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Efficient Utilization of Nitrogen by Sugar Beet Irrigated with Saline Water under Fertilizer Rates and Water Regime Using ^{15}N Tracer Technique

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ABSTRACT

A pot experiment was conducted in green-house of Soil and Water Research Department, Nuclear Research Center, Abou-Zaabal, Egypt in winter 2016. Nitrogen fertilization management and irrigation water regime were as field practices were followed to improve sugar beet production under salinity stress condition. Sugar beet plants were irrigated with 8 and 16 dS m^{-1} saline water at 100%, 80% and 60% water regimes. Plants were fertilized with 100%, 80% and 50% of fertilizer-N recommended rates. Shoot dry weight was not significantly affected by experimental factors while root dry weight significantly but negatively affected by reduction in water quantities and raise of water salinity. On the other hand, dry weight of root of plants treated with N50 was superior over other N rats especially under W80 and W60 water regimes. Nitrogen uptake by shoot and roots was variably significantly affected by water and N fertilizer regimes under different water salinity levels. Based on mean averages of water and nitrogen treatments, W100, N80 and N100 interacted with salinity levels were the best treatments. Generally, N uptake was negatively affected by shortage in water requirement (regime). The highest values of N uptake by shoots of plants irrigated with 8 and 16 dS m^{-1} salinity levels were recorded with application of 50% N recommended rate. N80 and N100 interacted with salinity levels resulted in the best N uptake by root under W100, W80 and W60, respectively. Nitrogen derived from fertilizer (Ndff) by shoot tended to ~~be~~ reduce~~d~~ with irrigation water shortage up to W60 (water scarce). On the other hand, in most cases, Ndff values were increased with irrigation water salinity levels. It means that sugar beet as salinity tolerant plant acted well and able to gain more nitrogen from chemical fertilizer. More Ndff by shoot was gained when plants fertilized with either N80 or N50 rates. Ndff by root was negatively affected by shortage of water requirement and declined with increasing water salinity but enhanced with low rate of chemical fertilizer added especially at W100 regime. Interaction of salinity and nitrogen rates (S x N) resulted in the increase of %NUE with S8 and S16 salinity levels comparing to fresh water (FW) treatment. This was true, but in low extent, with W80 and W60 water regimes. The highest %NUE by root was recorded with N50 interacted with FW under W100 regime. It means that low N rates meet the plant demand without risk on production and achieved the most benefits from the added doses.

Keywords: Integrated management, N rate, ^{15}N, NUE, salinity, sugar beet, water regime

INTRODUCTION

Water scarcity is defeating billion peoples in different regions of the world (Oki and Kanae, 2006). In the same time, agriculture systems consumed large quantities of available water which accounted for 70% worldwide (Gerbens-Leenes and Nonhebel, 2004; Sepaskhah and Ahmadi, 2010). In dry areas, it becomes a serious issue in recent years (Kang and Zhang, 2004). So, improvement of water use efficiency and productivity is particularly important in the regions suffered from water scarcity (Molden *et al*., 2003). One of the alternatives to solve water shortage is the use of unconventional saline water resources.

Egypt is located in the northern subtropics and like other countries of North Africa and West Asia, it lies in arid and semi arid areas of the world. The only successful agricultural activity is in a small area of the Nile delta where intensive irrigated agriculture is practices over 3.1 million hectares (about 5% of the country area). Even in this area, secondary salinization of the soil is a serious problem. The total area of salt affected soil is estimated to be 1.8 million ha. The salt affected soils in Egypt are located mainly in the Northern Delta region and also spotted in some area in Middle, Western and Eastern area of the Nile Delta beside that found in El-Fayoum, Wadi El-Natroon and Oasis in the Western desert area of Egypt as well as coastal land in Sinai (Aly, 2004).

