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Foliar Application of Potassium to Mitigate the Adverse Impact of Salinity on some Sugar Beet Varieties. 2: Effect on Yield and Quality

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ABSTRACT

A pot experiment was carried out in the Greenhouse of National Research Centre. Giza. Egypt in order to evaluate the impact of foliar potassium (2.0 % KNO_3) on yield and quality of four sugar beet varieties (Top, Tyloz, Ghazil and Boly) grown under saline irrigation (Tap water as control, 2500 and 5000 ppm of mixed $CaCl_2$ and NaCl 1:2). Root and top yield as well as root dimensions were significantly decreased by increasing irrigation water salinity levels as compared with the control treatment (tap water). Foliar spraying with potassium significantly increased all the studied yield characters except shoot / root ratio. Ghazil cultivar was superior in all the studied characters. On the other hand, Boly cultivar plants recorded the lowest values for all the previous characters. As for the interaction between salinity, foliar spraying with potassium and plant varieties, the highest values for all these characters were recorded in Gahzil variety irrigated with tap water and sprayed with 2% K_2O. On the other hand the least values were recorded in Boly variety irrigated with 5000 ppm and sprayed with tap water. Irrigating sugar beet plants with 5000 ppm saline water significantly increased the content of sucrose, TSS and recoverable sugar as well as sucrose loss to molasses. On the other hand, irrigating plants with 2500 ppm recorded the highest values for purity % and quality index. Potassium treatments significantly increased percentage of sugar, purity, total soluble solids (TSS), quality index, and recoverable sugar %**.** Top variety recorded the highest values for sucrose, purity, recoverable sugar % and consequently quality index. Meanwhile, Ghazil variety recorded the greatest values for sucrose loss to molasses. On the other hand, Boly variety recorded the highest values for TSS. As for Interaction treatments, Top variety recorded the highest values for sucrose, purity , recoverable sugar % and consequently quality index under 5000 ppm saline irrigation and foliar spraying with2% K_2O. While Boly treatment recorded the highest TSS% under the same treatments. On the other hand, Top variety recorded the highest values for sucrose loss to molasses under 5000 ppm and sprayed with tap water. Moreover, Top variety sprayed with 2.0 % KNO_3 and irrigated with tap water recorded the highest values for K and K/Na. On the other hand, Boly variety sprayed with tap water and irrigated with tap water, recorded the highest values for Na and α Amino nitrogen and Ghazil variety sprayed with 2.0 % KNO_3 and irrigated with tap water recorded the highest values for (AIV).

Key words: Sugar beet varieties, Salinity, Potassium, Yield, Quality.

Introduction

Salinity is one of the major constrains on crop production in numerous parts of the world, It leads to metabolic alterations and graded reduction in the plant growth and consequently yield and quality, especially in arid and semi-arid regions, where soil and water-borne salts become concentrated due to inputs of irrigation water and high rates of evapotranspiration (Munns and Tester, 2008). Plants vary in their ability to cope with salinity and differences in salt tolerance exist not only between species but also amongst genotypes of certain species (Munns, 2002). This latter aspect attracts increasing studies on the impact of salt tolerance and applied research such as adaptation of crop species to saline soils (Deinlein *et al*., 2014). Salinity adversely affecting physiological and metabolic processes, finally diminishing growth and yield (Ashraf and Harris, 2004). Excessive salts injure plants by disturbing the uptake of water into roots and interfering with the uptake of competitive nutrients (David Franzen, 2007). The inhibitory effect of salinity on plant growth and yield has been ascribed to osmotic effect on water availability, ion toxicity, nutritional imbalance, reduction in enzymatic and photosynthetic efficiency and other physiological disorders (Khan *et al*., 1995). Salinity is considered as a global environmental challenge, affecting crop production on over 800 million hectares, or a quarter to third of all agricultural land on earth (Rengasamy, 2010). However, salinity is also increased in dry land agriculture in many parts of the world (Rengasamy, 2006). Development of crops with improved salt tolerance is proposed as part of solution to this problem (Zhang *et al*., 2010).

Sugar beet (*Beta vulgaris* L) is a glycophytic member of *Chenopodiaceae* (Ghoulam and Fares, 2001). It ranks second to sugar cane as a source of sucrose in the world. The predominant influence of salinity stress on plants is growth suppression. It has been reported that the fresh and dry weight of roots and leaves of sugar beet

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varieties were reduced with increasing salt concentration in irrigation water (Mekki and El-Gazzar, 1999). El-Etreiby (2000) indicated that water salinity is the major limiting factor for sugar beet growth in most of soils. Sugar beet plants grown under salinity stress showed imbalanced nutrient contents in their tissues. The effect of salt stress on the nutrient concentration in the plant varies among elements. Increasing the salt concentration in growth media resulted in reducing K^+ uptake by sugar beet plants and in turn, K^+ content in shoots.

One approach to minimize effects of salinity is use of nutrient foliar application or nutrient enrichment to increase tolerance of plant to salinity by alleviating Na^+ and Cl^- injury (Tzortzakis, 2009). Numerous studies have shown that K mitigates the adverse effects of salinity on plant growth (Marschner, 1995) by regulating desirable K/Na ratio. Previous work indicated that nutrient foliar application alleviated harmful effects of NaCl salinity and corrected nutrient status causing increases in salt tolerance of different plants (El-Fouly *et al*., 2002). Many investigators have confirmed the enhancement impact of potassium in increasing salt tolerance of sugar beet by enhancing the biosynthesis of organic metabolites and improving nutritional status (Fathy *et al*., 2009). In this concern, Liu *et al*., (1992) stated that K^+ enhanced salt tolerance of sugar beet. Khalil *et al*., (2001) found that sucrose, total soluble solids increased with increasing K^+ level, but decreased with salinity stress. Moreover, potassium plays important roles in photosynthesis, protein synthesis, translocation of assimilates as well as increasing plant growth and yield. In this concern, Amer *et al*., (2004) found that adding potassium up to 90 kg K_2O/fed. resulted a significant increase in N %, P % and K % in beet root. Much more K is required to fulfill other major functions in plants. Potassium is essential for growth and is the main element used to maintain cell turgor (rigidity) and to regulate the water content of the plant **(**Rengel and Damon, 2008). Aparna (2001) added that K is considered to be the most important cation not only from the viewpoint of its relative amounts but also from the viewpoint of its physiological and chemical functions. This could be because K^+ is usually absorbed as a single charge cation by an active mechanism and it can translocate along electrochemical potential gradient (Roghieh and Arshad, 2009). The objective of this study was to evaluate the efficiency of foliar spraying with potassium on mitigation the negative impact of saline irrigation on yield and quality of four sugar beet cultivars and assessment of their salt tolerance.

