# Mitigation the Adverse Effects of Salinity Stress on Germination of Sunflower Plant (*helianthus annuus* l.) Grown on Sand Culture by using Potassium Sulfate, Sodium Silicate or Sal-wax®ca

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## ABSTRACT

**The present study was conducted to assess whether application of potassium sulfate, sodium metasilicate or Sal-Wax®Ca can ameliorate the adverse effects of salinity stress on germination of sunflower plant variety Sakha 53 grown in sand culture. The salinity levels were 0, 25, 50, 75 and 100 mM NaCl and mitigation treatments were control, 89.7 ppm potassium sulfate, 3 mM sodium metasilicate and 1.8 ppm Sal-Wax®Ca. Plants were grown in plastic pot containing 500 g pre-washed sand and irrigated three times weekly by 100 mL per pot of one-tenth modified Hoagland and Arnon nutrient solution containing the salt level and mitigation treatment. After three weeks from sowing, the plants were collected. The results referred that increasing salinity stress decreased the growth parameters at all mitigation treatments. On the other hand, fresh and dry shoot/root ratio, whole plant and root moisture content, electrolyte leakage, and chlorophyll content index were increased with increasing salinity stress at all mitigation treatments. Soil application of potassium sulfate with irrigation solution lead to improve the studied growth parameters of sunflower plants under salinity stress, compared to sodium silicate and Sal-Wax®Ca.**

**Keywords: Salinity stress, sunflower, potassium sulfate, sodium silicate, Sal-Wax®Ca, electrolyte leakage, chlorophyll content index.**

## INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a major oil crop worldwide, and it is also an important crop in Mediterranean areas where salinity is an increasing problem (Caterina *et al.*, 2007). Sunflower is moderately sensitive to soil salinity (Ayers and Westcot, 1985). The promotion of sunflower could be successful to increase the domestic production provided proper cultivars are available which are suitable to different soil and climatic conditions (Khatoon *et al.*, 2006).

Soil salinization is one of the most important issues that can seriously decrease food production. High salt concentrations in soils inhibiting crop growth and productivity are frequent constraint to agriculture in arid and semi-arid regions. Irrigation with poor quality water is one of the main factors resulting in salt accumulation and decrease of agricultural productivity. Salt-affected soils area about 831 million hectares (ha) (FAO, 2000). More than 45 million ha of irrigated soil are salinity affected that account 20% of soil and 1.5 million ha of soil are out of cultivation each year owing to increased salinity levels (Pitman and Lauchli, 2002 and Munns and Tester, 2008), if it continuous in such way, 50% of agricultural soils can be lost by the middle of the twenty-first century (Mahajan and Tuteja, 2005). Salinity might be resulted by natural reasons (as weathering, precipitation of sea salt carried by wind and rain, etc.) in addition to, human activities as irrigation by underground water, saline water, poor drainage, etc. (Hasanuzzaman *et al.*, 2013, Munns, 2005 and Manchanda and Garg, 2008). High levels of saline have adverse effects on germination, plant growth, and reproducibility via adverse effects on different metabolic activities as photosynthesis, respiration, transpiration, membrane properties, nutrient balance, enzymatic activities, cellular homeostasis and hormone balance. Therefore, mitigation the adverse effects of soil salinity on crops has become a hot global research area that is of great importance in ensuring sustainable food security.

Potassium is an essential nutrient that affects most of the biochemical and physiological processes that influence plant growth and metabolism. It also contributes to the survival of plants exposed to various biotic (e.g., pathogens, insects, and weeds) and abiotic (e.g., drought, salinity, cold, frost and waterlogging) stresses (Wang *et al.*, 2013). Potassium content in plant tissues is progressively decreased with increasing salinity. Therefore, maintenance of adequate level of $K^+$ is essential for plant survival under salt stress (Asch *et al.*, 2000, Sanjakkara *et al.*, 2001, Hu and Schmidhalter, 2005). Regulation of $K^+$ uptake and/or prevention of $Na^+$ entry or the efflux of $Na^+$ from the cell are the strategies commonly used by the plants to maintain desirable $K^+/Na^+$ ratio in the cytosol under salt stress (Chinnusamy *et al.*, 2005).

