EFFECT OF SEED SOAKING IN GIBBERELLIC ACID AND FOLIAR APPLICATION OF CALCIUM ON YIELD AND QUALITY OF SUGAR BEET UNDER SALINE SOIL CONDITIONS

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ABSTRACT

Two field experiments were conducted at El-Sirw Agricultural Research Station, Damietta Governorate (latitude of 31.14^0 N and longitude of 31.39^0 E) during 2012/2013 and 2013/2014 seasons to investigate the efficacy of seed soaking in gibberellic acid solution (GA_3) and foliar application of calcium on growth, yield and quality of sugar beet crop (*Beta vulgaris* var. *saccharifera,* L.) grown in a saline soil conditions. The present work included eighteen treatments, represented the combinations of six seed soaking treatments: 1. dry seeds (control); 2. seeds soaked in tap water (hydro-soaked); 3. seeds soaked in 50 ppm GA_3; 4. seeds soaked in 100 ppm GA_3; 5. seeds soaked in 150 ppm GA_3 and 6. seed soaked in 200 GA_3. Furthermore, three concentrations of Calso-x (8% chelated calcium as calcium carbamide, claw on humic acid 10% and free amino acids 3%): 1. without calcium (control); 2. half liter Calso-x/400 liter water/fed, equivalent to 144 ppm calcium/fed and 3. one liter Calso-x/400 liter water/fed, equivalent to 288 ppm calcium/fed, which were sprayed twice at 4-6 and at 6-8 leaf stage later. The treatments were arranged in split-plots design with four replicates.

The results showed that sowing sugar beet using seeds soaked in 150 ppm GA_3 produced significantly higher values of root length, diameter, root, top fresh weight/plant, root, top and sugar yields/fed and caused an appreciable increase in root and top dry weight/plant as well as the lowest quantities of sugar lost to molasses in both seasons and their combined.

Increasing calcium application up to 288 ppm/fed resulted in higher values of root length, diameter, root and top fresh weight/plant, root, top and sugar yields/fed, Ca and K contents in leaves as well as decreased sodium content/leaves. Moreover, it improved sucrose and sugar recovery percentages significantly .

The interaction between seed soaking treatments and calcium levels significantly affected root length and root yield/fed in both seasons, where the combination of soaking seeds in 150 ppm GA_3 with spraying sugar beet with 288 ppm calcium/fed led to the maximum root yield of 19.92 and 19.32 t/fed, in the 1st and 2nd season, respectively.

Key words: Calcium, Gibberellic acid, Saline soil, Sugar beet.

INTRODUCTION

Seeds are particularly vulnerable to stress encountered between sowing and seedling establishment, while plant salt tolerance usually increases with plant ontogeny. Soil salinity may affect the germination of seeds either by creating osmotic potential external to the seeds preventing water uptake or through the toxic effects of Na^+ and Cl^- ions on germinating seed (**Khajeh, *et al*. 2003**). Sugar beet is one of the salt tolerant crops, but it is reported to be less tolerant to salinity during germination, emergence and in the seedling stage. Therefore, any treatment which could be used to improve seed germination and subsequent seedling establishment under saline conditions would be highly desirable (**Eisa, 2006**). One of these approaches is pre-sowing seed treatments such as seed soaking. It has been used to reduce the seedling emergence time, synchronize emergence, improve emergence rate, which ultimately result in better seedling stand in many crops. Furthermore, it is an easy, low cost and low risk technique used to overcome agricultural problems and control hydration technique in which, seeds are soaked in solutions of low-osmotic potential before the actual germination takes place and that allows metabolic activities to proceed before radical protrusion as a result of stress conditions (**Iqbal and Ashraf, 2005** and **Farooq, *et al*., 2006**).

Plant growth regulators are considered organic compounds that produced in small amounts in plants and play an important role in growth, development and yield of agricultural crops. Gibberellic acid (GA_3) is an important endogenous growth regulator, has profound and diverse effects on plant growth and development. **Iqbal, *et al*. (2001)** found that GA_3 increased germination percentage under salt stress and improved fresh and dry weight of plumule and radical along with an increase in their length. One of the roles of gibberellins is the induction of seed germination and the promotion of radical elongation and mobilization of endosperm reserves during early embryo growth. **Jamil and Rha (2007)** indicated that water uptake of soaked seeds was increased significantly with appropriate concentration of GA_3 as compared to the control. In addition, GA_3 plays an important role in the induction of tolerance to salinity and overcome limitations created by the environmental stress such as osmotic effects, ion toxicity and nutritional imbalance. **Nasri,*et al*. (2012)** indicated that the inhibitory effect of salt stress on seed germination is alleviated by phyto-hormones, including gibberellic acid, as well as the exogenous application of gibberellins increased germination percentage and improved length and fresh weight of roots and shoots under salt treatment.

