EFFECT OF SELENIUM ON SALT TOLERANCE IN MAIZE PLANTS

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ABSTRACT

Two pot experiments during the seasons of 2017 and 2018 were conducted to investigate the effect of Se as Na₂SeO₄ (2.5 and 5 µM) as foliar applications on growth, photosynthetic pigments, Na/K homeostasis and eventually the yield of maize plants grown under three different levels of salinity (0, 50 and 100 mM NaCl). The results indicated that Se at 2.5 µM recorded the highest significant values in leaves and stem dry weights, total grain yield plant⁻¹ and grain filling as indicated by the weight of 100 kernels; as well as, Chl a, Chl b and K concentrations. On contrary, there was a significant decrease in Na concentration and Na/K ratio. Additionally, carotenoids did not reveal any significant changes between Se-treated plants and the untreated ones.

Key words: Zea mays, selenium, salinity, pigments, ionic balance and yield.

INTRODUCTION

Salinity is considered one of the most environmental factors that drastically restrict plant growth and productivity (Dash and Panda, 2001; Schleiff, 2008). It can accelerate senescence, leaf abscission and plant death (Allu et al., 2014; Sade et al., 2017). Additionally, salt stress can negatively affect photosynthesis (Munns and Tester, 2008; Hniličková et al., 2017), water absorption (Munns, 2002), nutrient balance (Munns, 2005) and hormone metabolism (Fahad et al., 2015). It can also disturb the stability of
cell membranes, activity of enzymatic systems, and production of reactive oxygen species (ROS) (Pang and Wang, 2008; Jamil et al., 2012).

Maize (Zea mays) represents the third most important cereal crops cultivated worldwide after wheat and rice. It has a high nutritional value for both human and animal and provides suitable raw materials for several industries such as starch, fodder, silage and biofuels (Dhugga, 2007; Ostrander, 2015; Kleinmans et al., 2016). Under saline conditions, maize plants could demonstrate severe damages and significant losses in their growth and yield (Farooq et al., 2015).

Selenium (Se) is an essential trace element with dual effects on the higher plants; At low concentrations, it stimulates plant growth (Turakainen et al., 2004), photosynthesis (Habibi, 2017), antioxidant capacity (Jiang et al., 2017), delay senescence (Xue et al., 2001) and induce tolerance to various abiotic stresses including drought (Germ et al., 2007; Ibrahim and Ibrahim, 2016), salinity (Hawrylak-Nowak, 2009; Jiang et al., 2017; Elkelish et al., 2019), heavy metals (Cartes et al., 2010), UV-irradiation (Valkama et al., 2003), cold (Chu et al., 2010), high temperatures (Djanaguiraman et al., 2010) and oxidative stress (Hasanuzzaman et al., 2010). Adversely, at high concentrations, Se could be toxic because it may be similar and replaced with Sulphur in amino acids and consequently corrupt the three-dimensional structure of proteins and enzymatic functions (Amweg et al., 2003).
Currently, with global climatic changes and scarcity of freshwater particularly in the arid and semi-arid regions like Egypt, increasing the risk of soil salinization has become one of the most challenges that could threaten the existence of mankind by affecting sustainable agriculture and different socio-economic activities. Therefore, this study aimed to know the possible role of foliar application of Se as Na$_2$SeO$_4$ (0, 2.5 and 5 µM) on regulating maize salt tolerance by affecting its growth, yield and several biochemical constituents.

