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SOLUBLE SILICA MEDIATED MITIGATION OF SALT STRESS IN WHEAT (*Triticum aestivum L.*)

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Abstract: Extensive use of chemicals in agriculture poses severe threat to soil composition leading to decline in quality of crop now a days to enhance productivity is resulting in various types of negative changes in soil composition. Salt stress is one of them which is declining quality of crops. Silicon supplementation has proved beneficial in overcoming different stress in plant and resulted in enhanced yield, improved disease resistance etc. The objective of the work was to evaluate potential of soluble silica in alleviating salt stress in wheat. Study was conducted in open field on wheat (*Triticum aestivum L.*) from November 2019 to April 2020 at Loharpipliya village, Dewas road (M.P.). Four different conc. of NaCl were applied twice, on 5th day (first salt stress) and 20th day (second salt stress) of sowing seeds. Soluble silica was sprayed twice at interval of 15 days after second salt application. After 15 days of both the salt treatment there was no significant change in the levels of chlorophyll a, b and carotenoid observed across all salt treatments as compared to control. And after 15 days of soluble silica spray there was a highly significant increase was found in the content of chlorophyll a and chlorophyll b especially in plants treated with 50mM and 150mM salt treatments respectively while the change in chlorophyll a and b content was not statistically significant as compared to control. Present study revealed that soluble silica is beneficial in counteracting stress caused by the presence of sodium chloride and can enhance productivity by promoting growth of wheat.

Keywords- Carotenoid, Chlorophyll, Sodium chloride.

I. INTRODUCTION

Salt stress is one of the most prominent abiotic stresses faced by plant during growth and development (Garsallah et al., 2016). The sudden change in climatic condition and poor resources for cultivation results in increase in amount of salt in the agriculture soil. (Islam et al., 2019). The ionic imbalance and osmotic stress caused by a high salt level negatively affects plant growth (Rahneshan et al., 2018). Salt stress has adversely affected about more than 20% cultivable land due to continuous natural and anthropogenic activities (Arora, 2019). By altering soil porosity and hydraulic conductivity, salt stress can cause decrease in water availability to plants. Various physiological and metabolic changes involving germination of seed, photosynthesis, growth is negatively altered by high salt concentration (Munns, 2011). Higher salinity conditions adversely affect soil, ground water and decreases agricultural productivity (Liu et al., 2019). Imbalances caused in ionic and osmotic mechanism due to salt stress impairs plant's growth and development (Ahmad et al., 2019). Excessive salt deposition reduces the concentration of photosynthetic pigments and degrades photosynthetic machinery (Fing et al., 2018).

The second most abundant element in earth crust, silicon is considered beneficial or "quasi essential" for the growth of plants (Ma and Takahashi, 2002). Application of silicon has shown many advantages in the agricultural field such as enhanced yield, improved disease resistance etc. (Liu et al., 2019). In a study conducted on two varieties of tomato one was drought sensitive and other was drought tolerant, silicon supplementation improved different responses. In drought tolerant variety, application of silicon enhanced Sulphur and ammonium production and in sensitive variety, improved proline and GABA levels (Ali et al., 2018).

Lots of work is going on in this myriad field of agriculture to search for the ways to reduce effect of salinity stress on plant growth and metabolism. The objective of the work was to evaluate potential of soluble silica in alleviating salt stress in wheat.

II. MATERIAL AND METHOD:

Study was conducted in open field on wheat (*Triticum aestivum L.*) from November 2019 to April 2020 at Loharpipliya village, Dewas road (M.P). Geographical location of fields selected as per latitude longitude read by GPS 76 Garmin was N- 22 54'40"-41.4" E- 075 59" 35.1"- 37".

Wheat seeds were sown in square blocks of 2*2 meter^2. Randomized block design was used for treatment. Each block contains approx. 80-100 plants. Following treatments were given in respective blocks.

A B

Fig. 1 A) Sowing of wheat seeds; B) Soluble silica spray on wheat plant.