Calcium plays two roles in the production of sugar beet. First, it is a major plant nutrient, uptake being greater than phosphorus or magnesium, but less than nitrogen or potassium. Second, its presence in large quantities in soil is essential because it is the main regulator of soil P^H, as well as it is important in many physiological processes and is believed to act as a second messenger where, in plant cells, calcium functions as a second messenger represented in coupling a wide range of extracellular stimuli to intracellular responses. Salinity can alter Ca^{2+} uptake and transport leading to Ca^{2+} deficiency in plants. It has been shown that increased salinity reduced the amount of calcium bound to plasma membranes of roots and protoplasts and greatly reduced calcium concentration in root apical meristem **(Lazof and Lauchli, 1991). Bonilla, *et al.* (2004)** reported that calcium is known to exert important consequences on several physiological processes in plants like ion transport, translocation of carbohydrates, protein and other enzymatic activities. Moreover, it has been reported to inhibit Na^+ uptake and thereby reduce its adverse effect and increase plant growth, where, there is a competition between Na^+ and Ca^{2+} ions to enter into cell membrane. Therefore, it has been defended that higher calcium levels protect cell membrane from negative effects of salinity **(Arshi,*et al.* 2006)**, and may be involved in signal transduction involving new gene expression . It also controls guard-cell turgor and stomatal aperture and helps in turgor maintenance **(Bhattacharjee, 2009). Artyszak (2014)** revelead that calcium as foliar spraying resulted in increases of root, top and sugar yields/fed compared with the control treatment. At the same time, a positive effect on the roots technological quality found as a result of a significant reduction of α-amino-N, K and Na contents.

The aim of the present study was to evaluate the influence of applying different soaking treatments of sugar beet seeds in GA_3 along with foliar application of calcium, to get the best stand, growth, quality as well as the highest root and sugar yield under a saline soil conditions.

MATERIALS AND METHODS

Two field experiments were conducted at El-Sirw Agricultural Research Station, Damietta Governorate (latitude of 31.14^0 N and longitude of 31.39^0 E) during 2012/2013 and 2013/2014 seasons to investigate the efficacy of seed soaking in gibberellic acid solution (GA_3) and foliar application of calcium on growth, yield and quality of sugar beet crop (*Beta vulgaris* var. *saccharifera,* L.) grown in a saline soil conditions. The present work included eighteen treatments, represented the combinations of six seed soaking treatments: 1. dry seeds (control); 2. seeds soaked in tap water (hydro-soaked); 3. seeds soaked in 50 ppm GA_3; 4. seeds soaked in 100 ppm GA_3; 5. seeds soaked in 150 ppm GA_3 and 6. seed soaked in 200 GA_3. Furthermore, three concentrations of Calso-x (8% chelated calcium as calcium carbamide, claw on humic acid 10% and free amino acids 3%): 1. without calcium (control); 2. half liter Calso-x/400 liter water/fed, equivalent to 144 ppm calcium/fed and 3. one liter Calso-x/400 liter water/fed, equivalent to 288 ppm calcium/fed, which were sprayed twice at 4-6 and at 6-8 leaf stage later. The treatments were arranged in split-plots design with four replicates. The three levels of calcium were allocated in the main plots and the six seed soaking in gebberellic acid treatments were randomly distributed in the sub-plots. The sub-plot area was 10.5 m^2 including 5 ridges of 3.5 m in length and 60 cm in width. Phosphorus fertilizer was applied in the form of calcium super phosphate (15 % P_2O_5) at the rate of 200 kg/fed at seed bed preparation. Nitrogen fertilizer was applied as (a mixture of ammonium nitrate and ammonium sulphate at 50:50 ratio) at rate of 60 kg N/fed in two equal doses, after thinning and one month later. Potassium fertilizer was added in the form of potassium sulphate (48% K_2O) at the rate of 48 kg/fed before canopy closer. Seeds of the commercial sugar beet variety "Sultan" were sown in the lower part of ridges (to avoid the negative influence of salts appeared on the top of ridges on the germination of beets). Hills were spaced at 20 cm apart. Planting took place during the 1st week of October, while harvesting was done at age of 7 months later, in both seasons. Plants were thinned at 4-leaf stage to ensure one plant per hill.

Preparation of soaking solution:

Gibberellic acid 10% in the form of tablets weighing 10 g, a tablet has (1 g GA_3). To prepare the studied concentrations of the soaking solutions 0.5, 1.0, 1.5 and 2.0 tablets were dissolved in a little amount of water for 3-5 minutes and completed to 10 liters of water for 12 hours to obtain 50, 100, 150 and 200 ppm GA_3, respectively. After soaking process, the seeds were dried in ambient temperature conditions before sowing.

Soil physical properties were analyzed using the procedure described by **Black, *et al.* (1981)**. Soil chemical analysis was determined according to the method described by **Jackson (1973)**. Physical and chemical analyses of the soil (the upper 30-cm) of the experimental site are given in Table 1.

Table 1: Particle size distribution and some chemical properties of a representative soil sample of the experimental site in 2012-2013 and 2013-2014 seasons.

Soil properties	2012/2013 season	2013/2014 season
Particle size distribution:		
Sand %	24.10	27.23
Silt %	36.30	34.21
Clay %	39.60	38.56
Texture class	clay lame	clay lame
Organic Matter %	1.65	1.59
Available Nitrogen mg/kg soil	84.40	78.44
Available P_2O_5mg/kg soil	7.85	8.55
Available K_2Omg/kg soil	282	300
Available calcium mg/kg soil	580	620
pH at (1:2.5) soil : water suspension	8.15	7.90
EC dS/m^{-1}	9.00	8.70
Soluble Cations (meq/L^{-1})		
k^+	3.70	3.59
Na^+	58.5	47.7
Mg^{++}	31.1	37.2
Ca^{++}	18.5	19.8
Soluble Anions (meq /L^{-1})		
$So_4^=$	20.29	23.29
Cl^-	85.3	79.1
HCO_3^-	6.21	5.90
$CO_3^=$	-	-
SAR %	9.91	7.69
ESP %	13.87	10.76

The recorded data:

1. Root length and diameter (cm).
2. Root and top fresh weight (g/plant).
3. Root and leaves dry weights as g/plant were determined as follows:
   100 g of the fresh leaves and minced fresh roots were oven dried at 70 °C to a constant weight. Then the dry matter percentages of these two portions were multiplied by their fresh weight/plant.