**MATERIALS AND METHODS**

**Experiment Layout and growth conditions:** Two pot experiments were conducted on 25$^{th}$ and 22$^{nd}$ of May 2017 and 2018 respectively in the Experimental Farm, Faculty of Agriculture, Ain Shams University, Cairo, Egypt to investigate the effect of foliar applications with distilled water as a control and selenium (Se) as Na$_2$SeO$_4$ (2.5 and 5 µM) on maize plants irrigated with three different concentrations of saline water (0, 50 and 100 mM NaCl). The foliar application of Na$_2$SeO$_4$ was done twice at 30 and 60 days after sowing; whereas, the irrigation with saline water was started at 36 days after sowing (vegetative growth stage). The experimental design was split plot with Completely Randomized Block Design (CRBD) of main plots. All pots (324) were divided to three equal main groups as replicates. Different saline irrigation treatments were distributed randomly into each replicate as main plots and the foliar treatments as sub-plots. All different treatments of...
irrigation and foliar applications to each experiment were respectively arranged as follow:
Seeds of maize hybrid triple white (Giza 310) were purchased from The Agriculture Research Center, Giza, Egypt. Five seeds were sown in plastic pots 50 cm length X 30 cm width filled with 27 kg pre-washed sand. After three weeks, pots were thinned to one uniform seedling in size to each pot in order to homogenize the plant material used in the experiments. Applied fertilizers were calculated per pot as recommended by Egyptian Ministry of Agriculture in sandy soil. In the first dose, each pot was provided with 1.6 g calcium triple superphosphate (37.5% P₂O₅), 2.1 g ammonium nitrate (33.5% N) and 1.9 g potassium sulfate (48% K) at two weeks after sowing. In the second and third doses, equal amounts of N and K fertilizers were provided with two weeks intervals at 30 and 45 days after sowing. The other macro and micronutrients, disease and pest control programs were also followed according to the recommendations of Egyptian Ministry of Agriculture.
Studied parameters

Vegetative growth

The leaves, stem and total shoot dry weight of maize plants were determined at 90 days after sowing, the samples were cleaned by washing with tap water then dried in an air-forced ventilated oven at 70 °C until a constant weight.

Biochemical constituents

Leaf pigments

Chlorophyll a, b and carotenoids were extracted in pure acetone and determined as described by Costache et al. (2012). The concentrations were calculated using the following equations:

\[
\text{Chlorophyll a} = 11.75 \times A_{662} - 2.350 \times A_{645} \\
\text{Chlorophyll b} = 18.61 \times A_{645} - 3.960 \times A_{662} \\
\text{Carotenoids} = 1000 \times A_{470} - 2.270 \times \text{Chl a} - 81.4 \times \text{Chl b}/227. 
\]

Leaf Mineral Concentration: Dry leaves were grounded and digested using sulphuric acid and hydrogen peroxide. Leaf mineral concentrations of Na and K were determined according to Cottenie et al. (1982).

Yield and its components: Ears of maize plants were harvested at 115 days after sowing; the total amount of grains (g. plant\(^{-1}\)) and 100 kernel weights were estimated.

Statistics: Data were analyzed using SAS (1988). Means were calculated and Duncan’s multiple range test (P\(\leq\) 0.05) was used to determine the significant differences between means.
RESULTS AND DISCUSSION

Vegetative growth: Data presented in Table 1 show that increasing the level of salinity negatively affected ($P \leq 0.05$) leaves, stem and total shoot dry weights of maize plants. In this regard, the lowest significant ($P \leq 0.05$) values were observed at high salinity level (100 mM) compared to the moderate one (50 mM) and those that had grown in the absence of applied NaCl. Maize has been known as the most susceptible crop of cereals to salt stress (Katerji et al., 1996) In several previous studies, it was established that all growth parameters including plant length, shoot fresh and dry weights, leaf and internode growth rate of maize plants had been reduced by exposing to a wide array of NaCl salt concentrations (Cramer et al., 1994; Parvaiz, 2014; Soufan and Okla, 2014; Farooq et al., 2015); These effects could be directly attributed to decrease the rate of cell division and elongation (Barakat, 2003; Tabur and Demir, 2010; Valenzuela et al., 2016) through affecting the activities of some transport proteins like H$^+$-PPase and H$^+$-ATPase (Shi et al., 2007) or indirectly by affecting multiple vital processes including protein, DNA and RNA synthesis, enzyme function, photosynthesis and respiration (Seckin et al., 2009; Sabbagh et al., 2014; Farooq et al., 2015).
Table (1): Effect of foliar application of Na$_2$SeO$_4$ at 0 (distilled water) as a control, 2.5 and 5 µM on some growth parameters of maize plant irrigated with three different concentrations of saline water as NaCl at 90 days after sowing.