Treatments-

Treatments	Salt stress conc. in mM
T1	Control- no salt stress
T2	50mM Salt conc.
T3	50mM Salt conc. + Soluble silica spray
T4	100mM Salt conc.
T5	100mM Salt conc. + Soluble silica spray
T6	150mM Salt conc.
T7	150mM Salt conc. + Soluble silica spray
T8	200mM Salt conc.
T9	200mM Salt conc. + Soluble silica spray

Salt stress was given in soil in the form of sodium chloride. Four different conc. of NaCl were applied twice, on 5th day (first salt stress) and 20th day (second salt stress) of sowing seeds. Firstly the sample was collected after 15 days of second salt stress i.e. 35th day. Then the plants were sprayed with soluble silica (7.5 ml/L) two times i.e. on 35th day (first silica treatment) and 50th day (second silica treatment). Sample were again collected after 15th day of each soluble silica treatment i.e. on 50th day and 65th day.

Parameters studied: -

1. Number of leaves
2. Shoot length- It was recorded by using the standard inch tape.
3. Chlorophylls and carotenoids content- Wheat leaves sample 200 mg was extracted in 2 ml of 80% acetone and absorbance at 646, 663 and 470 nm was read in spectrophotometer. Their concentration was calculated using the equation of Lichtenthaler and Welburn (1983).

Formula-

Chlorophyll a in mg/g tissue=12.21(A_{663})-2.81(A_{646})

Chlorophyll b in mg/g tissue =$20.13(A_{646})-5.03(A_{663})$

Carotenoid in mg/g tissue = $[1000(A_{470})-3.27(\text{Chl a})-104\ (\text{Chl b})]/229$

III. RESULT AND DISCUSSION: -

Treatments	Height			No. of leaves		
	After 15 days of 2nd NaCl Treatment	After 15 days of first SS spray	After 15 days of 2nd SS spray	After 15 days of 2nd NaCl Treatment	After 15 days of first SS spray	After 15 days of 2nd SS spray
T1	53.33±2.51	85.66±4.16	89.33±2.30	4.66±0.57	5.33±0.58	5.33±0.57 ^{NS}
T2	55.66±2.51`a^{NS}	92.66±3.78 ^{aNS}	97±1a ***	5.33±0.57 ^{aNS}	5.33±0.58 ^{aNS}	5.66±0.57 ^{aNS}
T3	60.66±4.93 ^{aNS}	92.33±5.13a^{NS},b^{NS}	100.66±1.52a**,b*	6.33±0.57a*	5.33±0.57 $^{aNS, bNS}$	5.66±0.57 $^{aNS, bNS}$
T4	61±3a*	92.66±2.08a ^{NS}	98.33±2.08a**	6.66±0.57a**	5.66±0.57 ^{aNS}	5.33±0.57 ^{aNS}
T5	56.33±0.57 ^{aNS}	85.66±3.78a^{NS},b^{NS}	97±1.73 ^{a*,b*}	6.33±0.57a*	5.33±1.15 $^{aNS, bNS}$	5.33±0.57 $^{aNS, bNS}$
T6	57±2.64 ^{aNS}	74±3.46a*	95±3.46a ^{NS}	5.66±0.57 ^{aNS}	5.66±0.57 ^{aNS}	4.66±0.57 ^{aNS}
T7	62±2 a**	71.66±3.21a**,b^{NS}	89.33±6.42 $^{aNS, bNS}$	6.33±0.57a*	5.33±0.57 $^{aNS, bNS}$	4.660.57 $^{aNS, bNS}$
T8	54.66±0.57 ^{aNS}	68±4.58a**	83±5.29a ^{NS}	5.33±0.57 ^{aNS}	5.66±0.57 ^{aNS}	4.66±0.57 $^{a`NS}$
T9	62.66±2.08a**	71.33±6.4a*,b^{NS}	85.33±1.52 $^{aNS, bNS}$	5.66±0.57 ^{aNS}	5±1 $^{aNS, bNS}$	4.33±0.57 $^{aNS, bNS}$

Table 1. The effect of different salt treatments and soluble silica on growth parameters of *Triticum aestivum L.* (Wheat).