*** Chemical and quality characteristics**:

4. Sucrose percentage (Pol%) was estimated in fresh samples of sugar beet roots, using Saccharometer according to the method described in A.O.A.C. (2005).

5. Sugar lost to molasses percentage (SLM %) was calculated by the follwing formula according to **Devillers (1988)**:

SLM% = 0.29 + (Na + K) 0.343 + 0.094 (α-amino N).

6. Sugar recovery % was calculated using the following equation according to **Cooke and Scott (1993).**

Sugar recovery % = (Pol % - 0.29) - 0.343(K + Na) - α- amino N (0.0939).

Where: K, Na and α-amino N were determined as meq/100 g beet.

7. Juice quality percentage (QZ %) was calculated according to **Cooke and Scott (1993)** using the following equation:

Q Z % = (sugar recovery % x100)/Pol %.

8. Impurities%: K, Na and α-amino N contents were estimated as meq/100 g beet according to the procedure of sugar company using an Automated Analyzer as described in **Cooke and Scott (1993).**

9. **Foliage contents of Ca, K and sodium**:

The dry matter of leaves was digested using an acid mixture consisting of nitric, perchloric and sulfuric acids in the ratio of 8:1:1 (v/v), respectively **(Chapman and Pratt 1978)**. Calcium was determined using flame photometer (Genway). Potassium and sodium was measured using Dr. Lang-M8D Flame-photometer.

* **Root, top and sugar yields/fed (t/fed)**:

At harvest, plants of two guarded ridges were uprooted, topped and weighed to determine the following parameters:

10. Top yield (ton/fed).
11. Root yield (ton/fed).
12. Sugar yield (ton/fed), which was calculated according to following equation:

Sugar yield (ton/fed) = roots yield (ton/fed) x sugar recovery%.

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip plot design as published by **Gomez and Gomez (1984)** by means of **"MSTAT-c"** computer software package. Least significant differences between treatment means at 5% level of probability as were described by **Snedecor and Cochran (1980).**

RESULTS AND DISCUSSION

1. Root length, diameter and fresh weight:

The combined analysis of the two growing seasons in Table 2 manifest a significant effect of soaking sugar beet seeds in GA_3 solution on root length, diameter and fresh weight. Soaking sugar beet seeds in 150 and/or 200 ppm GA_3 gave higher values of these traits compared with the other treatments. This finding may be due to that GA_3 causes the release of enzymes as amylase and protease, which participate in the break down of stored starch to simple sugars. These sugars translocate to growing embryo, where they provide energy for growth and hence enhance seed germination, leading to better seedlings growth. In addition, GA_3 plays an important role in the induction of tolerance to salinity and overcome limitations created by the environmental stress such as osmotic effects, ion toxicity and nutritional imbalance. In addition it may cause a significant increase in photosynthetic activity of during the vegetative stage of the crop and it might attribute to development processes such as elongation (**Iqbal** ***et al.*****, 2001** and **Jamil and Rha, 2007**). The results showed insignificant difference between soaking seeds in 150 or 200 ppm GA_3 in their influence on these traits.

Table 2: Root length (cm), diameter (cm) and fresh weight (g/plant) as affected by seed soaking in gibbrelic acid (GA_3) and calcium fertilization in 2012/2013 and 2013/2014 seasons and their combined.

Treatments of sugar beet	Root length		Comb.	Root diameter		Comb.	Root fresh weight		Comb.
	1st season	2nd season		1st season	2nd season		1st season	2nd season	
Dry seeds	26.45	26.50	26.48	6.34	6.14	6.24	355.2	268.1	311.7
Soaking in water	27.46	26.95	27.20	7.27	6.54	6.90	423.8	357.0	390.4
Soaking in 50 ppm GA_3	26.51	26.53	26.52	6.75	6.22	6.48	394.7	300.9	347.8
Soaking in 100 ppm GA_3	27.49	27.08	27.29	7.28	6.67	6.97	439.3	356.5	397.9
Soaking in 150 ppm GA_3	28.61	27.47	28.04	7.73	6.99	7.36	483.9	422.2	453.1
Soaking in 200 ppm GA_3	27.86	27.49	27.68	7.78	7.04	7.41	461.3	420.0	440.7
LSD at 0.05 level	**0.98**	**0.41**	**0.63**	**0.43**	**0.22**	**0.26**	**28.58**	**46.56**	**29.16**
Without calcium	25.08	25.96	25.52	6.52	6.03	6.28	358.9	286.4	322.6
144 ppm calcium/fed	27.34	26.97	27.15	7.23	6.59	6.91	432.3	352.8	392.6
288 ppm calcium/fed	29.78	28.09	28.93	7.82	7.17	7.50	487.9	423.2	455.6
LSD at 0.05 level	**2.19**	**0.62**	**0.45**	**0.52**	**0.53**	**0.18**	**54.05**	**65.17**	**20.62**

* Without calcium (Control): sugar beet plants were sprayed with water.