| Na$_2$SeO$_4$ (µM) | Salinity levels as NaCl | Mean | Salinity levels as NaCl | Mean |
|---------------------|-------------------------|------|-------------------------|------|
|                     | 0 mM  | 50 mM  | 100 mM |               | 0 mM  | 50 mM  | 100 mM |
|                     | 2017  | 2018   |        |                  |       |        |        |
| Leaves dry weight (g. plant$^{-1}$) |          |      |        |                  |       |        |        |
| 0                   | 58.76 ab | 48.11 cde | 39.06 f | 48.64 B | 66.91 ab | 58.75 cd | 48.72 f | 58.13 B |
| 2.5                 | 63.05 a  | 54.75 bc | 44.00 def | 53.94 A | 71.65 a  | 62.61 bc | 54.70 de | 62.99 A |
| 5                   | 61.92 a  | 50.05 cd | 42.66 ef | 51.55 AB | 69.93 a  | 60.06 c  | 51.74 ef | 60.57 AB |
| Mean                | 61.25 A  | 50.97 B  | 41.91 C |       | 69.50 A  | 60.47 B  | 51.72 C |

Stem dry weight (g. plant$^{-1}$)

|                     | Mean |      |       |                  |       |        |        |
|---------------------|------|------|--------|                  |       |        |        |
| 0                   | 203.97 ab | 169.10 c | 160.62 c | 177.9 0 B | 247.87 b | 190.72 cd | 158.31 e | 198.97 B |
| 2.5                 | 229.68 a  | 186.86 bc | 176.59 bc | 197.7 1 A | 276.22 a  | 211.95 c  | 171.95 de | 220.04 A |
| 5                   | 224.86 a  | 187.27 bc | 170.09 c  | 194.0 7 AB | 256.61 ab | 208.38 c  | 167.01 e  | 210.66 AB |
| Mean                | 219.50 A  | 181.07 B  | 169.10 B  |       | 260.23 A  | 203.68 B  | 165.75 C |

ISSN 1110-0826
Respecting the effect of foliar applications of Se, it can be observed that all investigated growth parameters (leaves, stem and total soot dry weights) was enhanced by both examined foliar treatments of Se at 2.5 or 5 µM compared to the control in the two seasons. In this respect, the highest significant ($P \leq 0.05$) increases in shoot dry weight were obtained by the lower concentration of Se at 2.5 µM compared to the other treatments in both seasons. Under salt stress, exogenous applied-Se was showed to stimulate growth of many plant species such as canola (Hashem et al., 2013), tomato (Diao et al., 2014) lettuce (Khalifa et al., 2016), maize (Jiang et al., 2017) and wheat (Elkelish et al., 2019). This positive effect could be due to that applied-Se could be implicated in photosynthesis and regulating of water status and ionic balance of salt-affected plants; Furthermore, it can act as an antioxidant by increasing the activities of both enzymatic and non-enzymatic antioxidant
systems leading to reducing NaCl-induced oxidative damages (Jiang et al., 2017; Elkelish et al., 2019).

Regarding the effect of interaction between the different levels of salinity and Se-applications, it can be noticed that the treatment of Se at 2.5 µM under non-saline conditions gave the highest significant ($P \leq 0.05$) results in all studied growth parameters compared to the untreated control in both seasons; whereas, under saline conditions, with exception of leaves dry weight in the second season, the general tendency was that no significant differences were detected between both Se foliar applications and the untreated plants in both seasons.