Silicon is the second most abundant element in the earth crust, after oxygen. It is not an essential element; however, it may play an important role in alleviating various biotic and abiotic stresses (Liang *et al.* 2007, Ashraf *et al.* 2009, Abdelaal *et al.* 2020). Silicon deposited in the cell walls of the roots, leaves and culms

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as silica gel in rice reduced the uptake and transport of $Na^+$, decreased transpiration and improved water status of the plants which in turn reduced salt toxicity by dilution effect (Gong *et al.* 2006, Gunes *et al.* 2007). Silicon could mediate salt-induced ion imbalance by (i) regulating $Na^+$ uptake, transport, and distribution and (ii) regulating polyamine levels. Silicon application direct/indirectly mitigates oxidative stress via regulating the antioxidant defense and polyamine metabolism (Zhu, 2019).

SAL-WAX®Ca is a solid formula with high organic contents of calcium and potassium carboxylates. It has been developed to activate roots, to optimize calcium and potassium nutrition, protect plants from salinity, condition the soil and improve the mechanisms of uptake and transport of water and nutrients in the plant. El-Kady *et al.* (2021) showed that application of Magic-Sal or Sal-Wax help's in early stages to increase the emergency percentage of five sugar beet varieties under high salinity water stress, increased leaf relative water content and root yield, but, it caused a reduction in quality parameters (sucrose, purity, and extractable sugar percentages).

The main objective of the present study therefore was to investigate whether the adverse effects of salt stress on sunflower could be mitigated by application of potassium sulfate, sodium silicate or SAL-WAX®Ca.

## MATERIAL AND METHODS

A pot experiment was carried out during summer growing season of 2020 at Etay Elbaroud Agriculture Research Station, El Beheira Governorate, Ministry of Agriculture and Land Reclamation (MALR), Egypt to investigate the differences between potassium sulfate, sodium metasilicate and Sal-Wax®Ca on mitigation of salinity stress of sunflower (*Helianthus annuus* L.) variety Sakha 53 The Sal-Wax®Ca used in this experiment is manufactured by CODIAGRO VALL D'ALBA Castellon, ESPANA and its composition was: 4% N, 15% $K_2O$, 14% CaO and 51.74% Carboxylic acids. Sodium metasilicate ($Na_2O_3Si.9H_2O$) used in this experiment is a type of sodium silicate where, Sodium silicate is a generic name (common name for all ionic compounds having the general chemical formula $Na_{2x}Si_yO_{2y+x}$).

The experiment was carried out as a randomized complete block design in a split-plot arrangement with three replicates. The main plot was five salt concentrations (0, 25, 50, 75 and 100 mM NaCl), and the sub-plot was four treatments (control, 89.7 ppm potassium sulfate, 3 mM sodium metasilicate, and 1.8 ppm Sal-Wax®Ca). These concentrations treatments were determined based on the recommended rates of previous studies and were added with irrigation nutrient solution.

Ten seeds of sunflower variety Sakha 53 were sown in plastic pot (12 cm inside diameter and 9 cm depth with holes in the bottom) containing 500 g pre-washed sand with distilled water of size fraction between 0.25 and 1 mm (Hewitt, 1966). Each pot was irrigated three times weekly with 100 mL of nutrient solution, which contains both one-tenth strength modified Hoagland and Arnon nutrient solution (Hewitt, 1966). The tested salt levels (0, 25, 50, 75 or 100 mM NaCl) and one of control, 1.8 ppm Sal-Wax®Ca, 89.7 ppm potassium sulfate or 3 mM sodium silicate. The concentrations of macro- and micro-nutrients in the base solution as mentioned by Abdelraouf and Elgarhy (2017) were as follows: the concentrations of macronutrients were 16.87, 8.47, 11.92, 29.99, 12.00, 4.78, and 6.38 mg $L^{-1}$ for $N\text{-}NO_3$, $N\text{-}NH_4$, P, K, Ca, Mg, and S, respectively. The concentrations of micronutrients were 0.50, 0.11, 0.05, 0.01, 0.01 and 0.005 mg $L^{-1}$ for Fe, Mn, B, Zn, Cu and Mo, respectively. The plants were thinned to five plants per pot after ten days from sowing.