Materials and Methods

A pot experiment was conducted in the green house of the National Research Centre, Dokki, Giza during the winter season of 2010-2011 to study the effect of foliar application with potassium on yield and quality of four sugar beet (*Beta vulgaris* L.) varieties grown under different levels of saline irrigation. Pots were arranged in complete randomize design with 3 replicates and included 24 treatments which were the combination of three levels of saline irrigation (Tap water, 2500 and 5000 ppm of mixture from $CaCl_2$ and NaCl 1 : 2 X two foliar treatments (Tap water and 2.0 % KNO_3) X four sugar beet cultivars (Top, Tyloz, Ghazil and Boly). Seeds were planted on 17 October in plastic pots 40 cm in diameter. The mechanical and chemical analysis of the soil was carried out by using the standard method described by Klute (1986), Table (1). Each pot was fertilized with 5.8 g calcium superphosphate (15.5% P_2O_5) and 3 g potassium sulphate (48.0 % K_2O) and 7.5 g urea (46.5% N) at the rate of 30 kg P_2O_5/fed., 48 kg K_2O/fed. and 120 kg N/fed., respectively. Foliar treatments were carried out twice, 30 days after sowing and one month later. Each pot was irrigated three times per week with the specified saline concentration.

Table 1: Mechanical and chemical analysis of the soil.

Mechanical and chemical analysis		Macro elements	
Sand%	21.98	Soluble N mg/100 gm soil	21.00
Silt %	30.90	P (p.p.m.)	19.70
Clay %	47.00	K (mg/ 100 gm soil)	21.37
Texture	clay	Mg (mg/ 100 gm soil)	189.00
Organic matter	2.10	Micro elements	
pH	7.52	Fe (p.p.m.)	2.00
Ec (millimose/cm)	0.64	Zn (p.p.m.)	12.70
$CaCO_3$%	1.84	Mn (p.p.m.)	13.96
		Cu (p.p.m.)	1.49

At harvest time (185 days from sowing) five guarded plants were taken at random to determine root dimensions cm (length and diameter) and fresh weight (kg) of shoot and root. Sucrose percentage was determined as described by Le- Docte (1927). Juice purity percentage were determined according to the method of Silin and Silina (1977). Total Soluble Solids (TSS %) was determined by using digital referactometer. Recoverable sugar % was calculated for each treatment: RS% = sucrose (%) - sugar loss (%) according to Cooke and Scott (1993). Recoverable sugar yield was calculated for each treatment. Potassium and Sodium were measured in the root dry weight at harvest time, by using the Flame photometer according to Eppendrof and Hing (1970), K/Na was calculated for each treatment, α amino nitrogen was also calculated by double beam filter photometry using the blue number method Sheikh_Aleslami (1997). Sucrose loss to molasses (SM) was calculated with the method of Reinfeld *et al*., (1974): SM% =0.343*(K+ Na) + 0.0393 **α**- amino N + 0.31. Quality index was calculated as (sugar recoverable % x 100)/sucrose %. Alkaline Index value was estimated according to the equation: AIV = K+Na / **α**- amino nitrogen. Data collected for yield and quality of sugar beet were subjected to the statistical analysis according to Gomez and Gomez (1984) and all means were compared at 5% level of probability.

Resuls and Discussion

1. Effect on sugar beet yield:

1 .1. Effect of irrigation water salinity on yield:

Date in Table (2) show that, root and top yield as well as root dimensions were significantly decreased by increasing irrigation water salinity levels as compared with the control treatment (tap water). The magnitudes of reduction differed from character to another. It is evident that the root fresh weight / plant was the most affected character by the increase of irrigation water salinity levels amounted to 27.37 % and 38.10 % due to the increase of salinity level up to 2500 and 5000 ppm respectively. On the other hand the previous treatment significantly increased, shoot / root ratio. The injuries effect of salinity on sugar beet yield has been reported by several investigators (Katerji *et al*., 2003 and Almodares and Sharif, 2005).Yield parameters of sugar beet were reduced with increasing salt concentration of irrigation water as reported by Mekki and El-Gazzar (1999). Such reduction might be due to lower of the external water potential or the effect of ion toxicity on metabolic processes (De-Herralde *et al*., 1998). These results are in agreement with those obtained by Dadkhah and Grrifiths (2006) and Muhammad *et al*., (2012). In this regard, Farkhondeh *et al*., (2012) mentioned that, the reduction in yield as a result of salinity may be attributed mainly to the osmotic inhibition of water absorption, the excessive accumulation of ions such as Na^+ or Cl^- in plant cells and inadequate uptake of essential nutrients. In this regard, Eisa *et al*., (2012) stated that salinity is adversely affecting physiological and metabolic processes, finally diminishing growth and yield of plant. Moreover, Munns (2002) added that, highly soluble salts in the root zone cause physiological scarcity in plant to absorb water .Thus, the availability of water may then become so critically low hence growth parameters are inhibited, Munns and Tester (2008) suggested that the depressive effects of NaCl on the yield of plants may be due to The inhibitory effect of salinity on plant growth and yield has been ascribed to osmotic effect on water availability, ion toxicity, nutritional imbalance, reduction in enzymatic and photosynthetic efficiency and other physiological disorders. Plant mass is decreased due to inhibition in cell division and cell enlargement by salinity so production of protein and nucleotide is inhibited (Isla, *et al*., 1998). In our experiment, however, the reasons of decreasing sugar beet yield under considerable salinity levels may be due to osmotic stress which reduces leaf area and decreasing chlorophyll contents which in turn reduce sugar beet yield.