**Photosynthetic pigments:** Data in Table 2 show that under saline conditions, photosynthetic pigments including chlorophylls (Chl a and Chl b) and carotenoids were significantly ($P \leq 0.05$) decreased by raising the level of salinity. These effects could be attributed to that salt stress dramatically alters the chloroplast ultrastructure (Zhang et al., 2010) and consequently its pigment complex composition (Parida et al., 2003), it causes a considerable elevating in the concentration of reactive oxygen species (ROS) (Menezes-Benavente et al., 2004; Elkelish et al., 2019) leading to fast degradation to the leaf pigments.

Concerning the effect of Se treatments, it can be observed that both examined concentrations of Se exhibited an improving in the concentrations of chlorophylls (Chl a and Chl b). In this regard, it was found that the treatment of Se at 2.5 µM revealed the highest significant ($P \leq 0.05$) increases
in both traits compared to the untreated control in both seasons. On the other hand, no significant differences were observed between all foliar treatments in respect to the concentration of carotenoids.

Improving the concentration of chlorophylls in the Se-treated plants in comparison to the untreated ones had been reported in many previous studies (Moldovan et al., 2009; Saffaryazdi et al., 2012; Ibrahim and Ibrahim, 2016; Elkelish et al., 2019). Selenium at optimal concentration may be involved in enhancing leaf pigments by increasing the capacity of antioxidants and delaying the leaf senescence (Germ et al., 2007; Elkelish et al., 2019). In this context it was found that applied Se increased the activities of several antioxidant enzymes and inhibited the excessive release of ROS (Hartikainen et al., 2000; Ibrahim and Ibrahim, 2016). Conversely, under the circumstances of this study, the non-significant changes in carotenoids between all Se-treated plants and those that untreated indicate that in maize plants, Se may be related to another antioxidant systems or it has not been involved in the pathway of the biosynthesis of carotenoids.

Concerning the effect of interaction, it is obvious that the treatment of Se at 2.5 µM achieved the highest values ($P \leq 0.05$) of Chl a under all levels of salinity in both seasons respectively. On the other hand, all foliar treatments did not affect the concentration of Chl b and carotenoids under the same level of salinity in both seasons.
**Table (2):** Effect of foliar application of Na$_2$SeO$_4$ at 0 (distilled water) as a control, 2.5 and 5 µM on photosynthetic pigments of maize plant irrigated with three different concentrations of saline water as NaCl at 90 days after sowing.

| Na$_2$SO$_4$ (µM) | Salinity levels as NaCl | Mean | Salinity levels as NaCl | Mean |
|------------------|------------------------|------|------------------------|------|
|                  | 0 mM | 50 mM | 100 mM | 2017 |                  | 0 mM | 50 mM | 100 mM | 2018 |
| 0                |      |       |        |      |                  |      |       |        |      |
| 2.5              |      |       |        |      |                  |      |       |        |      |
| 5                |      |       |        |      |                  |      |       |        |      |
| Mean             |      |       |        |      |                  |      |       |        |      |

| Chl a (mg/g f.wt) | 2.49 b | 2.19 d | 1.90 f | 2.19 C | 2.54 ab | 2.22 c | 1.98 d | 2.25 B |
|------------------|---------|--------|--------|--------|---------|--------|--------|--------|
| 2.5              | 2.60 a  | 2.30 c | 2.02 e | 2.31 A | 2.65 a  | 2.44 b | 2.07 cd| 2.39 A |
| 5                | 2.52 ab | 2.25 cd| 1.99 e | 2.25 B | 2.60 ab | 2.40 b | 2.02 d | 2.34 AB|
| Mean             | 2.53 A  | 2.25 B | 1.97 C |        | 2.60 A  | 2.35 B | 2.03 C |        |