After three weeks from sowing, the whole plants were collected. After washing the plants by distilled water were then separated into shoots and roots and the fresh weight of shoots and roots and shoot height were measured.

Samples of shoot and root were dried in an oven at 70 °C for 48 h and the oven-dried weight were measured. Fresh and dry weight shoot/root ratio and moisture content were calculated. The value of relative decrease of most parameters was calculated as (control - treatment) / control x 100.

Total leaf chlorophyll content (SPAD) was nondestructively estimated using the SPAD-502 chlorophyll meter. Average of three measurements was taken on different plants chosen randomly in each pot before collecting plants.

Electrolyte leakage was used to assess membrane permeability according to Lutts *et al.* (1995). Leaf samples were cut into discs of uniform size. Leaf discs were put in closed test tubes containing 10 mL of distilled water and incubated at room temperature (25 °C) for 24 h and subsequently electrical conductivity of the solution ($EC_1$) was recorded. Samples were then autoclaved at 120 °C for 20 min and the final electrical conductivity ($EC_2$) was obtained after cooling the solution to room temperature. The electrolyte leakage was calculated as $EC_1/EC_2$ and expressed as percentage.

Analysis of variance of all parameters was computed using the Costat computer package. Least significance difference between the means was calculated according to Snedecor and Cochran (1980).

## RESULTS AND DISCUSSION

### Growth of whole plant

Table (1) showed that increasing salt levels decreased significantly fresh and dry weights of the whole sunflower plant. The mean relative decrease with increasing the salinity levels were 13.5, 24.0, 48.2 and 60.1 % of the fresh whole sunflower plant weight and were 25.7, 40.0, 57.1, and 65.7 % of the dry whole sunflower plant for 25, 50, 75 and 100 mM NaCl concentrations, respectively, as compared to zero mM NaCl (control). Also, mitigant treatments was affect significantly on the dry weight of whole sunflower plant under all salt concentrations. The results showed that potassium sulfate had increased the sunflower resistant to salinity, while sodium silicate and Sal-Wax®Ca had reverse effect on sunflower resistant (Table 1). However, mitigant treatments had no significant effects on the fresh weight of whole sunflower plant under all the different salt concentrations. Moreover, the interaction between salt concentrations and mitigant treatments had no significant effects on the fresh and dry weights of whole sunflower plant (Fig. 1 and 2).

**Table 1. Effects of salt levels and different mitigant treatments on whole, shoot and root fresh and dry weights of sunflower seedlings**

| Treatment | Fresh weight ($g\ plant^{-1}$) | | | Dry weight ($g\ plant^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Whole | Shoot | Root | Whole | Shoot | Root |
| Salinity levels (mM NaCl) | | | | | | |
| 0 | 3.71$^{a}$* | 2.44$^{a}$ | 1.27$^{a}$ | 0.35$^{a}$ | 0.23$^{a}$ | 0.12$^{a}$ |
| 25 | 3.21$^{ab}$ | 2.35$^{a}$ | 0.86$^{b}$ | 0.26$^{b}$ | 0.20$^{ab}$ | 0.06$^{b}$ |
| 50 | 2.82$^{b}$ | 2.04$^{a}$ | 0.78$^{b}$ | 0.21$^{b}$ | 0.17$^{bc}$ | 0.04$^{c}$ |
| 75 | 1.92$^{c}$ | 1.45$^{b}$ | 0.47$^{c}$ | 0.15$^{c}$ | 0.12$^{cd}$ | 0.03$^{cd}$ |
| 100 | 1.48$^{c}$ | 1.21$^{b}$ | 0.27$^{c}$ | 0.12$^{c}$ | 0.10$^{d}$ | 0.02$^{d}$ |
| Mitigant | | | | | | |
| Control | 2.67$^{a}$ | 1.89$^{ab}$ | 0.78$^{a}$ | 0.22$^{ab}$ | 0.16$^{ab}$ | 0.06$^{a}$ |
| $K_2SO_4$ | 2.91$^{a}$ | 2.10$^{a}$ | 0.81$^{a}$ | 0.25$^{a}$ | 0.19$^{a}$ | 0.06$^{a}$ |
| $Na_2SiO_3$ | 2.45$^{a}$ | 1.81$^{b}$ | 0.64$^{a}$ | 0.19$^{b}$ | 0.15$^{b}$ | 0.04$^{a}$ |
| Sal-Wax®Ca | 2.47$^{a}$ | 1.78$^{b}$ | 0.69$^{a}$ | 0.19$^{b}$ | 0.14$^{b}$ | 0.05$^{a}$ |

