. (2015). Beneficial repercussion of silicon (Si) application on photosynthetic pigments in maize plants. *Australian Journal of Crop Science*, *9*(11), 1113–1118.

Barus, W. A., Risnawati, & Ahmad, Y. S. (2021). Pemanfaatan debu vulkanik sinabung untuk pertumbuhan dan produksi tanaman bawang merah (Allium ascolonicum) dalam beberapa dosis pupuk KCL. *Jurnal Penelitian Bidang Ilmu Pertanian*, *19*(1), 47–62.

Boora, R., Rani, N., Kumari, S., Yashveer, S., Kumari, N., & Grewal, S. (2023). Efficacious role of silica nanoparticles in improving growth and yield of wheat under drought stress through stress-gene upregulation. *Plant Nano Biology*, *6*(July), 100051. https://doi.org/10.1016/j.plana.2023.100051

BPS. (2020). Distribusi Perdagangan Komoditas Bawang Merah 2020 Indonesia. *Badan Pusat Statistik*, 132.

BPS. (2021). *Provinsi Sumatera Utara dalam Angka*. *4*(2), 100.

Chaudhry, U. K., Öztürk Gökçe, Z. N., & Gökçe, A. F. (2020). Effects of Salinity and Drought Stresses on the Physio-Morphological Attributes of Onion Cultivars at Bulbification Stage. *International Journal of Agriculture and Biology*, *24*(6), 1681–1691. https://doi.org/10.17957/IJAB/15.1611

Chen, D., Wang, S., Yin, L., & Deng, X. (2018). How does silicon mediate plant water uptake and loss under water deficiency? *Frontiers in Plant Science*, *9*(281), 1–7. https://doi.org/10.3389/fpls.2018.00281

Cheraghi, M., Motesharezadeh, B., Mousavi, S. M., Basirat, M., Alikhani, H. A., & Zarebanadkouki, M. (2024). Application of silicon improves rhizosheath formation, morpho-physiological and biochemical responses of wheat under drought stress. *Plant and Soil*, *March*. https://doi.org/10.1007/s11104-024-06584-z

Dehghanipoodeh, S., Ghobadi, C., Baninsab, B., GheysariI, M., & Shiranibidabadi, S. (2018). Effect of Silicon on Growth and Development of Strawberry under Water Deficit Conditions. *Horticultural Plant Journal*, *4*(6), 226–232. https://doi.org/10.1016/j.hpj.2018.09.004

El-All, A. E. A., Abdelhalim, A. K., & El-Namas, A. (2017). Assessment of Deficit Irrigation and Foliar Application of Salicylic Acid and Potassium Silicate on Performance of Drip – Irrigated Onion Crop in Sandy Soils. *Menoufia Journal of Soil Science*, *2*(1), 29–40. https://doi.org/10.21608/mjss.2017.175899

Fitriani, H. P., & Haryanti, S. (2016). Pengaruh Penggunaan Pupuk Nanosilika terhadap Pertumbuhan Tanaman Tomat (Solanum lycopersicum) Variasi Bulat. *Buletin Anatomi Dan Fisiologi*, *24*(1), 34–41.

Gedam, P. A., Thangasamy, A., Shirsat, D. V., Ghosh, S., Bhagat, K. P., Sogam, O. A., Gupta, A. J., Mahajan, V., Soumia, P. S., Salunkhe, V. N., Khade, Y. P., Gawande, S. J., Hanjagi, P. S., Ramakrishnan, R. S., & Singh, M. (2021). Screening of Onion (Allium cepa L.) Genotypes for Drought Tolerance Using Physiological and Yield Based Indices Through Multivariate Analysis. *Frontiers in Plant Science*, *12*(February), 1–16. https://doi.org/10.3389/fpls.2021.600371

Goyal, H., Bafna, A., Vyas, N., & Gupta, R. (2022). Effect of Soluble Silica on the Plant Growth, Leaves Chlorophyll Content and Bulb Quality of the Garlic (Allium sativum L.) against Drought Stress.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2168

Indian Journal Of Agricultural Research, *I*, 1–7. https://doi.org/10.18805/ijare.a-5889

Guerriero, G., Hausman, J. F., & Legay, S. (2016). Silicon and the plant extracellular matrix. *Frontiers in Plant Science*, *7*, 1–8. https://doi.org/10.3389/fpls.2016.00463

Hadiawati, L., Suriadi, A., & Irianty, F. (2017). Penurunan Hasil Bawang Merah Akibat Kekeringan Pada Beberapa Fase Pertumbuhan. *Seminar Nasional : Mewujudkan Kedaulatan Pangan Melalui Penerapan Inovasi Teknologi Pertanian Spesifik Lokasi Pada Kawasan Pertanian*, 287–292.