| Chl b (mg/g f.wt) | 1.40 a | 1.22 bc | 1.19 c | 1.27 B | 1.48 a | 1.25 bcd | 1.15 e | 1.29 B |
|------------------|--------|---------|--------|--------|--------|----------|--------|--------|
| 2.5              | 1.47 a | 1.29 b  | 1.25 bc| 1.34 A | 1.55 a | 1.32 b   | 1.21 cde| 1.36 A |
| 5                | 1.43 a | 1.25 bc | 1.22 bc| 1.30 AB| 1.52 a | 1.30 bc  | 1.18 de| 1.33 AB|
| Mean             | 1.43 A | 1.25 B  | 1.22 B |        | 1.52 A | 1.29 B   | 1.18 C |        |
Cont. Table (2):

|       | Carotenoids (mg/g-1 f.wt) |
|-------|---------------------------|
| 0     | 0.53 ab                    |
|       | 0.46 bc                    |
|       | 0.39 c                     |
|       | 0.46 A                     |
|       | 0.69 ab                    |
|       | 0.61 c                     |
|       | 0.50 d                     |
|       | 0.60 A                     |
| 2.5   | 0.56 a                     |
|       | 0.50 ab                    |
|       | 0.41 c                     |
|       | 0.49 A                     |
|       | 0.73 a                     |
|       | 0.64 bc                    |
|       | 0.53 d                     |
|       | 0.63 A                     |
| 5     | 0.55 ab                    |
|       | 0.48 abc                   |
|       | 0.40 c                     |
|       | 0.48 A                     |
|       | 0.71 a                     |
|       | 0.62 bc                    |
|       | 0.51 d                     |
|       | 0.61 A                     |
| Mean  | 0.55 A                     |
|       | 0.48 B                     |
|       | 0.40 C                     |
|       | 0.71 A                     |
|       | 0.63 B                     |
|       | 0.51 C                     |

In each variable, data followed by the same letters (small letters for interactions and capital letters for means) are not significantly different using Duncan multiple range test at 5% level.

Leaf Na, K concentration and Na/K ratio: Data presented in Table 3 show that NaCl stress leading to a significant ($P \leq 0.05$) increase in the concentration of Na in leaves Compared to control plants in both seasons. This accumulation was pronounced and significant ($P \leq 0.05$) between all investigated levels of salinity in the second season. On contrary, there was a significant ($P \leq 0.05$) decrease in the uptake of K in parallel with increasing the level of salinity in both seasons. These responses were directly reflected on Na/K ratio which was increased in the salt stressed plants compared to the unstressed plants in both seasons. It is well documented that Na is the main toxic ion which can interfere with uptake of K and the other nutrients in maize plants (Fortmeier and Schubert, 1995; Sumer, 2004; Eker et al., 2006). These responses could be attributed to the competition between the two elements under salt stress (Azevedo Neto and Tabosa, 2000; Shahzad et al., 2012).
As for the effect of foliar applications, it can be observed that Se-treated plants demonstrated a decrease in Na and increase in K relative to the untreated control in both seasons. In comparison to the untreated control, these findings reached the level of significance particularly by the treatment of Se at 2.5 µM in respect to K in the first season and Na in the second one respectively. A similar trend to Na was observed in regard to Na/K ratio in both seasons. These results could be explained by, that plants treated by Se specifically at the optimum concentration increase the activities of tonoplast H\(^+\) ATPase and Na\(^+\)/H\(^+\) anti-port in the roots leading to prevent of Na to reach the upper tissue (Zhang et al., 2006). On the other hand, increasing of K and decreasing of Na/K ratio in Se-treated plants under saline conditions could help in readjustment of osmotic balance and protect the essential processes (Gupta and Gupta, 2017).