***** Means within the same column followed by the same letter(s) are not significantly different according to LSD at 0.05 level of probability.

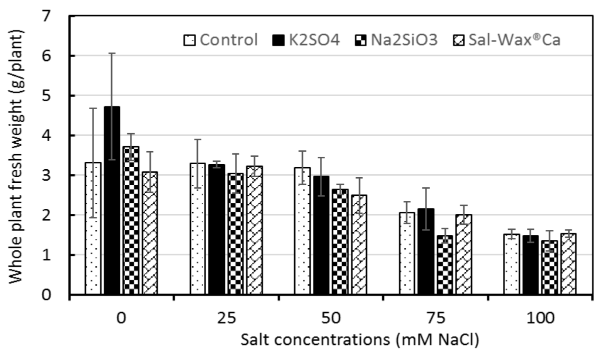


**Fig. 1. Interaction between salt concentrations and mitigant treatments on the fresh whole sunflower seedling weight**

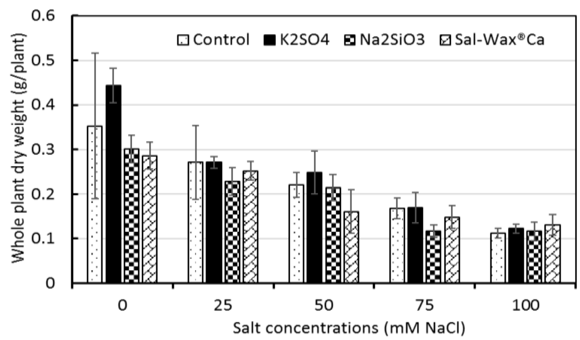


**Fig. 2. Interaction between salt concentrations and mitigant treatments on the dry whole sunflower seedling weight**

**Growth of shoots**

Table (1) showed that increasing salt levels decreased significantly fresh and dry shoot sunflower weights of all mitigant treatments. Mean relative decrease with increasing the salinity levels were; 3.7, 16.4, 40.6, and 50.4 % of the shoot fresh weight and were 13.0, 26.1, 47.8, and 56.5 % of the shoot dry weight at 25, 50, 75 and 100 mM NaCl, respectively, as compared to the control treatment. Also, there were significant differences between mitigant treatments with respect to shoot fresh and dry weights under different salt concentrations. However, there were no significant differences were observed between the interaction of salinity levels and mitigant treatments with respect to shoot fresh and dry weights. The results showed that the potassium sulfate lead to increasing shoot growth of sunflower under salt stress, while sodium silicate and Sal-Wax®Ca had reverse effect on sunflower shoot growth, where the shoot growth treated with these treatments was less than control (Table 1).

