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Evaluation of Some Sugar Beet Varieties under Water Salinity Stress in New Reclaimed Land

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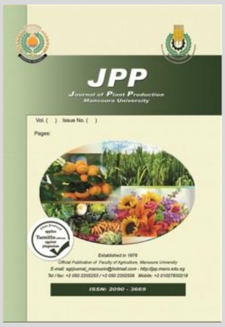

ABSTRACT

In line with sustainable agriculture that depends on modern methods and new sources of non-traditional irrigation, a field experiment was conducted at a privet farm behind Cairo-Alexandria Desert Road, Giza, Egypt during two seasons to evaluate five sugar beet varieties under water salinity stress condition. The present work included 15 treatments; represent five sugar beet varieties: *viz.* Multi-germs (Amina, Farida, and Faten) and Mono-germs (Unners and Sharleston), in combinations with two salinity treatments (Magic-Sal (13% humic acid + 20% carboxylic acid) and Sal-Wax (50% carboxylic acid) components) compared to control application. Results indicated that salinity treatments help in early stages to increase the emergency percentage of sugar beet varieties under high salinity water stress. As compared to control treatment, salinity treatments significantly increase proline accumulation, leaf relative water content (LRWC %),and root yield, but, it caused a reduction in quality parameters (sucrose, purity, and extractable sugar percentages) in both seasons. On the other hand, variety (Amina) overpassed the other varieties under salinity water stress with respect to germination ratio, proline content, LRWC%,and root yield (ton/fed) in both seasons. While, Sharelston variety surpassed significantly the other studied varieties with respect to sucrose, purity, and extractable sugar percentage (ES%) in both seasons.The distribution of stomata density of leaf increased as salinity water stress level increased. Results also showed that five sugar beet varieties under two salinity treatments (Magic-Sal or Sal-Wax) had positive effects and increased stomata area, but stomata density and its index as well as stomata closure% decreased compared with non-use.

Keywords: Newly reclaimed land. Selection index. Sugar beet. Water salinity.

INTRODUCTION

Sugar beet (*Beta vulgaris L.*) being often, the most important cash crop, so, it became the first source for the production of sugar in Egypt, according to Sugar Crops Council (2020). Salinity is one of the most important constraints in sugar beet production in Egypt. An understanding the performance sugar beet (*Beta vulgaris*) under salinity stress is crucial to gaining insight into salinity tolerance trajectories as well as to designing appropriate breeding strategies in saline stress conditions (Abbasi *et al.*, 2019). Water shortage and salinity (Singh, 2016) are major abiotic stresses affecting plant growth in arid and semi-arid regions. Noticeable reduction in available fresh water and consequently soil salinization is a major challenge in this region during the last decade that imperiled food production and agricultural economy. Due to the low available water, irrigation is necessary for successful crop growth. But, reduction in appropriate water resources is a major factor that can limit agricultural activities. One imperative response to this challenge is the use of anomalistic (saline) sources of water. Using saline water for cropland irrigation may lead to the soil salinization (Feng *et al.*,2017), reduction in the crop yield (Fathi *et al.*, 2017), and degradation of the soil resources, if appropriate management practices are not adopted (Ould Ahmed *et al.*, 2007).

Salinity treatments like Magic-Sal and Sal-Wax compounds are formulated with a high organic content of calcium carboxylates and carboxylic acids. It has been developed to activate roots, to optimize calcium nutrition, increase proline accumulation in plants, protect establishment of plants from salinity, to condition the soil and to improve water and nutrient uptake and transport mechanisms in the plant. As well as, it is recommended to increase root growth and increase the absorption and transport of water and nutrients to the plant, mobilize calcium in the soil and optimize calcium nutrition, protect the plant and condition the soil in saline conditions (Kafi and Rahimi, 2011).

At the early stage, sugar beet plants suffer from water deficit because of high solute potential in the environment. The result is a wide range of physiological and biochemical changes leading to inhibition of growth and development, reduction of photosynthesis, respiration, and protein synthesis, and disruption of nucleic acid metabolism (Sairam *et al.*, 2002). To survive salt stress, plants respond and adapt through sophisticated mechanisms that include developmental, morphological, physiological and biochemical strategies (Taji *et al.*, 2004). For example, a large number of genes involved in membrane transport, signal transduction, redox reaction and other processes have been shown to be involved in salt stress response (Zhang *et al.*, 2008). That soluble Ca, Mg and Na increased with increasing salinity level of irrigation water, while soluble K decreased with increasing salinity levels (Akhtar *et al.*, 2003). Sugar beet is a crop of halophytic nature and can

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survive high salt conditions with a threshold electrical conductivity (EC) (the maximum soil salinity that does not reduce the crop yield) of 7.0 dS/m (Marschner, 1995). But, sugar beet is a sensitive to elevated salinity at the germination and early seedling phase of development (Ghoulam and Fares, 2001) that reflect on emergency percentage and plant density and finally decreased root and sugar yield. Using salinity treatments in this sensitive stage is important to avoid salinity stress on sugar beet plant by increase osmotic adjustment (Katerji *et al.,* 1997) by accumulation of compatible solutes such as inorganic ions (Ca and K), glycinebetaine, proline and polyols (Bohnert *et al.,* 1999) and lowering the toxic concentration of ions in the cytoplasm by restriction of Na influx or its sequestration into the vacuole and/or its extrusion (Binzel *et al.,* 1988).

Sugar beet varieties differed in response to show a high osmotic adjustment and accumulation of glycinebetaine, proline and inorganic ions under salt stress (Gzik, 1996). More tolerant sugar beet varieties must be selected and recommended for the saline areas. Accurate selection requires an understanding of the mechanisms involved in salt tolerance in this species. Under salt stress, sugar beet varieties have evolved complex mechanisms allowing for adaptation to osmotic and ionic stress caused by high salinity. Almodares and Sharif (2007) revealed that salinity of water has an adverse effect on sugar beet biomass. The effect of irrigation water quality was not significant for sugar characteristics such as brix, pol and purity. However, responses of cultivars on the above parameters were significant and sugar beet cultivars had higher brix, pol and purity and lower invert sugar and starch.