Sugar beet (*Beta vulgaris* L.) is classified as a field crop well suited for deficit irrigation applications (Vamerali *et al*., 2009). However, many studies reported yield losses in water deficit conditions. In this respect, Sahin *et al*., (2014) found significant polynomial relationships between irrigation quantities and root yield or white sugar yield (WSY) in both full irrigated (FI) and partially root dry (PRD) treatment. PRD technique increased by 34.9% irrigation water use efficiency (IWUE) compared to FI. In addition, Mahmoodi *et al*. (2008) showed that irrigation regimes had a significant effect on sugar yield of sugar beet and its quality. They indicated that optimum soil water content for maximum root yield and quality was 70% of the field capacity. Yonts (2011) expressed that root and sugar yield of sugar beet was the highest for full irrigation and sugar content did not significantly change by reducing irrigation to 25%. Kiziloglu *et al*. (2006) and Topak *et al*. (2011) observed a significant decrease of root, leaf, and total sugar yield of sugar beet under semiarid and cool season climatic conditions as affected by the deficit irrigation water practices. They found a linear relationship between evapotranspiration and root yield. Water use efficiency was the highest at non-irrigated or deficit irrigation water conditions.

This work aimed at recognizing the most and proper water and nitrogen management those helps sugar beet crop to combat salinity stress of irrigation water used.

MATERIALS AND METHODS

A pot experiment was carried out in the green-house of Soil and Water Research Department, Egyptian Atomic Energy Authority (EAEA), Egypt. The experiment was set up at 26 October 2016 and harvested at 20 April 2017. Pots were packed with 20 kg per each one of sandy clay loam soil (Table 1). Total of 108 pots were randomly distributed in the green-house and completely randomized block design was followed. Seeds of sugar beet (Beta vulgaris L. var. Natura KWS), were cultivated at rate of 6 seeds per pot thinned to 3 seedlings after 20 days of cultivation. Super phosphate (P 15.5%) and potassium sulfate (K 45%) fertilizers were added at soil preparation before seeding, at rates of 480 kg P ha-1 (equal to 4 g P pot-1) while potassium was applied at rate of 120 kg K ha-1 (equal to 1 g K pot-1). Nitrogen fertilizer was added in 15N-labeled ammonium sulfate with 2% atom excess. Three doses of N-fertilizer in addition to un-fertilized control were applied representing 100% (150 kg N ha-1, equal to 1.5 g N pot-1), 80% (120 kg N ha-1, equal to 1.2 g N pot-1) and 50% (75 kg N ha-1, equal to 0.75 g N pot-1) of the recommended rates stated by Ministry of Agriculture and Land reclamation of Egypt (MALR, 2006). These rates were splitted into three equal doses applied at 16 Nov., 2016; 12 Dec., 2016 and 11 Jan., 2017, respectively. Pots were irrigated on the basis of field capacity. Saline irrigation water with 8 and 16 dS m-1 were used. Irrigation with fresh water was also included as control treatment. Saline irrigation water was prepared by mixing sea water (35.5 dS m-1) with fresh water, (0.9505 dS m-1 as control) at different portions using the next equation of Ayers and Westcot (1989) which used for calculating the irrigation water EC.

$$\mathbf{EC_{s.w} \times EC_{F.W}}$$

$$\mathbf{[EC_{s.w} \times \text{proportion used}] + [EC_{f.w} \times \text{proportion used}] = EC_{mix.water}}$$

N-fertilization and irrigation water regimes could be described as following:

1-Unfertilized control

2-100% recommended (150 kg N ha^{-1} AS)

3-80% recommended (120 kg N ha^{-1} AS)

4-50% recommended (75 kg N ha^{-1} AS)

5- Water regime (100%, 80%, 60% of F.C.)

6-Water salinity (8, 16 dS m^{-1} in addition to F.W.)

4 Fertilizers doses X 3 W Regime X 2 Salinity levels X 3 Reps = 108 pots.

Table 1. Some physical and chemical characteristics of experimental soil

Particle size distribution %				Texture class		B. density gm cm^3		F. C %		PWP %	
Sand	**Silt**		**Clay**								
68.03	10.02		21.96	Sandy clay loam		1.35		27.5		13.8	
pH 1:2.5	$CaCO_3$ %	O.M %	EC (dS m^{-1}) at 25°c	Soluble cations (meq $100g^{-1}$ soil)				Soluble anions (meq $100g^{-1}$ soil)			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{--}
8.11	1	0.07	0.84	5.76	2.52	1.041	0.51	-	1.64	2.44	5.75
HW %						N mg kg^{-1}			P mg kg^{-1}		
1.58						1.6			53.6		

Soil chemical and physical analyses were carried out according to Carter and Gregorich (2008), while plant chemical analysis was carried out according to Estefan *et al*., (2013).