* 144 ppm and 288 ppm point to the application of 0.5 and 1.0 liter of Calso-x/400 liters water, which were sprayed twice at 4-6 and 6-8 leaf stage. Which, Calso-x contains 8% chelated calcium claw on 10% humic acid and 3 % free amino acids.

Root length, diameter, fresh weight of sugar beet were increased significantly by increasing the sprayed calcium levels in both seasons and their combined. The foliar application of 288 ppm calcium/fed gave 6.55%, 8.53% and 16.04% increase in root length, diameter and root fresh weight/plant, respectively, over plants received 144 ppm calcium/fed, and gave 13.36%, 19.42% and 41.22% increase in root length, diameter and root fresh weight/plant, respectively, over plants sprayed with water (without calcium). The increases in the above mentioned traits may be due to the role of calcium in physiological processes, where supplying plants with calcium may alleviate detrimental effects of Na^+ on the physiological performance of grown plants. There is evidence that Na^+ induces calcium deficiency in plant tissues consequently, it is assumed that calcium supply may mitigate Na^+ toxicity to plants (**Patel** ***et al.*** **2010**).

The interaction between soaking treatments in gibberellic acid (GA_3) and calcium fertilization had insignificant effect on the above-mentioned traits, with the exception of root length in both seasons (Table 2).

germination which allowed the emerging seedlings to accumulate more biomass relative to the control, this increase in dry matter possibly attributed to synergistic effect of soaking seeds on vegetative growth, number and area of leaves as well as photosynthesis rate which increased dry matter accumulation in roots, hence initiation of the early metabolic processes in the initial stage of germination. These results were mainly due to the enhancing role of GA_3 as shown by **Jamil and Rha (2007)**.

Table 4: Top fresh weight (g/plant), root and top dry weight (g/plant) as affected by seed soaking by gibbrelic acid (GA_3) and calcium fertilization levels in 2012/2013 and 2013/2014 seasons and their combined.

Treatments of sugar beet	Top fresh Weight (g/plant)		Comb.	Root dry weight (g/plant)		Comb.	Top dry Weight (g/plant)		Comb.
	1st season	2nd Season		1st season	2nd season		1st season	2nd season	
Dry seeds	221.7	217.2	219.5	57.38	40.71	49.05	19.61	17.49	18.55
Soaking in water	239.8	241.1	240.5	73.24	57.25	65.25	23.02	21.80	22.41
Soaking in 50 ppm GA_3	224.5	230.0	227.3	64.80	45.54	55.17	20.61	18.91	19.76
Soaking in 100 ppm GA_3	239.1	249.4	244.3	74.97	55.60	65.29	23.36	21.98	22.67
Soaking in 150 ppm GA_3	253.4	260.6	257.0	80.10	67.90	74.00	26.52	24.43	25.48
Soaking in 200 ppm GA_3	249.3	266.2	257.7	78..94	67.69	73.32	26.24	24.97	25.60
LSD at 0.05 level	**13.91**	**10.26**	**8.57**	**5.01**	**9.65**	**8.07**	**1.84**	**2.21**	**2.25**
Without calcium	219.4	218.9	219.2	63.91	53.18	58.54	19.68	17.81	18.74
144 ppm calcium/fed	237.7	244.4	241.1	73.52	56.06	64.79	22.61	22.20	22.40
288 ppm calcium/fed	256.8	268.9	262.9	77.29	58.11	67.70	27.40	24.79	26.09
LSD at 0.05 level	**16.05**	**8.55**	**6.06**	**NS**	**NS**	**5.71**	**NS**	**NS**	**1.59**

* Without calcium (Control): sugar beet plants were sprayed with water.
* 144 ppm and 288 ppm point to the application of 0.5 and 1.0 liter of Calso-x/400 liters water, which were sprayed twice at 4-6 and 6-8 leaf stage. Which, Calso-x contains 8% chelated calcium claw on 10% humic acid and 3 % free amino acids.

Combined analysis cleared that top fresh weight/plant, root and top dry weight increased significantly by raising the calcium level from zero to 288 ppm. This effect was more clear and pronounced when the level of calcium was doubled. This favourable effect may be attributed to formation ample canopy and increase dry matter accumulation. These result were in agreement with those found by **Artyszak (2014)**.

The interaction between soaking treatments in gibberellic acid (GA_3) and calcium fertilization failed to reach the level of significance in their effect on the above-mentioned traits in both seasons (Table 4).

3. Calcium, potassium and sodium contents in leaves/plant:

Soaking sugar beet seed in GA_3 significantly affected potassium content in leaves/plant as shown in Table 5. While calcium and sodium contents in leaves/plant was insignificantly influenced by soaking seed in GA_3 in both seasons and their combined. It could be noticed that seed soaked in GA_3 at 150 and 200 ppm significantly increased potassium content in leaves/plant and attained the highest significant values compared with the other treatments.

Table 5: Calcium, potassium and sodium contents in leaves (mg/100 g plant) as affected by seed soaking by gibbrelic acid (GA_3) and calcium fertilization in 2012/2013 and 2013/2014 seasons and their combined.