Therefore, this work was conducted to explore newer approaches and to test whether the application of salinity treatments (Magic-Sal and Sal-Wax) could be mitigated the adverse effects of saline water stress during the early sensitive initiation stage of sugar beet varieties or not, also to evaluate and determine the tolerant varieties for saline water by selection indices and the efficiency under sandy soil.

MATERIALS AND METHODS

A filed experiment was conducted at a privet farm behind Cairo-Alexandria Desert Road, Giza, Egypt (30°14 14.59″ N latitude and 30°46' 53.90″ E longitude) during 2017/2018 and 2018/2019 seasons. The present work included 15 treatments; represent five sugar beet varieties: viz. Multi-germs (Amina, Farida and Faten) and Mono-germs (Unners and Sharleston), in combinations with two salinity treatments (Magic-Sal (13% humic acid + 20% carboxylic acid) and Sal-Wax (50% carboxylic acid) components) compared to control application. Sugar beet varieties were sown on ridges 60 cm apart and 20 cm between hills. Each subplot included 5 ridges each is 4 m in length. Therefore, each subplot size was 12 m^2. Sugar beet seeds were sown on the first week of October of each season. A drip irrigation system was used in the experiment, where the dripper types were GR with 4 lit/hr. Nitrogen was added in the form of ammonium nitrates (33.5% N) at rate of 120 kg N/fed in five equal splits, the first was applied after thinning at 4-leaf stage and other splits were added every two weeks later. Phosphorous in the form of super phosphate (15.5%) at rate of 30 kg P_2O_5 /fed and compost at rate 5 ton/fed were added before sowing and during land preparation. Potassium in the form of potassium sulfate (48%) was added at the rate of 48 kg K_2O/fed with the last dose of N. Thinning took place to one plant/hill at 4-leaf stage (4 weeks from planting). Other culture practices were done according to the Sugar Crops Research Institute (SCRI) recommendation. Water and soil samples (0-60 cm depth) were collected from the experimental site to determine its physical and chemical properties using the methods described by Cottenie *et al.,* (1982) as shown in Tables 1 and 2. The experimental soil is classified as sandy soil and low nutrients and organic contents. The analysis of salinity treatments showed that, the composition of Magic-Sal compound is: 12% Cao, 13% humic acid, 7% fulvic acid, 5% sulfur, 5% Salicylic acid and 20% carboxylic acid, while the composition of Sal-Wax compound is: 15% K_2O, 14% CaO, 4% nitrogen and 50% carboxylic acid. Salinity treatments (Magic-Sal or Sal- Wax) was applied by fertigation during the first month after planting (sensitive initiation stage) at rate of 4 litter/fed in four equal splits (1 litter/fed/weekly). The statistical layout of the experiment was split plot design, where salinity treatments applications occupied the main plots and varieties distributed in the sub plots, in three replicates.

Table 1. Soil physical and chemical properties of soil samples

Soil layer (cm)	Particle size distribution %			Texture class				Moisture content (%)			
	Sand	Silt	Clay					F.C	W.P		A.W
0-20	91.5	6.5	2.0					14.8	5.9		8.9
20-40	94.0	4.3	1.7		Sandy			15.2	6.2		9.0
40-60	95.2	3.5	1.3					15.5	5.9		9.6
Soil layer (cm)	SAR	pH	EC (dS/m)	Soluble anions(meq/l)				Soluble cations(meq/l)			
				CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
0-20	0.95	7.90	0.50	0.0	0.50	3.50	0.98	1.50	0.50	2.85	0.13
20-40	1.23	8.10	0.32	0.0	0.50	2.00	0.68	1.00	0.50	1.60	0.08
40-60	1.52	8.00	1.60	0.0	1.00	10.5	4.48	4.50	2.50	8.70	0.28

Table 2. Chemical analysis of irrigation water

pH	EC (dS/m)	Soluble anions(meq/l)				Soluble cations(meq/l)				SAR
		CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+	
7.30	5.60	0.0	2.4	48	16.13	22.8	16.2	26.8	0.73	6.06

Recorded data

1.Germination ratio: The germination ratio (Gr) at each sub plot at the age of 10 days from sowing was determined by using the following formula:

$$G_r = \frac{N_p}{N_s} \times 100$$

Where:

N_p = Number of plants within a length of 10 m, N_s = Number of seeds delivered within the same length.

2.Proline content: was estimated by the ninhydrin method as cited by Bates *et al.* (1973) after 30 days from planting.

3.Leaf relative water content (LRWC %) was estimated according to the method of Weatherly (1950). Samples (0.5 g) of leaves were saturated in 100 ml distilled water for 24 h and their turgid weights were recorded. Then, they were oven-dried at 65°C for 48 h and their dry weights were recorded. LRWC was calculated as follows:

$$\mathbf{LRWC\ (\%) = [(FW - DW) / (TW - DW)] \times 100}$$

Where:

FW, DW and TW are fresh, dry and turgid weights, respectively.

4.Quality parameters:

At harvesting (210 DAP), a sample of ten roots were taken at random from each sub plot cleaned and sent to Sugar Beet Laboratory at Nubaria Sugar Factory, El-Boheira Governorate, Egypt, to determine the following:

I. **Sucrose percentage:** was estimated by using sacharometer lead acetate extract of fresh macerated roots according to Carruthers and Oldfield (1960).