Indarwati, L. D., Sulistyaningsih, E., & Kurniasih, B. (2021). Impact of salicylic acid and biosilica application on plant growth of shallot under water deficit. *IOP Conference Series: Earth and Environmental Science*, *883*(1). https://doi.org/10.1088/1755-1315/883/1/012049

Irfan, M., Maqsood, M. A., Rehman, H. ur, Mahboob, W., Sarwar, N., Hafeez, O. B. A., Hussain, S., Ercisli, S., Akhtar, M., & Aziz, T. (2023). Silicon Nutrition in Plants under Water-Deficit Conditions: Overview and Prospects. *Water (Switzerland)*, *15*(4). https://doi.org/10.3390/w15040739

Ishlah, M. A., Kristanto, B. A., & Kusmiyati, F. (2022). Pengaruh Trichoderma harzianum dan Nano Silika Terhadap Penyakit Moler dan Produksi Bawang Merah. *Agrotechnology Research Journal*, *6*(2), 118–126. https://doi.org/10.20961/agrotechresj.v6i2.65179

Johnson, S. N., Chen, Z. H., Rowe, R. C., & Tissue, D. T. (2022). Field application of silicon alleviates drought stress and improves water use efficiency in wheat. *Frontiers in Plant Science*, *13*, 1–13. https://doi.org/10.3389/fpls.2022.1030620

Juliani, V., Qurrohman, B., & Rachmawati, Y. (2023). Pengaruh Pemberian Pupuk Kotoran Burung Walet dan Pupuk Silika Terhadap Pertumbuhan dan Hasil Tanaman Bawang Merah (Allium cepa L.) Varietas Batu Ijo. *Prosiding Seminar Nasional Pertanian 2023*, *33*, 46–64.

Jung, M., Kim, J., Kim, E. Y., Yoo, C., Ko, D., Lee, H., Chae, Y., Kim, Y. M., & Yi, G. (2024). Climate change impacts on Allium crop production: Insights from long-term observations in South Korea. *Heliyon*, *10*(14), e34749. https://doi.org/10.1016/j.heliyon.2024.e34749

Kordi, S., Saidi, M., & Ghanbari, F. (2013). Induction of Drought Tolerance in Sweet Basil (Ocimum basilicum L) by Salicylic Acid. *International Journal of Agricultural and Food Research*, *2*(2), 18–26. https://doi.org/10.24102/ijafr.v2i2.149

Kurdali, F. (2024). Effects of Exogenous Silicic (Si) and Salicylic acid (SA) Applied Individually or Effects of Exogenous Silicic (Si) and Salicylic acid (SA) Applied Individually or in Combination on Barley Growth and Nitrogen Uptake under Various Watering Regimes. *Journal of Stress Physiology and Biochemistry*, *19*(4), 87–95.

Lawson, T., & Matthews, J. (2020). Guard Cell Metabolism and Stomatal Function. *Annual Review of Plant Biology*, *71*, 273–302. https://doi.org/10.1146/annurev-arplant-050718-100251

Lum, M. S., Hanafi, M. M., Rafii, Y. M., & Akmar, A. S. N. (2014). Effect of drought stress on growth, proline and antioxidant enzyme activities of upland rice. *Journal of Animal and Plant Sciences*, *24*(5), 1487–1493.

Luyckx, M., Hausman, J. F., Lutts, S., & Guerriero, G. (2017). Silicon and plants: Current knowledge and technological perspectives. *Frontiers in Plant Science*, *8*, 1–8. https://doi.org/10.3389/fpls.2017.00411

Malik, M. A., Wani, A. H., Mir, S. H., Rehman, I. U., Tahir, I., Ahmad, P., & Rashid, I. (2021). Elucidating the role of silicon in drought stress tolerance in

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2168

plants. *Plant Physiology and Biochemistry*, *165*, 187–195. https://doi.org/10.1016/j.plaphy.2021.04.021

Moeljani, I. R., Faristiawan, Y., & Sulistyono, A. S. (2021). Pengaruh Konsentrasi Pupuk Silika dan Umur Transplanting terhadap Pertumbuhan dan Hasil Bawang Merah dari Benih True Shallot Seed (TSS). *Agro Bali : Agricultural Journal*, *5*(1), 50–56. https://doi.org/10.37637/ab.v5i1.804

Nurfuad, F. L., Hidayat, T., & Utama, N. A. (2024). *Kualitas umbi benih bawang merah yang diaplikasikan dengan berbagai konsentrasi nano abu sekam secara foliar*. *1*(1), 382–400.