Table 2: Effect of salinity, foliar spraying with potassium and plant varieties on yield of sugar beet.

Cultivars	Shoot fresh weight (g/plant)	Root fresh weight (g/plant)	Shoot / root	Root diameter (cm)	Root length (cm)
Effect of salinity					
Control	775.95	795.56	1.01	6.71	23.58
2500	728.14	578.02	1.26	6.29	22.39
5000	653.18	492.39	1.36	5.52	19.44
LSD 5%	17.32	15.34	0 .031	0 .32	1.12
Effect of foliar spraying with potassium					
Control	704.96	607.42	1.21	6.03	21.22
2.0 % KNO_3	733.22	636.57	1.20	6.31	22.38
LSD 5%	18.65	15.98	NS	NS	1.02
Effect of plant varieties					
Top	709.47	606.73	1.22	6.08	21.56
Tyloz	736.37	649.10	1.18	6.32	22.24
Ghazil	762.53	650.53	1.22	6.45	22.79
Boly	667.99	581.61	1.21	5.83	20.62
LSD 5%	17.55	16.35	NS	0.31	1.09

1.2. Effect of foliar spraying with potassium on yield:

Data presented in Table (2) also indicated that foliar spraying with potassium significantly increased all the studied yield characters except shoot / root ratio and root diameter. These results are in agreement with those obtained with Salami and Saadat (2013). Many investigators reported that root length, root fresh weight, sucrose percentage, top, root and sugar yields (Ton/fed) were increased significantly with increasing potassium fertilizer rates (Hilal, 2005). The positive effect of potassium on growth and yield could be attributed to the stimulatory effect of K on rate of photosynthesis, as well as, transport of the photosynthetic product from the leaves to the storage root (Ohadi *et al*., 2002). However, the salt tolerance in plants increased by increasing K^+ uptake which leads to increasing K/Na ratio in plant cells (Akinci *et al.*, 2004). Moreover, potassium play an important role in regulating osmotic potential, increasing water uptake ability of sugar beet plants (Zengin *et al*., 2009). They added that, foliar application with K^+ could be used to avoid the depletion of this nutrient in the leaves that may cause reduction in photosynthetic rate and consequently reduce growth characters. Moreover, K may helps in maintaining a normal balance between carbohydrates and proteins (Monreal *et al*., 2003). In this concern, Zengin *et al*., (2009) stated that, the K^+ level in plant tissue interacts with some proteins and regulates the functions of some molecules to correct assembling of targeting ion channels.

1.3. Effect of different varieties performance on yield:

Data presented in Table (2) reveal also that all the studied sugar beet varieties exhibited among themselves significant differences in all yield criteria except for the criteria shoot/root ratio. For instance, Ghazil cultivar was superior in all the studied characters. On the other hand, Boly cultivar plants recorded the lowest values for all the previous characters. These results are in full agreement with those obtained by Dadkhah and Grrifiths (2006), who found that, the Madison cv was the least tolerant and P29 was the most tolerant cv. They added that, dry matter allocated to the shoot was increased under saline conditions, suggesting that root growth of sugar beet is more sensitive to salinity than shoot growth. In this respect, Refay (2010) mentioned that these differences might be due to the genotypic variation existing among these sugar beet varieties. Recently, and Ahmed *et al*., (2012) reported that sugar beet varieties differed significantly for all growth and yield characters. Under salinity conditions, different cultivars of the same plant has different behavior (Qadir *et al*., 2001).

1.4. Effect of interaction between salinity and plant variety on yield:

The interaction between salinity levels and sugar beet variety significantly affected all the studied yield characters i.e. fresh weight of shoot and root as well as root dimensions (Table, 3). Regardless plant variety, increasing salinity level of irrigation reduced all growth criteria for all varieties with different magnitude. However, Ghazil variety recorded the highest values for all the yield criteria under tap water (control) irrigation conditions, while the lowest values were recorded in Boly variety irrigated with 5000 ppm. The obtained results indicate that the difference between sugar beet varieties may be due to their relative tolerance to salinity. Similar results were obtained by Dadkhah and Grrifiths (2006). In this concern, Dadkhah (2011) exposed two sugar beet cultivars to different levels of salinity (0, 50, 150 , 250, and 350 mM, NaCl+CaCl2 in 5:1 ratio), he found that higher levels of salinity, significantly decreased all growth criteria. He added that, salinity had greater effect on root dry weight than shoot dry weight. Soil salinity decreases crop yield through increasing osmotic stress on the plant. Under saline conditions, nutrient imbalance, reduced nutrient uptake including K^+, and ion toxicity are resulted because of high Na^+ and Cl^- concentrations (Miransari and Smith, 2007).

Table 3: Effect of interaction between salinity and plant varieties on yield.

Salinity level	Plant variety	Shoot fresh weight (g/plant)	Root fresh weight (g/plant)	Shoot / root	Root diameter (cm)	Root length (cm)
Tap water	Top	769.18	784.64	1.01	6.55	23.38
	Tyloz	783.33	801.50	1.01	6.87	24.15
	Ghazil	830.00	844.01	1.00	7.10	24.55
	Boly	721.28	752.11	0.99	6.31	22.21
2500 ppm	Top	714.52	558.63	1.28	6.22	22.13
	Tyloz	749.86	620.41	1.21	6.42	22.67
	Ghazil	775.47	597.50	1.30	6.56	23.37
	Boly	672.72	535.56	1.26	5.94	21.38
5000 ppm	Top	644.71	476.91	1.37	5.47	19.16
	Tyloz	675.92	525.40	1.31	5.67	19.89
	Ghazil	682.11	510.09	1.36	5.70	20.44
	Boly	609.98	457.17	1.39	5.24	18.27
LSD 5%		25.36	24.01	0.045	0.41	1.55