II. **Extractable sugar percentage (ES%):** was estimated according to Reinefeld *et al.* (1974) by using the following formula:

$$\mathbf{ES\% = pol\text{-}[0.343(K + Na) + 0.094\ \alpha\text{-}amino\ N + 0.29]}$$

Where:

Pol = sucrose percentage

III. Juice purity percentage = (ES% / pol) × 100

5.Yields:

At harvesting time, root weight per plot was obtained and used to calculate:

I. **Root yield (ton/fed).**

II. **White sugar yield (ton/fed) = root yield (ton/fed) × (extractable sugar % /100).**

6. **Leaf stomata measurements**: The morphological changes of stomata (stomata density, size, stomatal closure % and its index) for abaxial and adaxial surface of fully expanded mature leaves were measured through Transmission Electronic Microscope (TEM) Model JEOL (JEM-1400 TEM, Japan) linked with the software program at TEM lab (FA-CURP), Faculty of Agriculture, Cairo University Research Park. The leaf stomata index (SI) was estimated using the following formula:

$$\mathbf{SI = \frac{Number\ of\ stomata}{Number\ of\ stomata + epidermis\ cell} \times 100}$$

7.Determination the tolerant varieties

Four selection indices mean productivity (MP), tolerance index (TOL), yield stability index (YSI) and reduction percentage were estimated for each variety based on root yield under stress (Ys) (saline water we used as control treatment) and non-stress (Yp) (filtered water we used as separated treatment in the same field) conditions. Quantitative salinity resistance indices were calculated using the following formulas

I. Tolerance index (TOL) and mean productivity (MP) as done by Rosielle and Hamblin (1981):

$$\mathbf{TOL = (Y_p - Y_s)\ and\ MP = (Y_s + Y_p) / 2}$$

II. Yield Stability Index (YSI):

$\mathbf{YSI = Y_s / Y_p}$ (Bouslama and Schapaugh, 1984)

III. $\mathbf{Reduction\ \% = (Y_P\text{-}Y_S/Y_P) \times 100}$ (Choukan *et al.* 2006)

Where,

Yp is the yield of each variety under non-stress condition; Ys the yield under stress

Statistical analysis

The collected data were statistically analyzed with one-way analysis of variance that computed for each trait according to Steel and Torrie (1980). A combined analysis over the two growing seasons was done according to Gomez and Gomez (1984). Treatment means were compared using LSD at 5% level of probability.

RESULTS AND DISCUSSION

Germination ratio:

Concerning to germination ratio of varieties after 10 days from planting as shown in Figure (1), an observed difference between the evaluated varieties under the combination of treatments under study was detected during both seasons, whereas the germination ratio overcome in the second season compared to the first season for all varieties, except variety (Amina) in the first season under study. Multi-germ: Amina and mon-germ: Unners varieties gave the highest mean values; while, Sharleston variety showed the lowest one during both seasons. Sugar beet is among the most salt tolerant crops, but is to be less tolerant during germination and emergence (Kaffka and Kurt, 2004). The detrimental effects of water salinity and sugar beet varieties on germination and seedling growth are early reported by many investigators among them, Kaffka and Hembree (2004) they reported that sugar beet is among the most salt tolerant crops, but is to be less tolerant during germination and emergence. They also found that seedling dry weight and the rate of emergence declined at EC levels greater than 6 dS/m. Rizk *et al.*, (2002) attributed the depression in germination % either due to the increase in the osmotic concentration through decreasing the rate and the total amounts of water absorbed, therefore seeds cannot absorbed all water required for germination, or due to the specific toxic effects of salts on germination and growth of plants due to the adverse effect of the salts on the enzymatic processes. El-Geddawy *et al.*, (2014) who mentioned that the difference between varieties led to the environmental conditions and gene extraction action, and because of the studied varieties grown in one location, then it could be concluded that the differences between the studied varieties mainly due to gene make up and it is tolerant to water salinity stress.

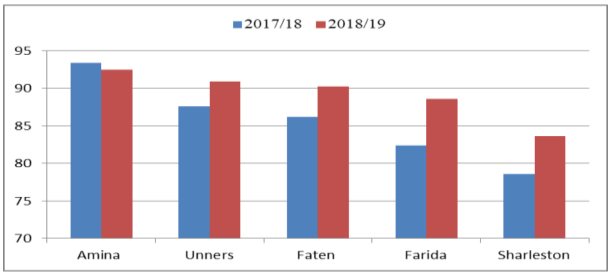

Fig. 1. Germination ratio of five sugar beet varieties during 2017/18 and 2018/19 seasons.

Proline content and leaf relative water content(LRWC %):

Results in Table 3 showed that, salinity treatments significantly increased proline content (u moles/g leaf fresh weight) and leaf relative water content (LRWC %) compared to control in both seasons. Where, proline content increased by 22 and 27% under application of Magic-Sal (12% humic acid + 20% carboxylic acid) and by 53 and 66%

under application of Sal-Wax (50% carboxylic acid) compared to control unit in 2017/18 and 2018/19 seasons, respectively.

On the other hand, data in Table (3) revealed that sugar beet grown under Sal-Wax compound significantly recorded higher values of Leaf relative water content (LRWC %) by 5.88 and 12.78 % in the 1st and 2nd seasons, respectively compared to beets grown in normal case (control).

Table 3. Proline accumulation (u moles/g leaf fresh weight) and Leaf relative water content (LRWC %) of sugar beet varieties as affected by different salinity amendments during 2017/2018 and 2018/2019 seasons.

Characteristics	Proline accumulation (u moles/g leaf fresh weight)								LRWC* %							
Seasons	2017/18				2018/19				2017/18				2018/19			
Salinity amendments / Varieties	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean
Sharleston	2.92	3.69	4.38	3.66	2.81	3.61	4.47	3.63	78.61	81.31	84.66	81.53	80.44	85.01	94.49	86.65
Farida	3.07	3.8	4.6	3.82	2.83	3.8	4.86	3.83	79.68	82.3	85.2	82.39	81.39	86.2	95.09	87.56
Faten	3.18	3.85	4.79	3.94	3.13	3.9	5.12	4.05	80.28	82.91	85.87	83.02	82.17	88.26	95.84	88.76
Unners	3.31	3.97	5.17	4.15	3.22	4.07	5.36	4.22	80.65	83.34	86.28	83.42	83.22	90.98	96.19	90.13
Amina	3.52	4.19	5.58	4.43	3.44	4.23	5.8	4.49	80.81	84.05	87.4	84.09	84.24	93.29	96.9	91.48
Mean	3.20	3.90	4.90	4.00	3.09	3.92	5.12	4.04	80.01	82.78	85.88	82.89	82.29	88.75	95.70	88.91
LSD at 5%																
Salinity amendments	0.05				0.3				0.23				0.53			
Varieties	0.04				0.26				0.16				0.25			
Salinity amendments ×Varieties	0.07				0.44				NS*				0.43			

LRWC = Leaf relative water content **NS= non-significant**

Data presented in Table (3) appeared significant differences between the examined sugar beet varieties in respect to proline content and leaf relative water content (LRWC %) in the two growing seasons. multi-germ variety Amina recorded the highest values of the above mentioned studied characteristics followed by Unners variety then Faten > Farida > Sharleston in both seasons.