Pascual, M. B., Echevarria, V., Gonzalo, M. J., & Hernández-Apaolaza, L. (2016). Silicon addition to soybean (Glycine max L.) plants alleviate zinc deficiency. *Plant Physiology and Biochemistry*, *108*, 132–138. https://doi.org/10.1016/j.plaphy.2016.07.008

Polakitan, A., Salamba, H. N., & Manoppo, C. N. (2022). The Effect of Watering Techniques for Increasing the Yield of Shallots (Allium cepa L) in Dry Land. *E3S Web of Conferences*, *361*. https://doi.org/10.1051/e3sconf/202236104021

Purba, L. A. A., Hasanah, Y., & Haryati. (2015). Respons Pertumbuhan dan Produksi Bawang Merah (Allium ascalonicum L.). *Jurnal Online Agroekoteknologi*, *3*(2), 552–557. http://download.garuda.kemdikbud.go.id/article.php?article=1429680&val=4122&title=Respons Pertumbuhan Dan Produksi Bawang Merah Allium ascalonicum L terhadap Pemberian Abu Vulkanik Gunung Sinabung dan Arang Sekam Padi

Rahmawati, N., & Wulandari, N. (2024). Foliar application of SiO2 nanoparticles to increase shallot production under water stress as an effort to mitigate climate change. *IOP Conference Series: Earth and Environmental Science*, *1302*(1), 3–8. https://doi.org/10.1088/1755-1315/1302/1/012031

Ramírez-Olvera, S. M., Trejo-Téllez, L. I., Gómez-Merino, F. C., Ruíz-Posadas, L. D. M., Alcántar-González, E. G., & Saucedo-Veloz, C. (2021). Silicon stimulates plant growth and metabolism in rice plants under conventional and osmotic stress conditions. *Plants*, *10*(4). https://doi.org/10.3390/plants10040777

Rehman, M. U. (2021). Application of Silicon: A Useful Way to Mitigate Drought Stress: An Overview. *Current Research in Agriculture and Farming*, *2*(2), 9–17. https://doi.org/10.18782/2582-7146.134

Ren, F., & Zhou, S. (2021). Phenolic components and health beneficial properties of onions. *Agriculture (Switzerland)*, *11*(9). https://doi.org/10.3390/agriculture11090872

Sagar, N. A., Pareek, S., Benkeblia, N., & Xiao, J. (2022). Onion (Allium cepa L.) bioactives: Chemistry, pharmacotherapeutic functions, and industrial applications. *Food Frontiers*, *3*(3), 380–412. https://doi.org/10.1002/fft2.135

Sah, S. K., Reddy, K. R., & Li, J. (2022). Silicon Enhances Plant Vegetative Growth and Soil Water Retention of Soybean (Glycine max) Plants under Water-Limiting Conditions. *Plants*, *11*(13). https://doi.org/10.3390/plants11131687

Saja-Garbarz, D., Libik-Konieczny, M., & Janowiak, F. (2024). Silicon improves root functioning and water management as well as alleviates oxidative stress in oilseed rape under drought conditions. *Frontiers in Plant Science*, *15*(February), 1–14. https://doi.org/10.3389/fpls.2024.1359747

Sakuraba, Y. (2022). Molecular basis of nitrogen starvation-induced leaf senescence. *Frontiers in Plant Science*, *13*(September), 1–15. https://doi.org/10.3389/fpls.2022.1013304

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2168

Sansan, O. C., Ezin, V., Ayenan, M. A. T., Chabi, I. B., Adoukonou-Sagbadja, H., Saïdou, A., & Ahanchede, A. (2024). Onion (Allium cepa L.) and Drought: Current Situation and Perspectives. *Hindawi Scientifica*, 1–12. https://doi.org/10.1155/2024/6853932

Sari, V. kartika, Haryono, K., & Basuki, B. (2021). Respon Varietas Tebu Unggul Baru Terhadap Pemberian Nano Silika Dan Cekaman Kekeringan. *Jurnal Penelitian Pertanian Terapan*, *21*(2), 91–98. https://doi.org/10.25181/jppt.v21i2.1988

Sayed, E. G., Mahmoud, A. W. M., El-Mogy, M. M., Ali, M. A. A., Fahmy, M. A. M., & Tawfic, G. A. (2022). The Effective Role of Nano-Silicon Application in Improving the Productivity and Quality of Grafted Tomato Grown under Salinity Stress. *Horticulturae*, *8*(4), 1–19. https://doi.org/10.3390/horticulturae8040293