Treatments of sugar beet	Calcium content in leaves (mg/100 g plant)		Comb.	Potassium ccontent in leaves (mg/ 100 g plant)		Comb.	Sodium ccontent in leaves (mg/ 100 g plant)		Comb.
	1st season	2nd season		1st season	2nd season		1st season	2nd season	
Dry seeds	38.15	36.30	37.23	176.9	158.8	167.9	95.22	80.92	88.07
Soaking in water	44.95	40.22	42.59	214.3	187.6	200.9	90.21	80.21	85.21
Soaking in 50 ppm GA_3	40.36	42.15	41.26	179.4	161.8	170.6	91.80	79.48	85.64
Soaking in 100 ppm GA_3	46.32	41.98	44.15	220.6	187.7	204.2	89.67	81.13	85.40
Soaking in 150 ppm GA_3	49.15	42.78	45.97	239.4	201.1	220.3	83.08	75.98	79.53
Soaking in 200 ppm GA_3	49.29	44.50	46.90	253.6	194.4	224.0	90.09	79.11	84.60
LSD at 0.05 level	**NS**	**NS**	**NS**	**30.29**	**NS**	**25.19**	**NS**	**NS**	**NS**
Without calcium	26.83	24.25	25.54	171.8	111.8	141.8	115.9	95.59	105.8
144 ppm calcium/fed	44.13	41.54	42.84	218.7	193.7	206.2	90.59	80.10	85.35
288 ppm calcium/fed	63.15	58.18	60.67	251.7	240.2	245.9	63.53	62.72	63.12
LSD at 0.05 level	**9.56**	**15.71**	**5.37**	**37.41**	**64.95**	**17.81**	**22.03**	**15.74**	**8.87**

* Without calcium (Control): sugar beet plants were sprayed with water.
* 144 ppm and 288 ppm point to the application of 0.5 and 1.0 liter of Calso-x/400 liters water, which were sprayed twice at 4-6 and 6-8 leaf stage. Which, Calso-x contains 8% chelated calcium claw on 10% humic acid and 3 % free amino acids.

Data in the same time, showed that these elements were significantly influenced by the sprayed calcium fertilization level when raised from zero up to 288 ppm calcium/fed in both seasons and their combined. Application of 288 ppm calcium/fed resulted in the highest values of calcium, potassium and lowest values of sodium contents in leaves/plant compared to other calcium treatments. This result may be due to that preserving of calcium and potassium contents in the plants sprayed with calcium helps in regulating ion transportation and membrane permeability and hence normal growth of sugar beet plants. These results are in agreement with those obtained by **Gul and Khan (2008)** who revealed that sodium content significantly increased in tissues of plants under saline soil, but decreased with increasing calcium supply to plants. Although, uptake mechanisms of both potassium and sodium are similar but the sodium can not move through the plasma membrane lipid bilayer, where, the ion is transported through both low-and high-affinity transport systems, which are necessary for potassium acquisition. As a consequence, sodium could enter the cell through high affinity potassium carriers or through the low affinity channels called nonselective cation channels. These cation channels could allow entry of large amount of sodium from a highly saline soil if not adequately regulated, and whereas that calcium is an efficient blocker of nonselective cation channels, Which, is considered a major route for sodium uptake into the cell. Thus, it may be directly reduce amount of sodium accumulation in plants leaves.

The interaction between soaking treatments in gibberellic acid (GA_3) and calcium fertilization had insignificant effect on the previously mentioned traits in both seasons (Table 5).

4. Potassium, sodium and alpha amino-N contents/beet:

The combined analysis in Table 6 show that soaking sugar beet seeds in GA_3 had insignificant effects on potassium and alpha amino-N contents while, there were significant differences between soaking treatments in their effect on sodium content in roots at harvest. Both seeds treatments (without soaking and soaked in 50 ppm GA_3) gave the highest values of sodium content in roots compared with the rest of seed soaked treatments.

Table 6: Potassium, sodium and alpha-amino N contents (meq/100 g beet) as affected by seed soaking by gibbrelic acid (GA_3) and calcium fertilization levels in 2012/2013 and 2013/2014 seasons and their combined.

Treatments of sugar beet	Potassium (meq/100 g beet)		Comb.	Sodium (meq/100 g beet)		Comb.	Alpha-amino N (meq/100 g beet)		Comb.
	1st season	2nd season		1st season	2nd season		1st season	2nd season	
Dry seeds	3.53	3.65	3.59	2.52	2.31	2.42	2.34	2.17	2.26
Soaking in water	3.48	3.57	3.53	2.31	2.35	2.33	2.30	2.15	2.23
Soaking in 50 ppm GA_3	3.55	3.61	3.58	2.47	2.34	2.41	2.36	2.18	2.27
Soaking in 100 ppm GA_3	3.50	3.58	3.54	2.34	2.33	2.34	2.34	2.17	2.26
Soaking in 150 ppm GA_3	3.44	3.56	3.50	2.28	2.30	2.29	2.29	2.11	2.20
Soaking in 200 ppm GA_3	3.49	3.57	3.53	2.30	2.32	2.31	2.31	2.15	2.23
LSD at 0.05 level	**NS**	**NS**	**NS**	**0.10**	**NS**	**0.07**	**NS**	**NS**	**NS**
Without calcium	3.64	3.74	3.69	2.54	2.57	2.56	2.32	2.17	2.25
144 ppm calcium/fed	3.48	3.60	3.54	2.35	2.33	2.34	2.31	2.10	2.21
288 ppm calcium/fed	3.39	3.43	3.41	2.22	2.09	2.16	2.34	2.20	2.27
LSD at 0.05 level	**0.09**	**0.12**	**0.07**	**0.14**	**0.24**	**0.05**	**NS**	**NS**	**NS**

* Without calcium (Control): sugar beet plants were sprayed with water.
* 144 ppm and 288 ppm point to the application of 0.5 and 1.0 liter of Calso-x/400 liters water, which were sprayed twice at 4-6 and 6-8 leaf stage. Which, Calso-x contains 8% chelated calcium claw on 10% humic acid and 3 % free amino acids.