1.5. Effect of interaction between foliar spraying with potassium and plant varieties on yield:

The interaction effect between foliar spraying with potassium and sugar beet varieties significantly affected all the studied yield criteria i.e. fresh weight of shoot and root as well as root dimensions (Table, 4). Regardless plant cultivars, foliar spraying with potassium significantly increased all growth characters for all the studied varieties. Regarding to shoot / root ration, no significant effects were detected. However, Ghazil variety recorded the highest values under foliar spraying with potassium, while the lowest values were recorded in Boly variety under control treatment. Similar results were obtained by Salami and Saadat (2013), who stated that, the positive effect of potassium on growth and yield may be due to the reason that potassium has a prevalent action in plants and is involved in maintenance of ionic balance in cell. In this regard, Akinci *et al.*, (2004) stated that, potassium plays an important role by increasing K/Na ratio in plant cells and consequently increase plant tolerance to salinity stress, which lead to good growth and consequently satisfied yield. Moreover, Zengin *et al.*, (2009) proved that potassium play an important role in regulating osmotic potential, increasing water uptake ability and thus mitigate the adverse effects of salt stress and thus increase productivity of sugar beet plants. Such enhancement effect of foliar application with potassium might be attributed to the favorable influence of K^+ on metabolism and biological activity and its stimulating effect on photosynthetic pigments and enzymes activity which in turn encourage vegetative growth of plants (Michail *et al.*, 2004).

Table 4: Effect of interaction between foliar spraying with potassium and plant varieties on yield.

Foliar treatment	Plant variety	Shoot fresh weight (g/plant)	Root fresh weight (g/plant)	Shoot / root	Root diameter (cm)	Root length (cm)
Control	Top	691.51	589.50	1.22	5.91	20.93
	Tyloz	723.21	631.79	1.18	6.25	21.62
	Ghazil	745.95	634.61	1.22	6.23	21.96
	Boly	659.15	573.78	1.22	5.75	20.37
2.0 % KNO_3	Top	727.43	623.96	1.22	6.25	22.19
	Tyloz	749.53	666.42	1.17	6.40	22.85
	Ghazil	779.10	666.45	1.22	6.68	23.62
	Boly	676.84	589.45	1.21	5.91	20.87
LSD 5%		29.31	27.21	N.S	0.49	1.74

1.6. Effect of interaction between salinity, foliar spraying with potassium and plant varieties on yield:

Data in Table (5) show the interaction between salinity, foliar spraying with potassium and plant varieties on some yield characters. The highest values for all these characters were recorded in Gahzil variety irrigated with tap water and sprayed with 2% K_2O. On the other hand the least values for all the previous characters were recorded in Boly variety irrigated with 5000 ppm and sprayed with tap water. Similar results were reported by Abdel-Mawly and Zanouny (2004). One approach to minimize the adverse effects of salinity on plant growth and yield is use of nutrient foliar application to increase tolerance to plant salinity by alleviating Na^+ and Cl^- injury to plants (Koyro, 2006). In our study K^+ positively affected all the yield characters and mitigates the negative impact of salinity on growth with superiority to Ghazil variety, which records the highest values for all the studied growth characters. In this regards, Deinlein *et al*., (2014) stated that potassium is considered a major osmotically active solute of plant cell, where it enhances water uptake and root permeability and acts as a guard cell controller, beside its role in increasing water use efficiency.

Table 5: Effect of interaction of salinity, foliar spraying with potassium and plant varieties on yield.

Salinity level	Foliar treatment	Plant variety	Shoot fresh weight (g/plant)	Root fresh weight (g/plant)	Shoot / root	Root diameter (cm)	Root length (cm)
Control Tap water	Tap water	Top	748	758	0.99	6.31	22.77
		Tyloz	760	784	0.97	6.87	23.38
		Ghazil	805	822	0.98	6.91	23.55
		Boly	695	738	0.94	6.12	21.90
	2.0 % KNO_3	Top	791	811	1.04	6.79	24.00
		Tyloz	807	819	1.05	6.87	24.92
		Ghazil	855	866	1.03	7.29	25.56
		Boly	748	766	1.04	6.50	22.53
2500 ppm	Tap water	Top	695	546	1.27	6.11	21.89
		Tyloz	744	591	1.26	6.30	22.38
		Ghazil	768	585	1.31	6.28	22.92
		Boly	690	532	1.30	5.95	21.55
	2.0 % KNO_3	Top	734	571	1.29	6.33	22.38
		Tyloz	756	649	1.16	6.55	22.96
		Ghazil	783	610	1.28	6.84	23.83
		Boly	655	539	1.21	5.92	21.20
5000 ppm	Tap water	Top	632	464	1.41	5.32	18.13
		Tyloz	666	520	1.32	5.58	19.11
		Ghazil	665	496	1.38	5.49	19.40
		Boly	592	451	1.42	5.18	17.65
	2.0 % KNO_3	Top	657	490	1.34	5.62	20.19
		Tyloz	686	531	1.29	5.77	20.67
		Ghazil	700	524	1.34	5.91	21.49
		Boly	628	463	1.36	5.31	18.89
LSD 5%			32.54	29.87	0.055	0.52	2.01

2. Effect on sugar beet quality:

2.1. Effect of irrigation water salinity on sugar beet quality:

Data presented in Table (6) revealed that irrigating sugar beet plants with 5000 ppm saline water insignificantly increased TSS and recoverable sugar as well as sucrose loss to molasses. Meanwhile the same treatment significantly increased the content of sucrose, On the other hand, irrigating plants with 2500 ppm recorded the highest values for purity % and quality index. Similar results were obtained by Abdel-Mawly and Zanouny (2004). Under saline irrigation condition, the uptake of Na and K increases and consequently, the impurities in root juice increases, resulting in low quality. Such decreases in juice purity were undesirable for sugar processing. These results are in harmony with those obtained by Mekki and El-Gazzar (1999) and El-Etreiby (2000).