Respecting the effect of interaction, it is obvious that generally, the treatment of Se at 2.5 µM achieved the lowest decreases in Na concentration and Na/K ratio; whereas, an opposite trend was observed in respect to K compared to the plants did not receive foliar treatment under all investigated levels of salinity in both seasons.
Table (3): Effect of foliar application of Na₂SeO₄ at 0 (distilled water) as a control, 2.5 and 5 µM on the concentrations of Na, K and Na/K ratio in the leaves of maize plant irrigated with three different concentrations of saline water as NaCl at 90 days after sowing.

| Salinity levels as NaCl | Mean | Salinity levels as NaCl | Mean |
|-------------------------|------|-------------------------|------|
| Na₂So₄ (µM)             |      |                         |      |
| 0 mM                    | 50 mM| 100 mM                  | 0 mM | 50 mM | 100 mM |
| 2017                    | 2018 |

| Na% | 0    | 2.5  | 5    | Mean |
|-----|------|------|------|------|
| 0   | 0.81 bcd | 0.75 d | 0.79 cd | 0.78 B |
| 2.5 | 1.03 a | 1.01 ab | 1.00 ab | 1.00 A |
| 5   | 1.08 a | 0.94 a | 1.04 a | 1.04 A |
| Mean| 1.04 A | 1.04 A | 0.89 C | 1.16 A |

| K% | 0    | 2.5  | 5    | Mean |
|----|------|------|------|------|
| 0  | 1.09 bc | 1.20 a | 1.15 ab | 1.15 A |
| 2.5| 0.97 de | 1.05 cd | 1.00 cd | 1.00 B |
| 5  | 0.81 f | 0.89 ef | 0.84 f | 0.85 C |
| Mean| 1.00 B | 1.00 B | 0.85 C | 0.86 C |

| Na/K ratio | 0    | 2.5  | 5    | Mean |
|------------|------|------|------|------|
| 0          | 0.74 cd | 0.63 d | 0.69 d | 0.69 C |
| 2.5        | 1.06 ab | 1.14 ab | 1.24 ab | 1.24 A |
| 5          | 1.35 a | 0.94 A | 0.98 A | 0.93 B |
| Mean       | 1.05 A | 0.72 f | 0.76 ef | 0.76 C |

In each variable, data followed by the same letters (small letters for interactions and capital letters for means) are not significantly different using Duncan multiple range test at 5% level.
Yield and its components: Data presented in Table 4 show that generally, increasing the level of salinity resulted in significant ($P \leq 0.05$) decreases in ear weight (g.plant$^{-1}$), weight of kernels (g.ear$^{-1}$) and weight of 100 kernels (g). Several previous studies reported that salt stress especially during the reproductive phase causes reduction in the total yield of maize plants by affecting the number or weight of grains (Kaya et al., 2013). These influences could be related to the reduction that occur in photosynthesis and assimilate translocation from sources (leaves) to sinks (grains) leading to abortion or poor grain setting and filling (Lohaus et al., 2000; Schubert, 2011).

Respecting the effect of Se, it can be observed that all yield studied traits were enhanced by both investigated concentrations of of Se at 2.5 or 5 µM compared to the untreated plants. Generally, the highest significant findings were obtained by the treatment of Se at 2.5 µM in both seasons. Improving the quantity and quality of yield by Se as exogenous application either under normal or adverse conditions had been proved in many plant species including canola (Zahedi et al., 2009) potato (Ibrahim and Ibrahim, 2016), wheat (Shahzadi et al., 2017) and faba bean (Desoky et al., 2017). In this study, the positive effect of Se on plant growth (Table 1), photosynthetic pigments (Table 2) and Na/K homeostasis (Table 3) could be reflected on the final yield of grains and its filling in the salt-stressed maize plants compared to the unstressed ones in both seasons.

Concerning the effect of interaction, it can be noticed that the treatment of Se at 2.5 µM gave the highest significant increases in the yield of maize
plants under different levels of salinity. These results reflected the crucial role of Se in different vital processes in maize plants under normal or stressful conditions.