**Growth of roots**

Increasing salinity levels significantly decreased the roots fresh and dry weights of sunflower seedlings under all mitigant treatments (Table 1). The mean relative decrease with increasing salinity were 32.3, 38.6, 63.0, and 78.7 % of the root fresh weight and were 50.0, 66.7, 75.0, and 83.3 % of the root dry weight at 25, 50, 75, and 100 mM NaCl, respectively, as compared to the control. However, there were no significant differences between mitigant treatments on fresh and dry weights of sunflower roots under different salt concentrations. Also, there were no significant differences between the interaction of salt levels and mitigant treatments on fresh and dry weights of sunflower roots.

It is clear from the obtained that salt stress reduced plant growth of sunflower, however, application of potassium sulfate improved the plant growth in salt stressed plants. Generally, it is suggested that plant growth, and physiological phenomena such as stomatal regulation, photosynthesis, osmoregulation, protein synthesis and turgor-pressure-driven solute transport in xylem depend upon the availability of potassium to plants (Marschner, 1995). These results agree with those of Akram *et al.* (2009) who reported that foliar application of potassium sulfate significantly improved growth of the salt-stressed sunflower plants also, Badar-Uz-Zaman *et al.* (2018) concluded that under sodic saline soil, sunflower growth is improved with potassium sulphate application. While the application of silicon as a sodium silicate to roots was not improved sunflower plant growth in salt stressed conditions. The lack of response of the sunflower plant to the addition of silicon under salt stress, and the response may be reverse in some traits. It may be due to the accompanying sodium ion and the method of application to the roots (ground addition) only, where sunflower is a one of species which show little uptake of Si via the roots (an Si-intermediate-accumulating plant). These results agree with those reported by Hurtado *et al.* (2021) who found that Si applications via roots for sorghum plants and the combined supplementation via root and foliar spraying of sunflower plants enhanced plant growth and productivity under salt stress conditions. Also, application of Sal-Wax®Ca was not improved the sunflower growth under salt stress.

**Shoot/root ratio**

Table (2) showed that the increase of salinity concentrations significantly increased the shoot/root ratio on fresh and dry weight basis, while there were significant effect due to different mitigant treatments on fresh shoot/root ratio, but there were no significant effect on dry shoot/root ratio under all salt concentrations. Moreover, the interaction between salt levels and mitigant treatments had significant effect on dry shoot/root ratio but had no significant effect on fresh shoot/root ratio. The highest value of shoot/root ratio on dry weight basis was 4.97 at 50 mM NaCl with application of Sal-Wax®Ca, while the lowest value was 1.44 at 0 mM NaCl with control mitigant treatment (Fig. 3). Increasing the shoot/root ratio on fresh and dry weight basis with increasing salt stress meaning that the reduction in the root growth was greater than that in the shoot growth. This means that the roots growth had adversely affected by salt stress more shoots. Values of dry shoot/root ratio were higher than the fresh shoot/root ratio. This is due to the higher water content of roots than shoots. The results of increasing shoot/root ratio of sunflower plant with increasing salinity stress agree with those reported by Abdelraouf *et al.* (2016) on broad bean genotypes and with Abdelraouf and Elgarhy (2017) on soybean genotypes who observed that the roots growth were more adversely affected by salinity than shoots.

**Moisture content**

Increasing salinity stress significantly increased the whole plant and roots moisture content, while they were had no significant effect on shoot moisture content of sunflower seedlings (Table 2). On the other hand, there were no significant effects of mitigant treatments on the whole plant, shoot and roots moisture content of sunflower seedlings under all salinity stress concentrations. The interaction between salt levels and mitigant treatments had significant effects on the whole sunflower plant and roots moisture content, while it was had no significant effect on shoot moisture content of sunflower seedlings. The highest whole plant moisture content value was 93.6 % at 50 mM NaCl with application of Sal-Wax®Ca, while the lowest value was 89.5 % at 0 mM NaCl with control mitigant treatment (Fig. 4).