Table 6: Effect of salinity, foliar spraying with potassium and plant varieties on sugar beet quality.

Cultivars	Sucrose %	TSS %	Purity %	Quality Index	Sucrose loss to molasses	Recoverable sugar %
Effect of salinity						
Control	17.82	21.34	83.52	76.62	4.17	13.65
2500	18.54	21.72	85.36	76.99	4.26	14.28
5000	18.73	22.11	84.72	76.42	4.41	14.32
LSD 5%	0.92	NS	NS	NS	NS	NS
Effect of foliar spraying with potassium						
Control	18.30	21.68	84.40	76.07	4.38	13.92
KNO_3	18.43	21.77	84.67	77.29	4.18	14.24
LSD 5%	NS	NS	NS	NS	NS	NS
Effect of plant varieties						
Top	18.81	21.53	87.36	77.22	4.26	14.53
Tyloz	18.59	21.64	85.89	76.95	4.28	14.31
Ghazil	18.32	21.79	84.06	76.63	4.29	14.04
Boly	17.73	21.94	80.84	75.91	4.27	13.46
LSD 5%	0.95	NS	4.86	NS	NS	0.74

2.2. Effect of foliar spraying with potassium on sugar beet quality:

It is well known that the most important factors which affect the quality of sugar beet are the percentage of sugar, purity, total soluble solids (TSS), quality index, and recoverable sugar % . Data in table (6) show that potassium treatments insignificantly increased all the previous characters as compared to the untreated ones. These results are in a harmony with those obtained by Ulgen *et al*., (2009) who found that potassium positively effects sugar content because of its specific physiological effects during synthesis, transport and storage of sugars. They added that potassium enhances many enzyme actions aids in photosynthesis process and sugar formation and translocation. Furthermore, Karam *et al.*, (2009) added that Potassium also has another equally important role in the transfer of sugars produced in the leaves to the storage root. In its passage from leaf to storage root each molecule of sugar has to pass through innumerable cell membranes, and K^+ ions are an essential component of the 'molecular pump' within the cell membranes that facilitate this passage. On the other hand, the same treatments adversely decreased sucrose to molasses. Eisa *et al*., (2012) proved an evidence of the role of potassium in improving juice quality and sugar recovery. Grzebisz *et al*., (2005) proved an evidence of the role of potassium in improving juice quality and sugar recovery as well as root yield. In this concern, Attia (2004) stated that, the increase in recoverable sugar yields might be due to the role of K in nutrients uptake and nutritional balance, which increase the biosynthesis of photosynthates. He added that, potassium increases photosynthetic output which in turn results in increased carbohydrate metabolism (sugar synthesis). In addition, potassium is vital for the efficient transport of photosynthetic products and their subsequent deposition in the storage organ.

2.3. Effect of different cultivars performance on sugar beet quality:

The same Table (6) also shows that there were significant differences in the values of sucrose, purity and recoverable sugar %, while these differences were insignificant for the criteria TSS, quality index and sucrose loss to molasses among the tested sugar beet varieties. However, Top variety recorded the highest values for sucrose, purity, recoverable sugar % and consequently quality index. Meanwhile, Ghazil variety recorded the greatest values for sucrose loss to molasses. On the other hand, Boly variety recorded the highest values for TSS. These results coincide with those obtained by Zaki *et al*., (2012). In this respect, Refay (2010) mentioned that these differences might be due to the genotypic variation existing among these sugar beet varieties.

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2.4. Effect of interaction between salinity and plant variety on sugar beet quality:

Fig (1) shows the interaction between salinity levels and sugar beet varieties affected all the studied characters. The highest values of sucrose%, purity%, quality index and recoverable sugar %, amounting to (19.44, 88.32, 77.35 and15.03) respectively were recorded in Top variety irrigated wish 500 ppm, while the highest values for TSS% and sucrose loss to molasses amounting to (22.28 and 4.44) were recorded in Boly variety irrigated with 5000 ppm. These results are in full agreement with those obtained by Dadkhah and Grrifiths (2006), who mentioned that these differences might be due to the genotypic variation existing among these sugar beet varieties. The increase in sucrose and juice purity content in Top variety might be attributed to its ability for more tolerate to salinity.

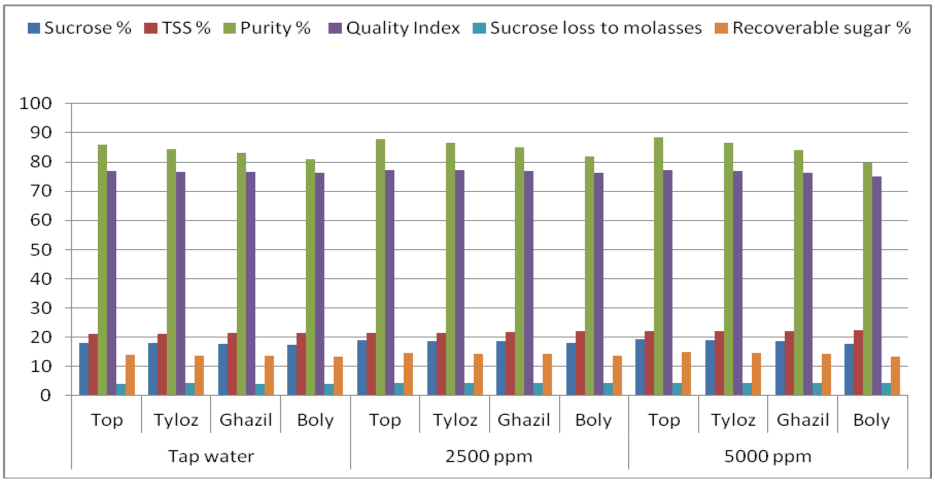

Fig. 1: Effect of interaction between salinity and plant variety on sugar beet quality (LSD 5%: Sucrose%= 0.83, TSS= 1.02, Purity%=4.52, QI= 3.98, SM= 0. 09, RS= 0.75)