The interaction between salinity treatments and varieties on proline accumulation (u moles/g leaf fresh weight) in both seasons and leaf relative water content (LRWC %) in second seasons was significant as introduced in Table 3. The difference in proline accumulation of Farida and Faten varieties under Magic-Sal amendment was non-significant in 1st season, while, a significant variance in this trait was detected between same varieties under Sal-Wax amendment in same season. On the other hand, there is a significant variance in LRWC% between Faten and Unners varieties under Magic-Sal compound and this variance was not significant between same varieties under Sal-Wax compound in 2nd season.

The increase in proline content was positively correlated to the level of salt tolerance. These trends led us to think that proline was involved in salt tolerance in these sugar beet cultivars. But from a quantitative point of view, the true contribution to osmotic adjustment of the achieved proline contents appeared to be weak in the tolerant variety (Ghoulam *et al*., 2002). In sugar beet, glycinebetaine was accumulated to a high level and played the main role in osmotic adjustment under osmotic stress and could mask the contribution of other nitrogenous components by competition in nitrogen (Colmer *et al*., 1996). Other functions have been postulated for proline accumulation in stressed tissues; it could be a protective agent of enzymes and membranes (Bandurska, 1993). Accumulation of proline is regarded as an adaptive metabolic acclimation of plants to salinity stress, proline can act as a free radical scavenger. They recoded the maximum proline accumulation compared with control in both seasons which might be due to the influence effect of different salinity treatments types on decreasing the hazard effect created by salinity stress by increasing the accumulation of carboxylic acid in plant, significant increases occurred in proline concentration in leaves of sugar beet plants due to the application of salinity treatments (Helmi *et al*., 2018). On the other hand, it's well-known that the differences between the studied varieties mainly due to gene make up effect to salinity stress. Salinity induced a reduction in leaves RWC, this reduction was more important in the less tolerant variety than in the more tolerant one (Ghoulam *et al*., 2002). The decrease in LRWC indicated a loss of turgor that resulted in limited water availability for cell extension process (Katerji *et al*., 1997).

Quality traits:

Data presented in Table 4 showed that, a significant increase in sucrose, purity and ES % amounted to (1.71 and 3.82), (2.90 and 4.95) and (6.42 and 13.2) % accompanying the control compared to Magic-Sal and Sal-Wax compound was gained in the 1st season, Corresponding to (1.68 and 4.67), (2.45 and 6.86) and (4.81 and 15.02) % in the 2nd one, respectively. Data in Table 4, revealed a significant difference between the tested varieties in sucrose, purity and extractable sugar (ES) %. Where, Sharleston and Amina variety gave the highest and lowest sucrose, purity and extractable sugar (ES) % in both seasons, respectively. Where, variety Sharleston overcome by (1.56 and 1.50), (2.49 and 2.35) and (5.74 and 5.95) % of sucrose, purity and extractable sugar (ES) % in 1st and 2nd seasons, respectively, compared to Amina variety. The interaction between salinity treatments and sugar beet varieties under study was significant on quality traits (sucrose, purity and extractable sugar percentages) in 2018/2019 season only (Table 4). Where, the effect of salinity treatments (Magic-Sal or Sal-Wax) on sucrose and ES% of Unners and Amina varieties was significant in second season, compared to the effect of water salinity on same varieties without used any salinity treatments (control).

It is plausible that salinity in general, and Na in particular, have an effect on the source-sink relationship of plants. The effect of salinity on the inhibition of starch synthase activity, an important enzyme in carbon partitioning between sucrose and starch. Moreover, plant hormones modify phloem loading and activity of sucrose phosphate synthase (Daie, 1986), another carbon-partitioning enzyme, and might affect shoot-root allometry. An efficient accumulation of sugar in storage roots of sugar beet is related to the effect of plant-growth regulators in modification of anatomy of storage root with increasing effect on sucrose concentration (Hosford *et al*., 1984). Sodium accumulation in shoot might produce signals affecting biosynthesis or transport of growth regulators, which in turn cause modifications in shoot-root allometry and allocation and/or assimilate partitioning. Same result was found by Feizi *et al*., (2018) who indicated that with higher levels of water salinity, molasses sugar, leaf weight and the concentrations of Na, K, and a- amino-N in sugar beet significantly increased.

Table 4. Sucrose, extractable sugar and purity percentages of sugar beet varieties as affected by different salinity amendments during 2017/2018 and 2018/2019 seasons.