**Table (4):** Effect of foliar application of Na$_2$SeO$_4$ at 0 (distilled water) as a control, 2.5 and 5 µM on the yield/plant and its components of maize plants irrigated with three different concentrations of saline water as NaCl at 90 days after sowing.

| Na2So 4 (µM) | Salinity levels as NaCl | 0 mM | 50 mM | 100 mM | Mean | 0 mM | 50 mM | 100 mM | Mean |
|--------------|-------------------------|------|-------|--------|------|------|-------|--------|------|
|              |                         | 2017 | 2017  | 2017   | 2017 | 2017 | 2017  | 2017   | 2017 |
| 0            |                         |      |       |        |      |      |       |        |      |
| 2.5          |                         |      |       |        |      |      |       |        |      |
| 5            |                         |      |       |        |      |      |       |        |      |
| Mean         |                         |      |       |        |      |      |       |        |      |

### Ear weight (g. plant$^{-1}$)

|          | 2017 | 2017 | 2017 | 2017 | 2017 | 2017 | 2017 | 2017 | 2017 |
|----------|------|------|------|------|------|------|------|------|------|
| 0        | 405.17 b | 370.67 d | 335.67 f | 370.50 C | 413.17 a | 369.17 d | 328.17 f | 370.17 C |
| 2.5      | 424.33 a | 390.67 c | 355.00 e | 390.00 A | 431.38 a | 381.17 c | 342.17 e | 384.91 A |
| 5        | 415.45 ab | 380.21 cd | 345.33 ef | 380.33 B | 425.00 a | 376.50 cd | 334.50 ef | 378.67 B |
| Mean     | 414.98 A | 380.51 B | 345.33 C | 423.18 A | 375.61 B | 334.94 C |

### Weight of kernels (g. Ear$^{-1}$)

|          | 2017 | 2017 | 2017 | 2017 | 2017 | 2017 | 2017 | 2017 | 2017 |
|----------|------|------|------|------|------|------|------|------|------|
| 0        | 174.99 bc | 162.20 d | 136.15 f | 157.78 B | 186.82 bc | 177.60 d | 149.81 e | 171.41 C |
| 2.5      | 183.18 a | 170.33 cd | 144.44 e | 165.98 A | 197.10 a | 186.15 bc | 157.08 e | 180.11 A |
| 5        | 179.72 ab | 165.41 d | 140.42 ef | 161.85 AB | 191.75 ab | 181.59 cd | 153.42 e | 175.59 AB |
| Mean     | 179.30 A | 165.98 B | 140.34 C | 191.89 A | 181.78 B | 153.44 C |
In each variable, data followed by the same letters (small letters for interactions and capital letters for means) are not significantly different using Duncan multiple range test at 5% level.

### CONCLUSION

The present study indicated that application of Se at low concentration (2.5 µM) enhanced growth, leaf pigments, the balance between Na and K and eventually the yield and its components of maize plants under salt stress conditions. Selenium as foliar applications could be recommended in order to mitigate the adverse effects of salt stress on maize plants.

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ناشر النتائج

نشرت تجربتي أصول موسمي 2017 و 2018 لاختبار تأثير السيلينيوم كرش ورقي في صورة (Na2SeO4) بتركيز 2.5 و 5 ميكرومولار على النمو، صبغات البناء الضوئي، والتنازع بين Na+ والمحصول للبذورات تحت ثلاث مستويات من الملح (0، 50 و 100 مليمولار NaCl). وقد دلت النتائج على أن معاملة 2.5 ميكرومولار حققت أعلى قيم معنوية في الوزن الجاف للدراز والسيقان، كلونيفيل ب و K، محصول الحبوب الكلي وامتلاء الحبوب من خلال وزن ال100 حبة. على العكس من ذلك، كان هناك نقص معنوي في تركيز Na من خلال وزن ال100 حبة. على العكس من ذلك، كان هناك نقص معنوي في تركيز Na. بينما لم تتب تغيرات معنوية بين النباتات المعالمة بالسيلينيوم وغير المعالمة.

الكلمات الدالة: سلسلة، سلسليوم، منهجية، البناء الضوئي، نسبة اليمانات والمحصول.