The moisture content of shoot was almost lower than in roots as shown in Table 2. Thus, whenever the salt levels increase, the moisture contents of whole plant and root of sunflower seedlings almost were increased. These results mean that the sunflower plant can tolerate the adverse effects of salinity stress by increasing its succulence. This means that the sunflower seedlings had increased its fresh weight by increasing their moisture content more than its effect on the dry biomass production because of increasing salinity stress. This response agrees with the findings of Khan *et al.* (2016) who reported that treated sunflower plant hybrid (Samsung-600) with different doses of sodium chloride had increased the moisture content.

**Table 2. Effects of salinity levels and different mitigant treatments on the shoot/root ratio on fresh and dry wight basis and moisture contents of sunflower**

| Treatment | Shoot/Root ratio | | Moisture content (%) | | |
|---|---|---|---|---|---|
| | Fresh weight | Dry weight | Whole | Shoot | Root |
| Salinity levels (mM NaCl) | | | | | |
| 0 | 2.01[d]* | 2.06[b] | 90.5[b] | 90.8[a] | 89.8[b] |
| 25 | 2.80[bc] | 3.56[a] | 92.1[a] | 91.5[a] | 93.4[a] |
| 50 | 2.67[c] | 4.15[a] | 92.6[a] | 91.8[a] | 94.6[a] |
| 75 | 3.36[b] | 4.14[a] | 92.2[a] | 91.7[a] | 93.3[a] |
| 100 | 4.68[a] | 4.27[a] | 91.8[a] | 91.9[a] | 91.0[b] |
| Mitigant | | | | | |
| Control | 2.84[b] | 3.41[a] | 91.8[a] | 91.5[a] | 92.4[a] |
| $K_2SO_4$ | 3.08[ab] | 3.78[a] | 91.5[a] | 91.1[a] | 92.4[a] |
| $Na_2SiO_3$ | 3.54[a] | 3.83[a] | 92.0[a] | 91.7[a] | 92.4[a] |
| Sal-Wax®Ca | 2.95[b] | 3.53[a] | 92.1[a] | 91.9[a] | 92.5[a] |

* Means within the same column followed by the same letter(s) are not significantly different according to LSD at 0.05 level of probability.

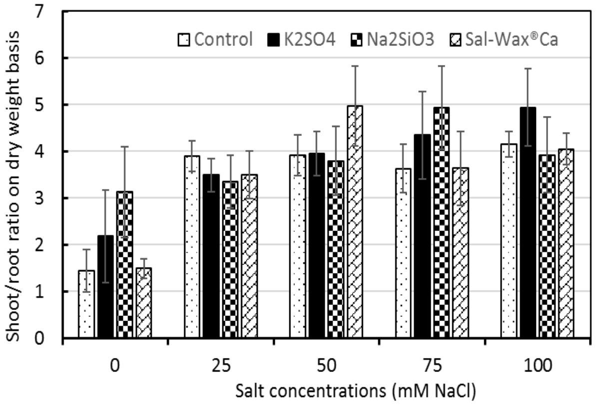


**Fig. 3. Interaction between salt concentrations and mitigant treatments on the shoot/root ratio on dry weight basis of sunflower seedlings**

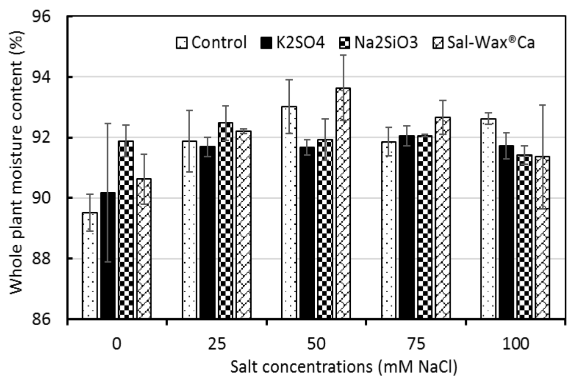


**Fig. 4. Interaction between salt concentrations and mitigant treatments on the whole plant moisture content of sunflower seedlings**