Characteristics	Sucrose%								Extractable sugar%								Purity%							
Seasons	2017/18				2018/19				2017/18				2018/19				2017/18				2018/19			
Salinity amendments / Varieties	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean
Sharleston	22.77	21.39	19.75	21.30	21.79	20.24	17.08	19.70	21.39	18.81	15.99	18.73	20.06	17.72	13.74	17.17	93.94	87.96	80.95	87.62	92.04	87.58	80.44	86.69
Farida	23.15	21.02	18.97	21.05	21.68	20	16.45	19.38	21.46	18.2	15.13	18.26	19.83	17.38	12.69	16.63	92.65	86.57	79.69	86.30	91.45	86.88	77.13	85.15
Faten	22.68	20.86	17.99	20.51	21.09	19.93	16.73	19.25	20.72	17.74	13.99	17.48	19.02	17.16	12.65	16.28	91.33	85.02	77.75	84.70	90.18	86.09	75.62	83.96
Unners	22.18	20.24	18.44	20.29	20.55	19.01	16.05	18.54	19.99	16.88	14.25	17.04	18.44	16.06	11.62	15.37	90.13	83.39	77.27	83.60	89.73	84.46	72.4	82.20
Amina	21.32	20.02	17.87	19.74	20.53	18.05	16.02	18.20	18.92	16.37	13.43	16.24	18.15	14.94	11.39	14.83	88.74	81.76	75.13	81.88	88.39	82.72	71.11	80.74
Mean	22.42	20.71	18.60	20.58	21.13	19.45	16.47	19.01	20.50	17.60	14.56	17.55	19.10	16.65	12.42	16.06	91.36	84.94	78.16	84.82	90.36	85.55	75.34	83.75
LSD at 5%																								
Salinity Amendments	0.23				0.18				0.22				0.15				0.06				0.34			
Varieties	0.3				0.2				0.3				0.2				0.35				0.3			
Salinity amendments × Varieties	NS				0.34				NS				0.35				NS				0.52			

Yields:

Data in Table 5 indicated that, salinity treatments had a significant influence on root and sugar yield (ton/fed) compared to control unit under water salinity stress in both seasons. Where, root yield significantly increased by (3.13 and 4.93) and (3.07 and 5.35) ton/fed under application of Magic-Sal and Sal-Wax compounds in 1st and 2nd seasons, respectively compared to control unit. On the other hand, the maximum values of white sugar yield (3.6 ton/fed) was significantly gained under application of Magic-Sal (13% humic acid + 20% carboxylic acid) compound in both seasons. Also, data in Table 3 indicated that, root yield of Amina variety showed significantly higher values (21.53 and 22.85 ton/fed) compared to other varieties under study in 1st and 2nd seasons, respectively. On the other hand, white sugar yield of Faten variety showed significantly higher value (3.51 ton/fed) compared to other varieties in second season only.

Table 5. Root and sugar yields (ton/fed) of sugar beet varieties as affected by different salinity amendments during 2017/2018 and 2018/2019 seasons.

Characteristics	Root yield (ton/fed)								White sugar yield (ton/fed)							
Seasons	2017/18				2018/19				2017/18				2018/19			
Salinity amendments / Varieties	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean	Control	Magic-Sal	Sal-Wax	Mean
Sharleston	14.92	20.06	21.93	18.97	16.85	20.96	23	20.27	3.19	3.77	3.51	3.49	3.38	3.71	3.16	3.42
Farida	16.78	20.43	21.97	19.73	17.71	21.29	23.52	20.84	3.6	3.72	3.32	3.55	3.51	3.7	2.98	3.40
Faten	18.11	20.93	22.36	20.47	19.73	21.96	23.89	21.86	3.75	3.71	3.13	3.53	3.75	3.77	3.02	3.51
Unners	18.41	20.78	22.7	20.63	19.75	22.33	24.43	22.17	3.68	3.51	3.23	3.47	3.64	3.59	2.84	3.36
Amina	19.67	21.32	23.6	21.53	19.94	22.76	25.85	22.85	3.72	3.49	3.17	3.46	3.62	3.4	2.94	3.32
Mean	17.58	20.70	22.51	20.26	18.80	21.86	24.14	21.60	3.59	3.64	3.27	3.50	3.58	3.63	2.99	3.40
LSD at 5%																
Salinity Amendments	0.19				0.37				0.07				0.15			
Varieties	0.26				0.29				NS				0.2			
Salinity amendments ×Varieties	0.45				0.5				0.13				0.35			

Data introduced in Table 5 showed that, root and white sugar yield (ton/fed) was significant under the interaction between salinity treatments and different varieties under study in 201/18 and 2018/19 seasons. In respect to root yield (ton/fed), the maximum values (23.60 and 25.85) was gained under interaction of applied Sal-Wax compound on Amina variety, while the minimum values (14.92 and 16.85) was gained under control unit of Sharleston variety in 2017/18 and 2018/19 seasons, respectively. On focused on first season, there is no significant differ in white sugar yield (ton/fed) of multi-germ: Farida and mono-germ: Unners varieties under Magic-Sal treatment compared to other application on same varieties.In addition, it helps plant growth through osmotic adjustment into its cell (Ibrahim and Naz, 2014) by increasing accumulation of suitable organic solutes (carboxylic acid) (Girija *et al.*, 2002). Also, it is an important nutrient for the plant growth and development where it enters in the composition of many important compounds such as glutathione, vitamins, co-enzymes, phytohormones. (Hasegawa *et al.*, 2000). it is also considered a good source of nutrients (Ca) (Fahmi and Abbas, 2012) that improves plant growth and increases the tolerance of the grown plants to water salinity (Gharaibeh *et al.*, 2012). Also, Ca recovers the membrane integrity and selectivity (Grattan and Grieve, 1998). Dadkhah (2011) reported that with increasing salt concentration decreased significantly root white sugar yield. Likewise, yields of root and white sugar yield significantly increased owing to the application of salinity treatments (Helmi *et al.*, 2018).

Analysis of stoma morphological parameters:

In relation to the morphological changes of stomata response to salinity stress varieties under the effect of salinity treatments, the microscopic analysis (images a, b, c, and d) showed that salinity stress and its treatments affected stomata density, size, stomatal closure % and its index of sugar beet varieties under study. Individual response of varieties to water salinity stress and salt treatments was observed for each parameter of stomata. A negative relationship between stomata density and size or area was found by Franks *et al.*, (2009).