Application of calcium levels significantly reduced the values of potassium and sodium contents in beet roots in both seasons and their combined. However, increasing calcium levels from zero up to 288 ppm failed to reach the level of significance in their effect on alpha-amino nitrogen content in roots. Fertilizing sugar beet with 288 ppm calcium/fed decreased the values of potassium and sodium compared to the use of 144 ppm calcium/fed or in untreated treatment.

The interaction between soaking treatments in gibberellic acid (GA_3) and calcium fertilization had insignificant effect on the previously mentioned traits in both seasons (Table 6).

5. Sucrose, sugar recovery and sugar lost to molasses percentages:

The combined analyses of data in Table 7 reveal that neither sucrose% nor sugar recovery% was significantly affected by seeds soaking treatments of GA_3. Whereas, higher values of sugar lost to molasses % was recorded by sowing sugar beet using dry seeds, soaking seeds in 50 and 100 ppm GA_3. The lowest quantities of sugar lost to molasses were observed when sugar beet was sown using seeds soaked in 150 and 200 ppm GA_3, followed by soaking seeds in water respectively.

Table 7: Sucrose, sugar recovery and sugar lost to molasses percentages as affected by seed soaking by gibbrelic acid (GA_3) and calcium fertilization levels in 2012/2013 and 2013/2014 seasons and their combined.

Treatments of sugar beet	Sucrose %		Comb.	Sugar recovery %		Comb.	Sugar lost to molasses %		Comb.
	1st season	2nd season		1st season	2nd season		1st season	2nd season	
Dry seeds	15.97	15.37	15.67	13.38	12.82	13.10	2.59	2.54	2.57
Soaking in water	16.20	15.64	15.92	13.70	13.12	13.41	2.50	2.52	2.51
Soaking in 50 ppm GA_3	16.10	15.38	15.74	13.53	12.84	13.19	2.57	2.55	2.56
Soaking in 100 ppm GA_3	15.97	15.63	15.80	13.46	13.10	13.28	2.51	2.53	2.52
Soaking in 150 ppm GA_3	16.21	15.69	15.95	13.74	13.19	13.47	2.46	2.50	2.48
Soaking in 200 ppm GA_3	16.27	15.79	16.03	13.77	13.28	13.53	2.49	2.51	2.50
LSD at 0.05 level	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.05**	**NS**	**0.04**
Without calcium	15.26	14.95	15.11	12.63	12.29	12.46	2.63	2.66	2.65
144 ppm calcium/fed	16.19	15.62	15.91	13.68	13.10	13.39	2.51	2.52	2.52
288 ppm calcium/fed	16.92-	16.19	16.56	14.48	13.79	14.14	2.43	2.39	2.41
LSD at 0.05 level	**0.71**	**0.53**	**0.23**	**0.73**	**0.54**	**0.24**	**0.06**	**0.08**	**0.03**

* Without calcium (Control): sugar beet plants were sprayed with water.
* 144 ppm and 288 ppm point to the application of 0.5 and 1.0 liter of Calso-x/400 liters water, which were sprayed twice at 4-6 and 6-8 leaf stage. Which, Calso-x contains 8% chelated calcium claw on 10% humic acid and 3 % free amino acids.

As for the effect of calcium levels, the combined analysis in the same table indicated that spraying calcium with 288 ppm/fed gave increases in sucrose and sugar recovery percentages amounted to 0.65 and 0.75 respectively, over that fertilized with 144 ppm calcium/fed. While, spraying calcium at the rate 144 ppm calcium/fed gave increases in the above-mentioned traits amounted to 0.80 and 0.93 over plants unfertilized with calcium respectively. These results are in accordance with those mentioned by (**Afzal *et al.* 2008**) who reported that better performance of foliar fertilization with Ca^{2+}under saline conditions may be due to enhancing oxygen uptake and increasing α-amylase activity for the efficiency of mobilizing nutrients. Also proved to be the most effective in inducing salt tolerance due to increase sugar contents as well as enhance potassium and calcium accumulations and decrease accumulation of sodium contents. The lowest quantities of sugar lost to molasses were recorded at 288 ppm contents and decreased leaves sodium content of sugar beet plants. It is clear here that the best growth rate where the top dry weight reach to highest possible compared with other treatments this results are in line with those reported by **Song *et al.* (2005)** who observed that maintaining a better nutrition with K and Ca, while limiting Na uptake, is a highly important trait contributing to high salt stress tolerance in plants. Consequently, higher Na/Ca and/or Na/K ratios are typical in the tissues of salt-tolerant plants, and are often used as a parameter to adapt for salt stress tolerance in plants. In the same table the results showed a significant influence of the applied calcium levels on juice quality% in the 1st and 2nd seasons and their combined. Application of 288 ppm calcium/fed resulted in the highest value of this trait compared to the other treatment. This result may be due to higher values of sucrose% (Table 7) and lower ratios of Na/Ca and Na/K in leaves.

The interaction between soaking treatments in gibberellic acid (GA_3) and calcium fertilization had insignificance in their effect on the above-mentioned traits in both seasons (Table 8).