**Shoot height**

Increasing salt concentrations more than 25 mM NaCl decreased significantly the sunflower seedlings shoot height at all mitigant treatments (Table 3). The mean relative decrease in shoot height with increasing salt stress were 1.2, 19.6, 39.2, and 51.4 % at 25, 50, 75, and 100 mM NaCl, respectively as compared to the control. Also, mitigant treatments had significant differences on shoot height of sunflower seedlings under salt stress. Moreover, there were significant differences between the interaction of salt levels and mitigant treatments on sunflower shoot height. The highest value of shoot height was 29.0 cm at 0 mM NaCl with application of potassium sulfate, while the lowest value was 11.6 cm at 100 mM NaCl with application of sodium silicate (Fig. 5). Khan *et al.* (2016) and Hafeez *et al.* (2017) reported that increasing salt stress of sunflower genotypes significantly reduced shoot height.

**Chlorophyll content**

Table (3) showed that increasing salinity levels significantly increased the chlorophyll content in leaves of sunflower seedlings with all mitigant treatments. The mean relative increase in chlorophyll content with increasing salinity stress were 6.1, 11.3, 20.6, and 17.2 % at 25, 50, 75, and 100 mM NaCl, respectively, as compared to zero mM NaCl. Moreover, mitigant treatments significantly affected the chlorophyll content under all salinity levels. The highest value of chlorophyll content (37.9 and 36.8 SPAD) was received with sodium silicate and potassium sulfate, respectively, while the lowest value (34.9 and 35.2 SPAD) was received with Sal-Wax®Ca and control treatments, respectively. However, the interaction between salinity concentration and mitigant treatments was not significantly affected the chlorophyll content. These results agree with Kafi and Rahimi (2011) who reported that chlorophyll content (SPAD values) of purslane plant increased with increasing salinity, but Silicon application did not have any significant effect on that trait.

**Electrolytes leakage**

Increasing salinity concentration significantly increased the membrane damage of sunflower seedlings where the electrolyte leakage from the sunflower leaf cells were increased by increasing salt stress up to 100 mM NaCl with all mitigant treatments (Table 3). The mean relative increase in electrolyte leakage (membrane damage) of all mitigant treatments with increasing salt levels were 31.1, 34.5, 95.2, and 128.7 % at 25, 50, 75, and 100 mM NaCl, respectively as compared to zero mM NaCl. On the other hand, the mitigant treatments had no significant effect on membrane damage under salinity. Moreover, the interaction between salinity concentrations and mitigant treatments had no significant effect of on sunflower membrane damage. Salinity stress increased electrolyte leakage as in five Coleus species (Kotagiri and Kolluru, 2017) and in lettuce, spinach, and common purslane (Hniličková *et al.*, 2019).

**Table 3. Effects of salt levels and different mitigant treatments on the shoot height, chlorophyll content and electrolytes leakage of sunflower seedlings**

| Treatment | Shoot height (cm) | Chlorophyll content | Electrolytes leakage (%) |
|---|---|---|---|
| Salinity levels (mM NaCl) | | | |
| 0 | 25.5$^{a*}$ | 32.6$^{d}$ | 302.3$^{c}$ |
| 25 | 25.2$^{a}$ | 34.6$^{cd}$ | 396.2$^{bc}$ |
| 50 | 20.5$^{b}$ | 36.3$^{bc}$ | 406.5$^{b}$ |
| 75 | 15.5$^{c}$ | 39.3$^{a}$ | 590.2$^{a}$ |
| 100 | 12.4$^{d}$ | 38.2$^{ab}$ | 691.3$^{a}$ |
| Mitigant | | | |
| Control | 20.1$^{ab}$ | 35.2$^{b}$ | 511.1$^{a}$ |
| $K_2SO_4$ | 20.8$^{a}$ | 36.8$^{ab}$ | 446.7$^{a}$ |
| $Na_2SiO_3$ | 18.7$^{c}$ | 37.9$^{a}$ | 488.5$^{a}$ |
| Sal-Wax®Ca | 19.6$^{bc}$ | 34.9$^{b}$ | 462.8$^{a}$ |

* Means within the same column followed by the same letter(s) are not significantly different according to LSD at 0.05 level of probability.