*indicates p value <0.05 and is Significant, ** indicates p value <0.01 and is highly significant, *** indicates p value <0.001 and is extremely significant, NS-non significant, a = p-value compared to control, b = p- value compared to respective salt treatment,

Growth parameters- As seen in table 1. there was highly significant increase observed in plant height among those treated with 150mM and 200mM salt solutions and in no. of leaves with all treatments as compared to control except 200mM salt treatment. As compared to control, reduction in plant height was observed to be significant with 150mM and above concentration, after 15 days of first soluble silica spray. In case of plant height and no of leaves no significant change was found in all soluble silica sprayed plants as compared to control. According to Aouz *et al.*, (2023) taller plants (54.77 cm) with more leaves per plant (LPP: 11.75) were recorded after treatment with Si, and shorter plants with low LPP were observed in case of combined salinity and heat stress. Impact of salt stress on five varieties of Wheat (Triticum aestivum L.) cultivars under laboratory condition was studied by Datta *et al.*, 2010. The data showed that different level of salinity significantly affected the growth attributes by reducing root and shoot length for salinity below 125mM. According to kowalska *et al.*, (2020) the foliar spray of orthosilicic acid (Si) increased plant height of wheat grown under salt stress. Rizwan *et al.*, (2015) suggested that silica increased plant growth by balancing water and nutrient content. However present study result reveals that concentration of silica used was able to mitigate salt stress on only growth of wheat up to 50mM salt concentration.

Treatments	Chlorophyll a (in µg/g)			Chlorophyll b (in µg/g)		
	After 15 days of NaCl Treatment	After 15 days of Ist SS spray	After 15 days of SS 2nd spray	After 15 days of NaCl Treatment	After 15 days of Ist SS spray	After 15 days of SS 2nd spray
T1	13.51 ± 4.11	15.87±0.69	22.57±0.14	15.01±6.40	37.67±1.07	33.70±5.92
T2	9.98±5.53 ^{aNS}	14.12±0.44a*	18.82±0.06a***	9.49±5.59 ^{aNS}	19.540.12a***	29.26±5.87 ^{aNS}
T3	14.12±0.12 ^{aNS}	18.14±1.43 $^{aNS, b**}$	19.47±0.12a*,b***	14.12±0.88 ^{aNS}	27.09±0.2a***, b^{NS}	27.19±0.75 $^{aNS, bNS}$
T4	15.53±0.18 ^{aNS}	19.03±0.35a*	22.13±0.20aNS	16.28±0.81 ^{aNS}	27.16±0.42a***	36.62±0.61 ^{aNS}
T5	16±0.07 ^{aNS,}	19.32±0.25a*,b^{NS}	22.43±0.07 $^{aNS, bNS}$	16.48±0.46 ^{aNS}	19.60±0.20a***,b^{NS}	27.22±0.31 $^{aNS, bNS}$
T6	16.2±0.12 ^{aNS}	16.04±0.48 ^{aNS}	19.96±0.12a***	17.09±0.50a ^{NS}	22.37±0.23a***	28.84±0.12 ^{aNS}
T7	16.06±0.13 $^{aNS, dNS}$	15.41±1.045 ^{aNS,bNS}	22.46±0.07 $^{aNS, bNS}$	18.23±0.20 ^{aNS}	23.52±0.64a***,b*	39.86±0.20 $^{aNS, bNS}$
T8	15.63±0.54 ^{aNS}	15.13±2.07 ^{aNS}	19.83±0.32a***	17.29±1.22 ^{aNS}	23.32±2.69a***	27.56±0.12 ^{aNS}
T9	15.47±0.27 ^{aNS,}	16.25±0.85a*,b^{NS}	23.89±0.14a***,b^{NS}	15.79±0.42 ^{aNS}	24.76±2.37a***,b^{NS}	39.45±0.34 $^{aNS, bNS}$