7. Root, top and sugar yields/fed:

Table 9: Root, top and sugar yields (t/fed) as affected by seed soaking in gibbrelic acid (GA_3) and calcium fertilization in 2012/2013 and 2013/2014 seasons and their combined.

Treatments of sugar beet	Root yield (t/fed)		Comb.	Top yield (t/fed)		Comb.	Sugar yield (t/fed)		Comb.
	1st season	2nd season		1st season	2nd season		1st season	2nd season	
Dry seeds	18.39	16.96	17.69	7.55	6.57	7.06	2.47	2.18	2.33
Soaking in water	18.71	17.64	18.17	8.16	7.44	7.80	2.57	2.32	2.45
Soaking in 50 ppm GA_3	18.33	16.82	17.57	7.51	6.89	7.20	2.49	2.17	2.34
Soaking in 100 ppm GA_3	18.67	17.51	18.09	8.07	7.48	7.78	2.52	2.30	2.42
Soaking in 150 ppm GA_3	19.35	18.28	18.81	8.36	8.12	8.24	2.67	2.42	2.55
Soaking in 200 ppm GA_3	19.10	18.12	18.61	8.48	8.01	8.26	2.64	2.39	2.52
LSD at 0.05 level	**0.29**	**0.40**	**0.27**	**0.43**	**0.50**	**0.35**	**0.07**	**0.10**	**0.06**
Without calcium	18.20	16.64	17.42	7.36	6.57	6.96	2.30	2.04	2.17
144 ppm calcium/fed	18.73	17.63	18.18	8.01	7.40	7.70	2.57	2.32	2.44
288 ppm calcium/fed	19.34	18.39	18.87	8.71	8.28	8.49	2.81	2.54	2.67
LSD at 0.05 level	**0.46**	**0.73**	**0.19**	**0.58**	**0.80**	**0.25**	**0.13**	**0.15**	**0.04**

* Without calcium (Control): sugar beet plants were sprayed with water.
* 144 ppm and 288 ppm point to the application of 0.5 and 1.0 liter of Calso-x/400 liters water, which were sprayed twice at 4-6 and 6-8 leaf stage. Which, Calso-x contains 8% chelated calcium claw on 10% humic acid and 3 % free amino acids.

The combined analysis in Table 9 show that pre-sowing seed soaking treatments significantly increased root, top and sugar yields/fed of sugar beet. Soaking sugar beet seed in 150 and/or 200 ppm GA_3 surpassed the other treatments and gave higher values of these traits. These results may be due to the physiological role of GA_3 in breaking seed dormancy, increasing the percentage of germination and shortening the duration of vegetative growth. These results are in agreement with those reported by **Jamil and Rah (2007)** and **Nasri *et al.* (2012)**.

Increasing calcium fertilizer levels from zero to 144 ppm calcium/fed led to significant increases in root, top and sugar yields/fed amounted to 0.76, 0.74 and 0.27 t/fed, respectively, compared to the unfertilized plants. When sugar beet plants were sprayed with 288 ppm calcium/fed, the increase was estimated by 0.69, 0.79 and 0.23 t/fed, respectively, compared to those sprayed with 144 ppm calcium/fed. These findings may be attributed to increasing vegetative growth, as well as, root length and diameter (Table 2), which participated in increasing the produced root, top and recoverable sugar yields/fed. These results are in harmony with those reported by **Bonilla *et al.* (2004)** and **Artyszak (2014)**.

The interaction between soaking treatments in gibberellic acid (GA_3) and calcium fertilization had insignificant effect on the above-mentioned traits, with the exception of root yield/fed in both seasons (Table 10).

Interaction effect:

Table 10: Root yield (t/fed) as affected by the interaction among soaking treatments in gibberellic acid (GA_3) and calcium fertilization levels in 2012/2013 and 2013/2014 seasons.

Treatments of sugar beet	2012/ 2013 seasons			2013/ 2014 seasons		
	Without calcium (control)	144 ppm calcium /fed	288 ppm calcium /fed	Without calcium (control)	144 ppm calcium /fed	288 ppm calcium /fed
Dry seeds	18.13	18.47	18.57	16.63	16.87	17.38
Soaking in water	17.87	18.48	19.77	16.33	17.90	18.68
Soaking in 50 ppm GA_3	18.08	18.42	18.48	16.23	16.80	17.42
Soaking in 100 ppm GA_3	17.96	18.53	19.52	16.70	17.50	18.32
Soaking in 150 ppm GA_3	18.73	19.39	19.92	17.03	18.50	19.32
Soaking in 200 ppm GA_3	18.42	19.10	19.78	16.90	18.23	19.23
LSD at 0.05% level for:			0.50			0.70

* Without calcium (Control): sugar beet plants were sprayed with water.
* 144 ppm and 288 ppm point to the application of 0.5 and 1.0 liter of Calso-x/400 liters water, which were sprayed twice at 4-6 and 6-8 leaf stage. Which, Calso-x contains 8% chelated calcium claw on 10% humic acid and 3 % free amino acids.