2.5. Effect of interaction between foliar spraying with potassium and plant variety on sugar beet quality:

The interaction effect between foliar spraying with potassium and sugar beet varieties significantly affected all the studied quality characters except TSS% and quality index which were insignificant (Fig,2). However, Top variety recorded the highest values for sucrose, purity, recoverable sugar % and consequently quality index under foliar treatment with 2.0 % KNO_3. On the other hand, Boly variety recorded the highest values for TSS% under foliar treatment with 2.0 % KNO_3, while the highest values for sucrose loss to molasses were recorded in Boly variety sprayed with tap water. In this respect, Refay (2010) mentioned that these differences might be due to the genotypic variation existing among these sugar beet varieties. In this concern. Amer *et al.*, (2004) stated that, potassium is a very mobile element in plant tissues and moves readily from older tissues to the growing points of the root and foliage. Morrsi (1997) cleared that K fertilization (up to 60 kg K_2O ha^{-1} and 48 kg K_2O/fad.) significantly increased quality parameters in terms of TSS, sucrose and purity percentages.

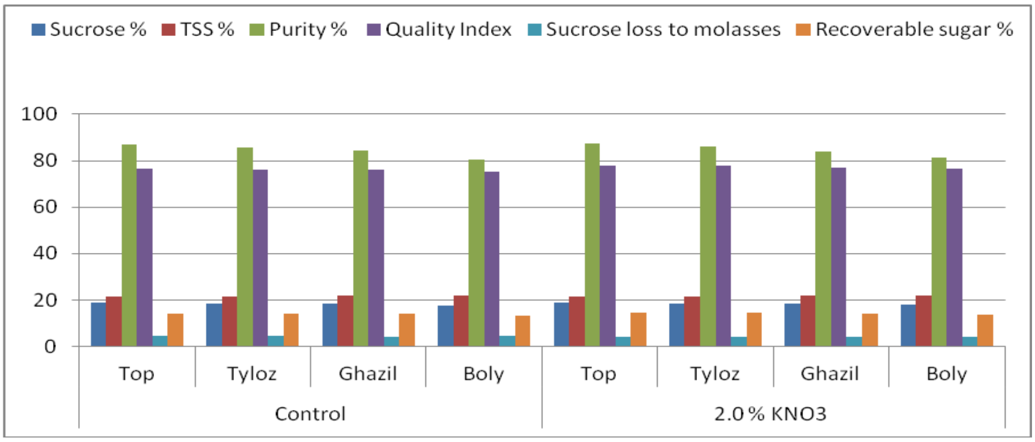

Fig 2: Effect of interaction between foliar spraying with potassium and plant variety on sugar beet quality (LSD 5%: Sucrose%= 0.831, TSS= 1.09, Purity%=4.35, QI= 3.78, SM= 0. 10, RS= 0.79)

2.6. Interaction between salinity, foliar spraying with potassium and plant variety on sugar beet quality:

Data in Table (7) show the interaction between salinity, foliar spraying with potassium and plant varieties on sucrose, TSS, purity and recoverable sugar % as well as quality index and sucrose loss to molasses. However, Top variety recorded the highest values for sucrose, purity, recoverable sugar % and consequently quality index under 5000 ppm saline irrigation and foliar spraying with2% K_2O. While Boly treatment recorded the highest TSS% under the same treatments. On the other hand, Top variety recorded the highest values for sucrose loss to molasses under 5000 ppm and sprayed with tap water. In this concern, Parida *et al*., (2002) stated that, accumulation of sugars under salt stress playing a leading role in osmoprotection, osmotic adjustment, carbon storage, and radical scavenging. Khalil *et al*., (2001) found that sucrose, total soluble solids and purity of sugar beet juice increased with increasing K level, but decreased with salinity stress.

Table 7: Interaction between salinity, foliar spraying and plant variety on sugar beet quality.

Salinity level	Foliar treatment	Cultivars	Sucrose %	TSS %	Purity %	Quality Index	Sucrose loss to molasses	Recoverable sugar %
Control Tap water	Tap water	Top	18.12	21.11	85.83	76.44	4.27	13.85
		Tyloz	17.89	21.25	84.20	76.02	4.29	13.60
		Ghazil	17.66	21.33	82.82	76.00	4.24	13.43
		Boly	17.23	21.44	80.36	75.73	4.18	13.05
	2.0 % KNO_3	Top	18.21	21.15	86.09	77.48	4.10	14.11
		Tyloz	18.00	21.34	84.35	77.27	4.09	13.91
		Ghazil	17.80	21.40	83.19	77.16	4.07	13.74
		Boly	17.63	21.68	81.34	76.86	4.08	13.55
2500 ppm	Tap water	Top	18.65	21.36	87.31	76.51	4.38	14.27
		Tyloz	18.76	21.68	86.53	76.52	4.41	14.35
		Ghazil	18.65	21.97	84.89	76.55	4.37	14.28
		Boly	17.98	21.99	81.76	76.01	4.31	13.67
	2.0 % KNO_3	Top	19.02	21.55	88.26	78.19	4.15	14.87
		Tyloz	18.69	21.51	86.89	77.84	4.14	14.55
		Ghazil	18.55	21.78	85.17	77.48	4.18	14.37
		Boly	18.02	21.95	82.10	76.82	4.18	13.84
5000 ppm	Tap water	Top	19.33	21.90	88.26	76.53	4.54	14.79
		Tyloz	18.97	21.91	86.58	76.18	4.52	14.45
		Ghazil	18.68	22.05	84.72	75.84	4.51	14.17
		Boly	17.65	22.19	79.54	74.48	4.50	13.15
	2.0 % KNO_3	Top	19.54	22.11	88.38	78.18	4.26	15.28
		Tyloz	19.23	22.16	86.78	77.90	4.25	14.98
		Ghazil	18.56	22.21	83.57	76.73	4.32	14.24
		Boly	17.87	22.36	79.92	75.54	4.37	13.50
LSD 5%			0.98	1.05	4.68	NS	0.22	0.92