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Treatments	Carotenoid (in µg/g)		
	After 15 days of NaCl Treatment	After 15 days of SS spray	After 15 days of SS 2nd spray
T1	0.03±0.02	0.014±0.0005	0.11±0.04
T2	0.01±0.01a^{NS}	0.03±0.017a^{NS}	0.07±0.04 ^{aNS}
T3	0.01±0.001 ^{aNS}	0.088±0.008a^{***,b**}	28.60±0.08 ^{aNS,bNS}
T4	0.02±0.002a ^{NS}	0.08±0.0005a***	28.16±0.23a^{NS}
T5	0.04±0.003 ^{aNS}	0.041±0.010a^{*,b***}	28.26±0.14 ^{aNS,bNS}
T6	0.05±0.002a ^{NS}	0.062±0.003a***	27.97±0.31a^{NS}
T7	0.05±0.001 ^{aNS}	0.078±0.005a^{***,b**}	27.02±0.17 ^{aNS,b**}
T8	0.04±0.009 ^{aNS}	0.080±0.02a**	27.13±0.30a^{NS}
T9	0.03±0.004 ^{aNS}	0.096±0.015a^{***,bNS}	25.25±0.40 ^{aNS,b**}

Table 2. The effect of different salt treatments and soluble silica on pigments in leaves of *Triticum aestivum L.* (Wheat).

*indicates p value <0.05 and is Significant, ** indicates p value <0.01 and is highly significant, *** indicates p value <0.001 and is extremely significant, NS-non significant, a = p-value compared to control, b = p- value compared to respective salt treatment.

Table 3. Showing the effect of different salt treatments and soluble silica on pigments in leaves of *Triticum aestivum L.* (Wheat).

*indicates p value <0.05 and is Significant, ** indicates p value <0.01 and is highly significant, *** indicates p value <0.001 and is extremely significant, NS-non significant, a = p-value compared to control, b = p- value compared to respective salt treatment.

In the present study, after 15 days of salt treatment there was no significant change in the levels of chlorophyll a, b and carotenoid observed across all salt treatments as compared to control. Spray of soluble silica cause highly significant increase in the content of chlorophyll a and chlorophyll b especially in plants treated with 50mM salt treatments respectively while the change in chlorophyll a and b content was not statistically significant as compared to control (Table 2). Alleviative effect of soluble silica on chlorophyll a was seen only after first spray in case of 50 mM salt conc. According to Li *et al*., (2015) application of silicon improved tomato growth, photosynthetic pigment and soluble protein contents, net photosynthetic rate and root morphological traits under salt stress. Exogenous Si supplementation induce a significant increase in chlorophyll quantity in tomato in the presence or absence of salt stress (Alam *et al*., 2022). In some plant decrease is observed in chlorophyll content and in some chlorophyll content increase under stress (Sepehri and Golparvar, 2011). Beneficial role of soluble silica in enhancing chlorophyll content in onion Leaves was studied. All the three concentrations of silica *viz*, 7.5, 10, 12.5 ml/ lit have the same effect on chlorophyll and carotenoid content (Rangwala *et al*., 2019). Hajiboland and Cheraghvareh (2014) reported that Supplementation with silica increased chlorophyll a, b and carotenoid concentration in control and salt stressed in tobacco leaves. Chlorophyll contents were lower in both cultivars grown at high salinity compared to control values; lowest values were in Izmir-85(Tuna *et al*., 2008)

However in case of carotenoid soluble silica spray resulted in extremely significant increase up to 150mM salt treatments, while no statistically significant change was noted in 200mM salt treatment (Table 3). After 15 days of second soluble silica spray highly significant increase was found in 150mM and 200mM salt treatments while no significant change was found in 50mM and 100mM salt treatments as compare to control.

IV. CONCLUSION

These results seem to show that silicon may alleviate salt stress in wheat by decreasing the permeability of plasma membranes to Na while maintaining integrity with respect to K and Ca. It can be concluded that application of soluble silica helps to enhances productivity by improving rate of photosynthesis. Present study revealed that concentration used of soluble silica is beneficial in counteracting stress caused by the presence of sodium chloride at low concentration. To alleviate salt stress at high concentration, increased concentration of soluble silica could be studied in wheat.

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