The distribution of stomata density on the lower surface (abaxial) and upper surface (adaxial) of the leaves were decreased in a much more pronounced way for the abaxial than the adaxial leaf surface under application of salinity treatments compared to the distribution of stomata density under salinity stress without used any application (Fig. 2). Another different behavior for stomata closure % was found (Fig. 3) with application of salinity treatments compared to control on sugar beet varieties. There were slight differences between Magic-Sal and Sal-Wax compounds but stomata were closed under severe stress resulted from water salinity stress (control) as a result of loss of guard cell turgor pressure. All varieties under salinity treatments had positive effects and increased stomata area but decreased stomata density and its index as well as stomata closure percentage compared with non-treatments (Fig. 2 and 3). The microscopic analysis (image a, b, c, and d) showed that: Sal-Wax with Sharelston variety was recoded high stomata area (Fig. 2), lower stomata density and stomata closure % (Fig. 3). Without use any treatments to salinity water on Amina variety affected all stomata parameter and recorded the high stomata closure %, an increase in density and reduce dimensions. Franks *et al.*, (2009) suggested that taking into account the leaf area limitation, there is a point when the only way to increase stomatal conductance is by decreasing stomatal size and increasing density. Many researchers indicated that salinity and drought stress results in increasing stomatal density and a decrease in stomatal size (Zhang *et al.*, 2006). Spence *et al.*, (1986) reported that high density and small size of stomata may enhance adaptation of plant to salinity and drought, it allows plants to be more efficient in regulation of water transport and transpiration (Dickison, 2000). Decreased photosynthetic rates under severe drought stress resulted from water salinity stress conditions may be due to lower stomata size and reduced intercellular CO_2 concentrations as a result of stomatal closure and CO_2 diffusion limitations under reduced free water conditions (Chaves *et al.*, 2003).

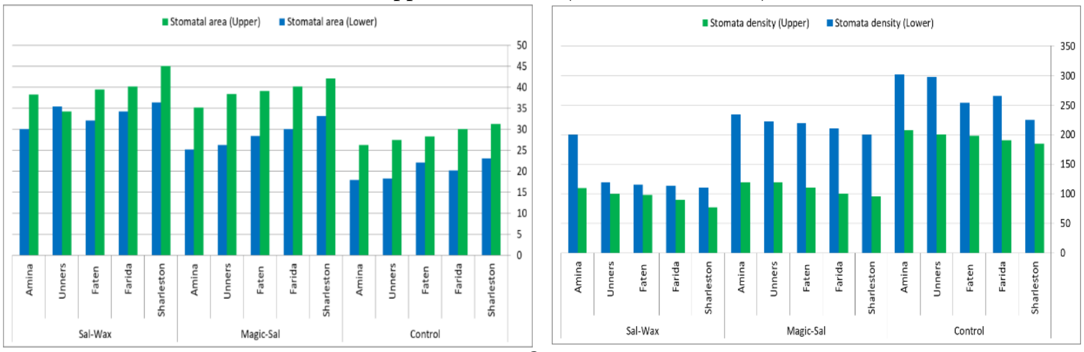

Fig. 2. Stomatal area (µm) and density (No. mm^{-2}) for upper and lower surfaces of sugar beet leaf of five varieties as affected by different salinity treatments (average of two seasons)

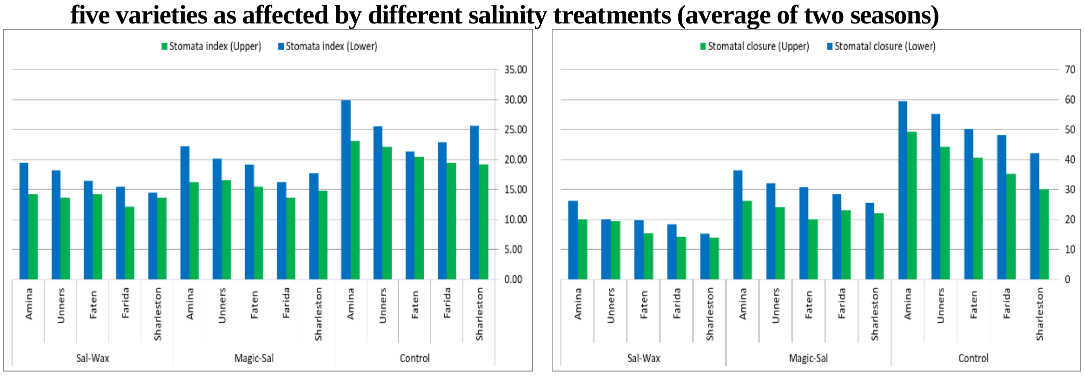

Fig. 3 Stomatal closure% and stomata index (SI %) for upper and lower surfaces of sugar beet leaf sugar beet leaf of five varieties as affected by different salinity treatments (average of two seasons).

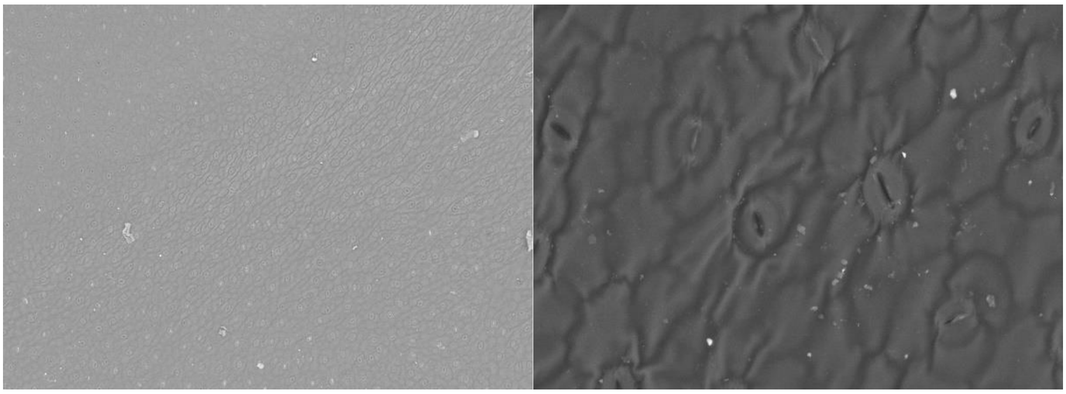

Image a. Electron microscopic images (magnification 250 and 2000) of (lower) abaxial surface stomata of sugar beet leaf of Amina variety under the effect of water salinity water (control).