15N/14N ratio analysis following the isotope dilution concept was carried out according to IAEA, (2001) and the following standard equations were used for calculation of nitrogen derived from fertilizer (Ndff), nitrogen use efficiency (%NUE).

Equations:

$$\% \text{ Ndff} = \frac{\% \, ^{15}\text{N atom excess in plant}}{\% \, ^{15}\text{N atom excess in fertilizer}} \times 100$$

$$\text{Nydff} = \% \text{Ndff} \times \text{total N uptake.}$$

$$\% \text{ FUE} = \frac{\text{Nydff}}{\text{Rate of fertilizer applied}} \times 100$$

Data of the current study were statistically analyzed using Statistical Software Program (PC-Mstat) according to Power (1985). Means of treatments were compared with the Least Significant Difference (L.S.D) at the 0.05 level according to Gomez and Gomez (1984) and (SAS, software program, 2002).

RESULTS AND DISCUSSION

Dry matter yield

Application of full water requirements as well as reduced quantities doesn't reflect any different responses of shoot dry weight (Table 2). All fertilizer-N rates resulted in some slight but insignificant increases in shoot dry weight over the unfertilized control. There were no significant differences between different N rates. On the other hand, interaction between salinity levels and nitrogen fertilizer rates showed significant reflection since the dry weight of shoot, in most cases, tended to increase with either 8 or 16 dS m-1 salinity levels. Dry matter yield of shoot was significantly affected by 16 dS m-1 salinity level. Interaction of salinity and nitrogen rate showed higher shoot dry weight with application of N80 than others under W100 water regime. Under W80 regime, N50 rate induced insignificant slight increase in shoot dry weight. In case of W60, increases in shoot dry weight were observed with interaction between S16 and N100 rate.

Root dry weight was significantly affected by different experimental factors (Table 2). With respect to water regime, data revealed significant increase in root dry weight under W100 followed by W60 then W80. This indicated gradual decrease in root dry weight with reduced water regime. Also, interaction between salinity levels and N rates reflected the superiority of N80 and N50 under W100 and W60, respectively. Under all water regimes, root dry weight was reduced by increasing water salinity levels. Severe reduction in root dry weight was detected with S16 interacted with N80 and N50 under W80 and W60 water regimes.

In conclusion, shoot dry weight was not significantly affected by experimental factors while root dry weight significantly but negatively affected by reduction in water quantities and increases of water salinity. On the other hand, dry weight of root of plants treated with N50 was superior over other N rates especially under W80 and W60 water regimes.

In accordance, results of Zare *et al*., (2012) showed that, shoot length diminished with increasing salinity levels in all studied genotypes. The most effective level in reducing plant attributes was 16 dS m-1 of NaCl. In addition, they found best level of NaCl concentration in root length, shoot length, seedling length and seed vigor was 4 dS m-1.

Seedling dry weight was increased with increasing osmotic potential until 8 dS m-1 but decreased with 12 dS m-1.

Table 2. Effect of water regime, salinity levels and nitrogen rate management on dry matter yield of sugar beet shoots and roots (g pot^{-1}).