3. Effect on sugar beet impurities:

3.1. Effect of salinity on sugar beet impurities:

Data in Table (8) shows that there were significant differences in the values of potassium, sodium and α Amino nitrogen as well as K/Na ratio and AIV between the different treatments. However, the highest values for K, K/Na and Alkalinity Index Values (7.81, 2.57 and 3.50) were recorded in plants irrigated with fresh water. On the other hand, the highest values of Na and α Amino nitrogen amounting to 4.20 and 3.72 meq/100 g were recorded in plants irrigated with 5000 ppm. These results coincide with those obtained by Gobarah and Mekki (2005). The accumulation of Na in leaves parallel with decreasing K content, may give us an important explanation for the reflection of salt stress on yield (Eisa *at al*., 2011). such reduction in sugar beet quality may be due to different stresses such as water stress, salt stress and ion imbalance stress as well as the toxic effect of Na^- or Cl^- ions and the osmotic potential of the soil solution (Gobarh, 2001). Selective K^+ uptake has been reported to be associated with salt tolerance in many species (Deinlein *et al*., 2014). They added that, higher K^+/Na^+ ratio does not always correlate with salt tolerance.

3.2. Effect of foliar spraying with potassium on sugar beet impurities:

Table (8) shows that, potassium treatment significantly decreased Na and α Amino nitrogen concentration in sugar beet juice extraction, while it increase K, K/Na ratio and AIV as compared with control treatment. Similar results were obtained by Tawfik *et al*., (2010). In this concern, Carter (1986) stated that α amino nitrogen (Neutral amino acid, glutamine, asparagines, pyrrolidone carbonic acid, amio-butric acid) is consider one of the main impurities and undesirable character which decrease the quality as their concentration in juice

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increases. They interfere with the crystallization process, which causes a greater proportion of the sugars to be recovered as molasses with a reduction in refined sugar. Moreover, Malbaša *et al*., (2008) found that these nitrogenous compounds affect the industrial purification of sucrose and contributes to the actual sugar so they affect the quality of sugar beet. . No clear effect was detected for AIV values. K/Na ratios increased with application of potassium.

Table 8: Effect of salinity, foliar spraying with potassium and plant varieties on sugar beet impurities.

Cultivars	Potassium meq/100 g	Sodium meq/100 g	α Amino nitrogen meq/100 g	K / Na	Alkalinity Index Value
Effect of salinity					
Control	7.81	3.07	3.12	2.57	3.50
2500	7.54	3.61	3.31	2.12	3.37
5000	7.33	4.20	3.72	1.77	3.10
LSD 5%	0.39	0.21	0.23	0.15	0.19
Effect of foliar spraying with potassium					
Control	7.52	3.94	3.48	1.95	3.32
KNO_3	7.60	3.32	3.30	2.35	3.33
LSD 5%	NS	0.20	NS	0.17	NS
Effect of plant varieties					
Top	7.78	3.41	3.45	2.35	3.25
Tyloz	7.66	3.54	3.32	2.23	3.39
Ghazil	7.52	3.69	3.19	2.10	3.54
Boly	7.27	3.86	3.58	1.93	3.12
LSD 5%	0.37	0.22	0.20	0.19	0.22

3.3. Effect of different cultivars performance on sugar beet impurities:

The same Table (8) also shows that there were significant differences in the values of potassium, sodium and α Amino nitrogen as well as K/Na ratio and AIV among the tested sugar beet varieties. However, Top variety recorded the highest values for potassium and K/Na ratio. Meanwhile, Boly variety recorded the greatest values for sodium and α Amino nitrogen and Ghazil Variety recorded the highest values for AIV. These results coinside with those obtained by Zaki *et al.,* (2012). Similar results were obtained by Roghieh and Arshad (2009). In this respect, Refay (2010) mentioned that these differences might be due to the genotypic variation existing among these sugar beet varieties.

3.4. Effect of interaction between salinity and plant variety on sugar beet impurities:

Data presented in fig (3) show that, the highest values for K and K/Na ratio were recorded in Top cultivars irrigated with fresh water, while the highest values of Na and α Amino N were recorded in Boly cultivar irrigated with 5000 ppm, meanwhile, the highest value of Alkalinity Index Value was recorded in Ghazil cultivar irrigated with fresh water. Similar results were obtained by Saadat *et al*., (2012). In this regard, Jafarzadeh and Aliasgharzad (2007) stated that some cultivars may have a degree of salt adaptation due to water retention capacity, membrane permeability and osmo-protection and or genetical and morphological factors.

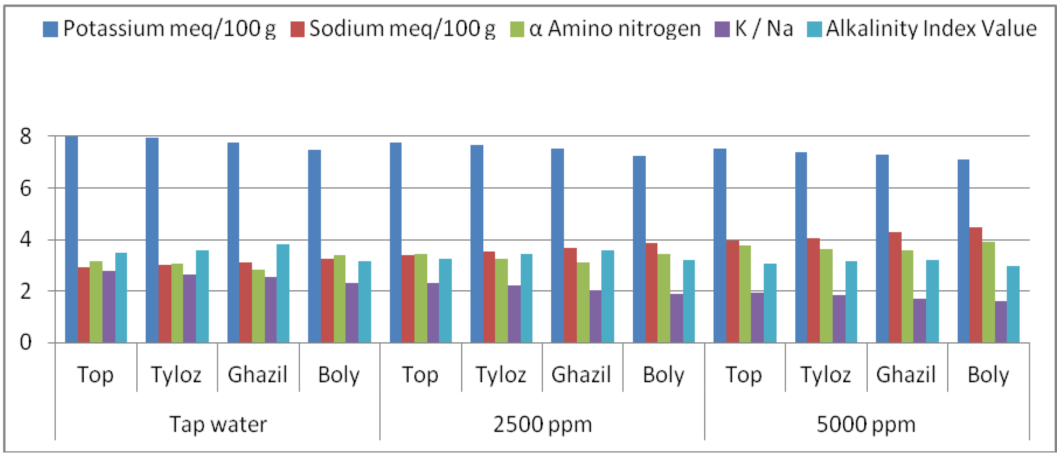

Fig. 3: Effect of interaction between salinity and plant variety on sugar beet impurities (LSD 5%: K= 0.73, Na= 0.39, α Amino nitrogen=0.35, K/Na= 0.22, AIV= 0.33)