Shabir, I., Pandey, V. K., Dar, A. H., Pandiselvam, R., Manzoor, S., Mir, S. A., Shams, R., Dash, K. K., Fayaz, U., Khan, S. A., Jeevarathinam, G., Zhang, Y., Rusu, A. V., & Trif, M. (2022). Nutritional Profile, Phytochemical Compounds, Biological Activities, and Utilisation of Onion Peel for Food Applications: A Review. *Sustainability (Switzerland)*, *14*, 1–15. https://doi.org/10.3390/su141911958

Sharma, M., Delta, A. K., & Kaushik, P. (2024). Correction: Effects of Funneliformis mosseae and Potassium Silicate on Morphological and Biochemical Traits of Onion Cultivated under Water Stress (Horticulturae, (2022), 8, 7, (663), 10.3390/horticulturae8070663). *Horticulturae*, *8*, 2–9. https://doi.org/10.3390/horticulturae10080776

Sianturi, P. L., Silaen, S., & Manik, H. (2020). Pengaruh Pemberian Pupuk Kandang Ayam Dan Abu Vulkanik Terhadap Pertumbuhan Dan Produksi Bawang Merah (Allium Ascalonicum L.) Serta Ketersediaan Silika Di Lahan Sawah. *Jurnal Rhizobia*, *2*(2), 80–88. https://doi.org/10.36985/rhizobia.v9i2.309

Singh, P., Kumar, V., & Sharma, A. (2023). Interaction of silicon with cell wall components in plants: A review. *Journal of Applied and Natural Science*, *15*(2), 480–497. https://doi.org/10.31018/jans.v15i2.4352

Srivastava, A., Sharma, V. K., Kaushik, P., El-Sheikh, M. A., Qadir, S., & Mansoor, S. (2022). Effect of silicon application with mycorrhizal inoculation on Brassica juncea cultivated under water stress. *PLoS ONE*, *17*(4 April), 1–15. https://doi.org/10.1371/journal.pone.0261569

Tarigan, E., & Hasanah, Y. (2015). Respons Pertumbuhan Dan Produksi Bawang Merah (Allium ascalonicum L.) terhadap Pemberian Abu Vulkanik Gunung Sinabung dan Arang Sekam Padi. *Jurnal Online Agroekoteknologi .*, *3*(3), 956–962.

Timotiwu, P. B., . A., . E., & Amalia, S. (2018). The Effects of Foliar Boron and Silica Through the Leaves on Soybean Growth and Yield. *Journal of Agricultural Studies*, *6*(3), 34–48. https://doi.org/10.5296/jas.v6i3.13169

Tori, H., Yusuf Kholil, A., & Author, C. (2023). Prospect Analysis of Onion (allium cepa L) Production in Indonesia. *Indonesian Journal of Agriculture and Environmental Analytics (IJAEA)*, *2*(1), 1–14. https://journal.formosapublisher.org/index.php/ijaea/index

Trejo-Téllez, L. I., García-Jiménez, A., Escobar-Sepúlveda, H. F., Ramírez-Olvera, S. M., Bello-Bello, J. J., & Gómez-Merino, F. C. (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. *PeerJ*, *6*, 3–28.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2168

https://doi.org/10.7717/peerj.9224

Verma, K. K., Song, X. P., Tian, D. D., Guo, D. J., Chen, Z. L., Zhong, C. S., Nikpay, A., Singh, M., Rajput, V. D., Singh, R. K., Minkina, T., & Li, Y. R. (2021). Influence of silicon on biocontrol strategies to manage biotic stress for crop protection, performance, and improvement. *Plants*, *10*(10), 1–22. https://doi.org/10.3390/plants10102163

Wadas, W., & Kondraciuk, T. (2023). Effect of Silicon on Micronutrient Content in New Potato Tubers. *International Journal of Molecular Sciences*, *24*(13), 1–11. https://doi.org/10.3390/ijms241310578

Wang, M., Wang, R., Mur, L. A. J., Ruan, J., Shen, Q., & Guo, S. (2021). Functions of silicon in plant drought stress responses. *Horticulture Research*, *8*(1), 1–13. https://doi.org/10.1038/s41438-021-00681-1

Yang, J., Song, J., & Jeong, B. R. (2022). Drenched Silicon Suppresses Disease and Insect Pests in Coffee Plant Grown in Controlled Environment by Improving Physiology and Upregulating Defense Genes. *International Journal of Molecular Sciences*, *23*(7). https://doi.org/10.3390/ijms23073543

Yusuf, M., Nursan, M., Tajidan, T., & Rahayu, M. (2024). The Economic Value of Onion Farming Land and Its Impact on Farming Activities in Lambu District, Bima Regency. *International Journal of Innovative Research in Multidisciplinary Education*, *3*(1), 23–28. https://doi.org/10.58806/ijirme.2024.v3i1n03