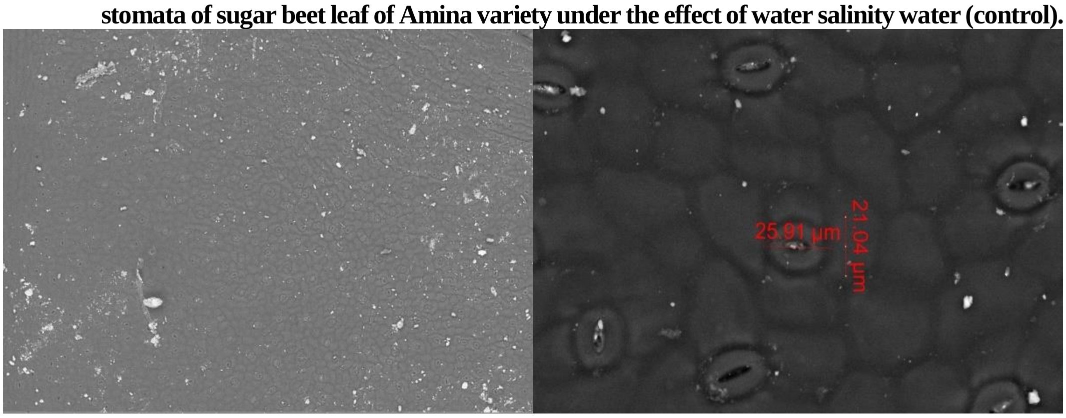

Image b. Electron microscopic images (magnification 250 and 2000) of (upper) adaxial surface stomata of sugar beet leaf of Amina variety under the effect of water salinity water (control).

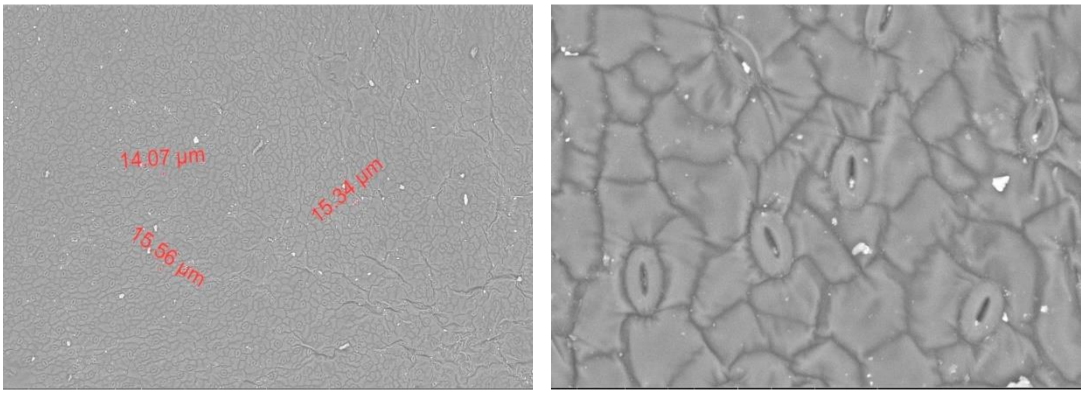

Image c. Electron microscopic images (magnification 250 and 2000) of (lower) abaxial surface stomata of sugar beet leaf of Sharleston variety under the effect of Sal-Wax salinity amendment.

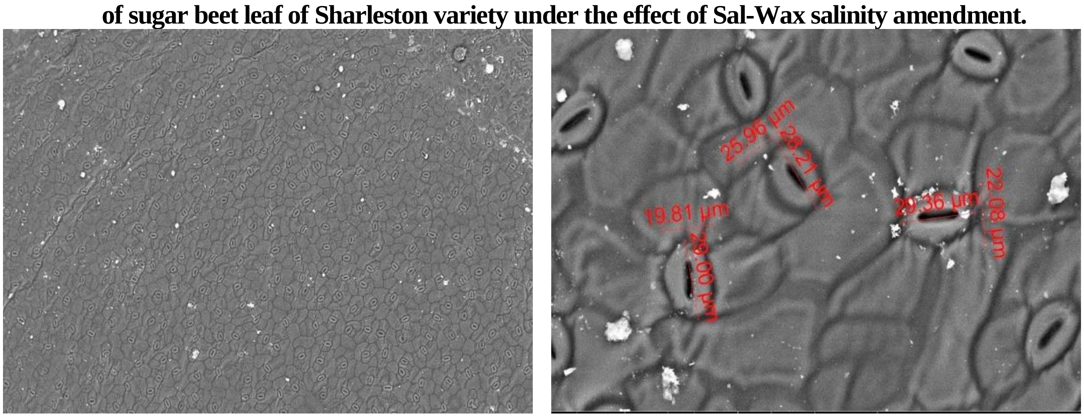

Image d. Electron microscopic images (magnification 250 and 2000) of (upper) adaxial surface stomata of sugar beet leaf of Sharleston variety under the effect of Sal-Wax salinity amendment.

Determination the tolerant varieties

In consequence, selection of varieties that have high root yield (ton/fed) under both stress and non-stress conditions. Based on the tolerance index (TOL) and reduction percentage of root yield (Fig. 4), varieties, Faten, Unners and Amina were found salinity tolerance with the lowest TOL (4.21, 4.49 and 4.92) and lowest root yield reduction percentage (18.18, 19.03 and 19.90%), while Sharleston and Farida displayed the highest amount of TOL (6.58 and 5.50) and highest root yield reduction percentage (29.29 and 24.18%). Also, with regard to mean productivity (MP) and yield stability index (YSI), varieties Faten, Unners and Amina were the most relative tolerant. In fact, the tolerance of different varieties was because of their physiological ability to control water loss during stress conditions. Several selection criteria have been proposed to select varieties based on their performance in stress and non–stress environments. Concluded that MP value is not a convenient parameter to select high yielding sugar beet varieties in both stress and non-stress conditions whereas a relative decrease in yield, TOL and YSI values are better indices to determine tolerance levels. The indices YSI, TOL and MP can be used as the most suitable indicators for screening stress tolerant varieties (Hesadi *et al.*, 2015; Abu-Ellail *et al.*, 2019).