With regarded to the influence of the interaction between seed soaking treatments and calcium levels in Table 10, the difference in root yield/fed between beets sprayed with 144 ppm calcium/fed and those untreated with calcium was insignificant when seeds used for growing sugar beet were dry or soaked in 50 ppm GA_3. However, the difference in this trait between the two levels of calcium was significant under conditions of the other seeds soaking treatments, in both seasons. In addition, raising calcium level from zero to 144 ppm calcium/fed increased root yield by 0.66 and 1.47 t/fed in the 1st and 2nd season, respectively, however root yield was markedly increased by 1.19 and 2.29 t/fed, when calcium dose given to sugar beets was raised to 288 ppm calcium/fed, compared to those unfertilized, when sugar beet seed was soaked in 150 ppm in the 1st and 2nd season, respectively. These results might be attributed to that under conditions of saline soils, salts interact with plant nutrients which become unavailable to sugar beet seedlings. However, the foliar nutrition with calcium given for plants sown with seeds soaked in gibberllic acid solution protect cell membrane from negative effects of salinity and increase the availability of nutrients for plants (**Arshi *et al.*, 2006**).

CONCLUSION

Sugar beet seeds soaking in 150 ppm GA_3 solution with the addition of 288 ppm calcium equivalent to one liter/fed from (8% chelated calcium claw 10% humic acid) as a foliar application can be recommended to enable sugar beet plants to grow successfully under saline conditions and to get the maximum yield and quality of sugar beet. Further research is needed to optimize the effectiveness of seed soaking with different plant growth regulators on number of cultivars of sugar beet.

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تأثير نقع التقاوي في حمض الجبرليك والإضافة الورقية للكالسيوم علي حاصل وجودة بنجر السكر تحت ظروف الأراضي الملحية

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أقيمت تجربتان حقليتان بمحطة بحوث السرو- محافظة دمياط (دائرة عرض ٣١.١٤ ° شمالاً وخط طول ٣١.٣٩ ° شرقاً) في موسمى ٢٠١٢/٢٠١٣ و ٢٠١٣/٢٠١٤ لدراسة تأثيرفاعلية معاملات مختلفة لنقع تقاوي بنجر السكر قبل الزراعة هي: ١- الزراعة بالتقاوي الجافة (مقارنة) ، ٢- الزراعة بتقاوي منقوعة في الماء ، ٣- الزراعة بتقاوي منقوعة في محلول حمض الجبريليك تركيزه ٥٠ جزء في المليون ، ٤- الزراعة بتقاوي منقوعة في محلول حمض الجبريليك تركيزه ١٠٠ جزء في المليون ، ٥- الزراعة بتقاوي منقوعة في محلول حمض الجبريليك تركيزه ١٥٠ جزء في المليون ، ٦- الزراعة بتقاوي منقوعة في محلول حمض الجبريليك تركيزه ٢٠٠ جزء في المليون ، وثلاث تركيزات من الكالسيوم تم إضافتهم رشاً علي دفعتين (عند تكوين من ٤-٦ و ٦-٨ ورقات حقيقية من الزراعة) هي:

١- الرش بالماء بدون كالسيوم (مقارنة) ، ٢- الرش بمحلول كالسيوم تركيزه ١٤٤ جزء في المليون/فدان (بما يعادل نصف لتر من مركب كالسيو-x) و ٣- الرش بمحلول كالسيوم تركيزه ٢٨٨ جزء في المليون كالسيوم/فدان (بما يعادل لتر من مركب كالسيو- x) ، وذلك لدراسة تأثيرها على بعض صفات النمو وحاصل وجودة بنجر السكر.

* استُخدِم تصميم القطع المنشقة مرة واحدة فى أربع مكررات في الموسمين ، حيث وضعت معاملات الرش الورقي بالكالسيوم في القطع الرئيسية ، فى حين وزعت معاملات نقع التقاوي عشوائياً في القطع الشقية.

أوضحت النتائج ما يلي:

١- أدى نقع تقاوى بنجر السكر في محلول حمض الجبريليك بتركيز ١٥٠ جزء في المليون إلى زيادة معنوية في طول و قطر و وزن الجذر والأوراق وحاصل الجذورو الأوراق والسكر/فدان، كما إزداد وزن المادة الجافة للجذور والأوراق ، فضلاً عن نقص كمية السكر المفقود في المولاس في الموسمين والتحليل التجميعي لهما.

٢- دلت النتائج علي أن الرش بإضافة ٢٨٨ جزء في المليون كالسيوم/فدان أدي الي زيادة معنوية في طول وقطر ووزن كلاً من الجذرو و الأوراق الطازجة والنسبة المئوية للسكروز، وكذلك حاصل الجذور والأوراق والسكر/فدان ، فضلاً عن محتوي الأوراق من الكالسيوم والبوتاسيوم مع نقص في محتواها من الصوديوم.

٣- أظهر التفاعل بين معاملات النقع المختلفة ومستويات الكالسيوم تأثيراً معنوياً علي طول الجذور وحاصل الجذور/فدان في الموسمين ، حيث أعطت التوليفة (نقع تقاوي بنجر السكر في ١٥٠ جزء في المليون محلول حمض الجبريليك مع التسميد الورقي بإضافة ٢٨٨ جزء في المليون كالسيوم/فدان) أعلي القيم لحاصل الجذور/فدان (١٩.٩٢ و١٩.٣٢ طن/فدان في الموسم الأول والثانى على الترتيب) ، مقارنة بالمعاملات الأخري.

بناءً علي نتائج هذا البحث ، فإنه يمكن التوصية بنقع تقاوي بنجر السكر قبل الزراعة في محلول تركيزة ١٥٠ جزء في المليون حمض الجبريليك مع التسميد الورقي بإضافة ٢٨٨ جزء في المليون كالسيوم/ فدان ، وذلك للتخفيف من التأثير الضار لملوحة التربة.