3.5. Effect of interaction between foliar spraying with potassium and plant variety on sugar beet impurities:

Data in Fig (4) show significant difference in the interaction between foliar treatments and sugar beet varieties. However, Top variety sprayed with 2.0 % KNO_3, recorded the highest values for K content and K/Na ratio. On the other hand Boly variety sprayed with tap water recorded the highest values for Na and α Amino nitrogen, while Ghazil variety sprayed with recorded the highest values for (AIV) Alkalinity Index Values. These results coincide with those Obtained by Abdel-Mawly and Zanouny (2004). The differences between studied cultivars in seedling parameters might be due to genetical factors and heredity variation among the five sugar beet cultivars.

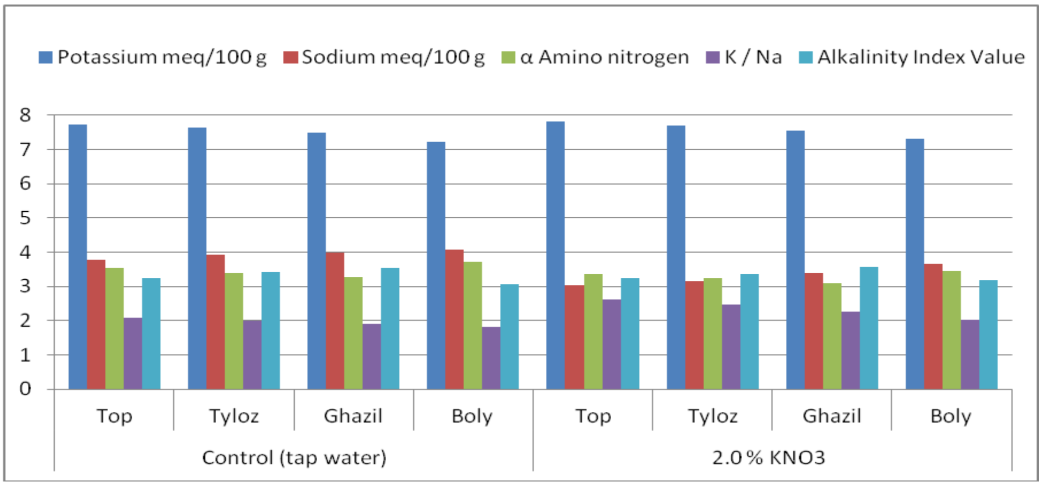

Fig. 4: Effect of interaction between foliar spraying with potassium and plant variety on sugar beet impurities (LSD 5%: K= 0.71, Na= 0.41, α Amino nitrogen=0.38, K/Na= 0.21, AIV= 0.30)

3.6. Effect of interaction between salinity, foliar spraying with potassium and plant varieties on sugar beet impurities:

Table (9) show the interaction effect between salinity, foliar K application and plant variety on sugar beet impurities. However, the Top variety sprayed with 2.0 % KNO_3 and irrigated with tap water recorded the highest values for K and K/Na.

Table 9: Effect of interaction between salinity, foliar spraying with potassium and plant varieties on sugar beet impurities.

Salinity level	Foliar treatment	Cultivars	Potassium meq/100 g	Sodium meq/100 g	α Amino nitrogen	K / Na	Alkalinity Index Value
Control (Tap water)	Tap water	Top	7.99	3.18	3.26	2.51	3.426
		Tyloz	7.92	3.32	3.20	2.38	3.512
		Ghazil	7.77	3.35	2.98	2.32	3.736
		Boly	7.48	3.41	3.53	2.20	3.088
	2.0 % KNO3	Top	8.07	2.63	3.05	3.07	3.512
		Tyloz	7.95	2.74	2.97	2.90	3.602
		Ghazil	7.79	2.85	2.73	2.73	3.905
		Boly	7.51	3.11	3.26	2.41	3.256
2500 ppm	Tap water	Top	7.71	3.75	3.53	2.06	3.251
		Tyloz	7.64	3.92	3.28	1.95	3.524
		Ghazil	7.50	3.98	3.16	1.88	3.636
		Boly	7.22	4.04	3.55	1.79	3.176
	2.0 % KNO3	Top	7.80	3.01	3.33	2.59	3.249
		Tyloz	7.68	3.13	3.22	2.45	3.355
		Ghazil	7.52	3.40	3.09	2.22	3.538
		Boly	7.25	3.64	3.35	1.99	3.251
5000 ppm	Tap water	Top	7.47	4.41	3.84	1.69	3.096
		Tyloz	7.33	4.52	3.67	1.62	3.228
		Ghazil	7.21	4.62	3.68	1.56	3.217
		Boly	7.00	4.77	4.04	1.47	2.912
	2.0 % KNO3	Top	7.60	3.49	3.71	2.18	2.989
		Tyloz	7.45	3.63	3.57	2.05	3.103
		Ghazil	7.35	3.94	3.50	1.87	3.224
		Boly	7.19	4.22	3.77	1.70	3.025
LSD 5%			0.38	0.18	0.17	0.11	3.304

On the other hand, Boly variety sprayed with tap water and irrigated with tap water, recorded the highest values for Na and α Amino nitrogen and Ghazil variety sprayed with 2.0 % KNO_3 and irrigated with tap water recorded the highest values for (AIV). These results coincide with those Obtained by Abdel-Mawly and Zanouny (2004). The decrease in Na^+ when the plants treated with K content can be attributed to K^+ competition with Na^+ for binding sites on the plasma membrane which suppressed the influx of Na^+ from the external solution (Al-Uqaili, 2003).

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