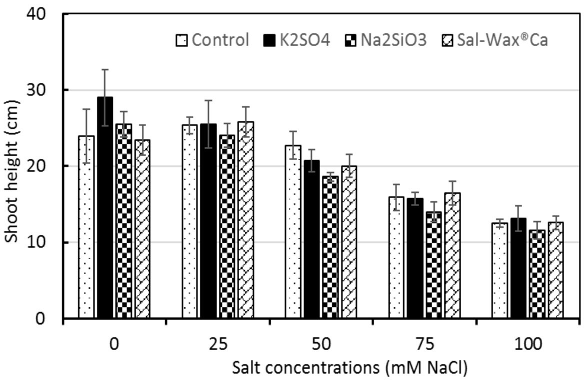


**Fig. 5. Interaction between salt concentrations and mitigant treatments on the shoot height of sunflower seedlings**

## CONCLUSION

The present study showed that increasing salinity stress decreased all the growth parameters of sunflower (*Helianthus annuus* L., cv. Sakha 53) at seedling stage. However, shoot/root ratio on fresh and dry weight basis, whole plant and roots moisture content, electrolyte leakage and chlorophyll content were increased with increasing salinity stress of all mitigant treatments. The soil addition with irrigation solution of potassium sulfate improved the growth parameters of sunflower plants under salinity stress, compared to sodium silicate and Sal-Wax®Ca.

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## الملخص العربي

# التخفيف من الآثار الضارة لإجهاد الملوحة على إنبات نبات زهرة الشمس المنزرع في مزرعة رملية باستخدام كبريتات البوتاسيوم أو سيليكات الصوديوم أو سال واكس – كالسيوم

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أجريت هذه الدراسة لتقييم ما إذا كان استخدام كبريتات البوتاسيوم أو ميتاسيليكات الصوديوم أو سال واكس–كالسيوم يمكن أن يخفف من الآثار السلبية للإجهاد الملحي على نبات زهرة الشمس صنف سخا ٥٣ المنزرع في بيئة رملية. كانت مستويات الملوحة صفر ، ٢٥ ، ٥٠ ، ٧٥ و ١٠٠ ملليمول كلوريد الصوديوم وكانت معاملات التخفيف كنترول ، ٨٩,٧ جزء في المليون من كبريتات البوتاسيوم ، ٣ ملليمول ميتاسيليكات الصوديوم و ١,٨ جزء في المليون سال واكس–كالسيوم. تمت زراعة النباتات في أوعية بلاستيكية يحتوي كل منها على ٥٠٠ جرام من الرمل المغسول مسبقًا ويتم ريها ثلاث مرات أسبوعياً بمقدار ١٠٠ مل لتر لكل وعاء تحتوي على عُشر محلول مغذي هوجلاند وأرنون المعدل ويحتوي على مستوى الملح ومعالجة التخفيف. بعد ثلاثة أسابيع من الزراعة، تم جمع النباتات. أشارت النتائج إلى أن زيادة إجهاد الملوحة يقلل من عوامل النمو في جميع معالجات التخفيف تحت الدراسة. من ناحية أخرى، تمت زيادة نسبة المجموع الخضري/الجذري على أساس الوزن الرطب والجاف ، ومحتوى الرطوبة في النبات بالكامل والجذر، وتسرب الأملاح ، ومحتوى الكلوروفيل مع زيادة إجهاد الملوحة في جميع معاملات التخفيف. أدت الإضافة الأرضية لكبريتات البوتاسيوم مع محلول الري إلى تحسين معايير نمو نباتات زهرة الشمس تحت الإجهاد الملحي مقارنة بكل من سيليكات الصوديوم و سال واكس–كالسيوم.

الكلمات المفتاحية: الاجهاد الملحى، زهرة الشمس، كبريتات البوتاسيوم، سيليكات الصوديوم، سال واكس–كالسيوم ، وتسرب الأملاح ، محتوى الكلوروفيل.