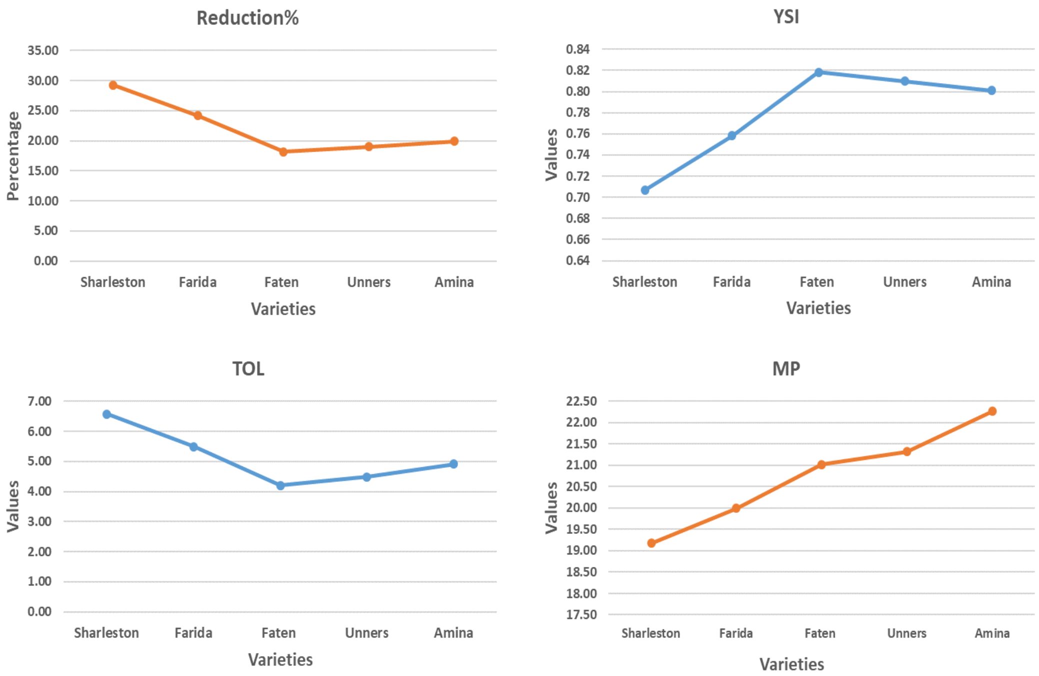

Fig. 4 Mean values of root yield stability index (YSI), tolerance index (TOL), mean productivity (MP), reduction percentage for sugar beet varieties

CONCLUSION

In new reclaimed area under salinity water stress, the present study revealed that the application of Sal-Wax (50% carboxylic acid) compound as a salinity amendment on Amina sugar beet variety was more efficient on germination ratio, proline accumulation, leaf relative water content (LRWC %) and yields (root and white sugar yield), while the application of Magic-Sal (13% humic acid + 20% carboxylic acid) on Sharelston variety was more efficient on quality parameters (sucrose, purity and extractable sugar percentages). The results also showed that, five sugar beet varieties under the two salinity treatments (Magic-Sal or Sal-Wax) had positive effects and increased stomata area, but stomata density and its index as well as stomata closure % decreased compared with non-use.

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تقييم بعض أصناف بنجر السكر تحت إجهاد ملوحة المياه في الأراضي المستصلحة الجديدة

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تماشياً مع الزراعة المستدامة التي تعتمد على الأساليب الحديثة والمصادر الجديدة للري غير التقليدي ، أجريت تجربة حقلية في مزرعة خاصة خلف طريق القاهرة - الإسكندرية الصحراوي ، الجيزة ، مصر خلال موسمين لتقييم خمسة أصناف من بنجر السكر تحت ملوحة المياه. اشتمل العمل الحالي على 15 علاجًا ؛ تمثل خمسة أصناف بنجر السكر: متعدد الأجنة (أمينة وفريدة وفاتن) و أحادية الجنين (أونرز وشارلستون) ، في توليفة مع علاجين للملوحة (ماجيك سال (13٪ حمض الهيوميك + 20٪ حمض كربوكسيل) وسال واكس (50٪) حمض الكربوكسيل) مقارنةً بتطبيق الكنترول. أشارت النتائج إلى أن معالجات الملوحة تساعد في المراحل المبكرة على زيادة نسبة الانبات لأصناف بنجر السكر تحت ضغط المياة عالية الملوحة. بالمقارنة مع المعاملة الكنترول ، أدت معاملات الملوحة إلى زيادة معنوية في تراكم البرولين ، ومحتوى الماء النسبي للأوراق(٪ LRWC) ، وحاصل الجذر ، ولكنها تسببت في انخفاض معايير الجودة (السكروز ، والنقاء ، ونسب السكر القابل للاستخراج) في كلا الموسمين. من ناحية أخرى ، تجاوز الصنف(أمينة)الأصناف الأخرى تحت ضغط تاثير ملوحة المياه من حيث نسبة الإنبات ، محتوى البرولين ،(٪ LRWC) ، وإنتاج الجذر (طن / فدان) في كلا الموسمين. بينما تفوق صنف (شارلستون) معنويا على الأصناف الأخرى المدروسة من حيث السكروز والنقاء ونسبة السكر المستخلص في كلا الموسمين. وزاد توزيع كثافة الثغور في الأوراق مع زيادة مستوى إجهاد المياه المالحة. كما أظهرت النتائج أن خمسة أصناف من بنجر السكر تحت معاملتي ملوحة (Magic-Sal) أو (Sal-Wax) كان لها تأثيرات إيجابية وزيادة مساحة الثغور ، بينما انخفضت كثافة الثغور ومؤشرها وكذلك إغلاق الثغور مقارنة مع عدم الاستخدام.

الكلمات المفتاحية: أرض مستصلحة حديثاً. ادلة الاختيار. بنجر السكر. ملوحة الماء