Water Regime	Water salinity (dS m^{-1})	Nitrogen fertilizer rate mg pot^{-1} N_0	N_{100}	N_{80}	N_{50}	Mean
		Shoot				
W100	FW	55.5	56.8	63.0	65.1	60.1
	S8	48.5	52.9	65.7	58.7	56.5
	S16	60.6	72.3	61.1	64.0	64.5
	Mean	54.9	60.7	63.3	62.6	60..4
W80	FW	61.7	49.9	54.7	63.6	57.5
	S8	53.6	52.5	68.2	67.0	60.3
	S16	64.4	71.6	59.3	54.3	62.4
	Mean	59.9	58.0	60.8	61.6	60.1
W60	FW	58.7	51.4	56.6	63.8	57.6
	S8	62.3	69.3	57.9	56.9	61.6
	S16	53.7	75.1	62.5	58.5	62.5
	Mean	58.2	65.2	59.0	59.7	60.5
LSD 0.05						
W, ns; S, ns; N, ns		WS, ns;WN, ns; SN, 9.50;WSN, ns				
		Root				
W100	FW	105.5	108.2	108.0	109.3	107.8
	S8	75.1	76.1	79.0	81.2	77.9
	S16	100.4	87.9	89.3	80.6	89.6
	Mean	93.7	90.7	92.1	90.4	91.7
W80	FW	72.5	60.1	54.4	89.6	69.2
	S8	35.0	52.1	95.2	64.6	61.7
	S16	88.8	64.7	48.5	44.3	61.6
	Mean	65.4	59.0	66.0	66.2	64.2
W60	FW	62.2	71.0	44.0	129.1	76.6
	S8	97.6	95.5	98.1	68.5	89.9
	S16	64.3	55.1	52.4	57.1	57.2
	Mean	74.7	73.9	64.9	84.9	74.6
LSD 0.05						
W, 1.98; S, 1.98; N, 2.29		WS, 3.43; WN, 3.96; SN, 3.96; WSN, 6.86				

FW, fresh water; S8, EC 8 dS m^{-1}; S16, EC 16 dS m^{-1}; W100, 100% ETc; W80, 80% ETc; W60, 60% ETc; N0, no nitrogen; N100, N80, N50, 100%, 80%, 50% of recommended rate

Dealing with water requirement regimes, Uçan and GençoĜlan (2004) stated that sugar beet is a crop, which is affected by water deficit. They found fluctuation in the yield related to the amount of water given. Their results indicated the highest sugar beet yields with the highest irrigation level I1 (1331 mm season-1) while the lowest was in level I6 (429 mm season-1). They processed Tukey's test and results showed that the root and sugar yields were significantly different (P<0.05) among the irrigation levels. Also, in consistent with our results, Sakellariou-Makrantonaki *et al.* (2002) found those 80% and 100% subsurface drip irrigation (SDI) treatments produced a similar root yield, but the first saved 16.6% of irrigation water requirements.

Nitrogen uptake

Water regime of 100% FC revealed that N uptake by shoot of sugar beet plants irrigated with fresh water tended to increase with increasing N fertilizer application rates (Table 3). For instance, application of 100% N rate increased N uptake by about 43% over the unfertilized control, while application of 80% and 50% N recommended rate resulted in relative increase in N uptake by shoot by about 23% and 26% over the untreated control, respectively. It seems that the highest N uptake was recorded with the full dose of 100% N recommended rate followed by those of 50% and then those of 80% N recommended rate. With respect to irrigation with saline water at 8 dS m-1, data indicated there was no significant difference in N uptake comparable to those of FW under unfertilized control and those treated with 100% N fertilizer. On the other hand, salinity levels 8 and 16 dS m-1 induced remarkable increase in N uptake over those recorded with fresh water especially when plants were treated with 80% and 50% N recommended rates. In this respect, the highest values of N uptake by shoots of plants irrigated with 8 and 16 dS m-1 salinity levels were recorded with application of 50% N recommended rate.

Table 3. Effect of water regime, salinity levels and nitrogen rate management on nitrogen uptake by shoots and roots of sugar beet (mg pot^{-1}).

Water Regime	Water salinity (dS m^{-1})	Nitrogen fertilizer rate mg pot^{-1} N_0	N_{100}	N_{80}	N_{50}	Mean
		Shoot				
W100	FW	1070	1530	1320	1350	1317.5
	S8	1010	1530	1580	1750	1467.5
	S16	1040	1530	1530	1680	1445.0
	Mean	1040	1530	1476	1593	1409.8
W80	FW	630	1170	1350	1080	1057.5
	S8	790	1080	1370	1120	1090.0
	S16	770	1680	1050	1490	1247.5
	Mean	730	1310	1256	1230	1131.5
W60	FW	1180	990	1200	1360	1182.5
	S8	1290	1260	1380	1370	1325.0
	S16	1300	1390	1660	1220	1392.5
	Mean	1250	1213	1413	1316	1298.0
LSD 0.05						
W, 27.6; S, 27.6; N, 32.2		WS, 48.2; WN, 55.6; SN, 55.6; WSN, 96.5				
		Root				
W100	FW	1200	1210	1580	1390	1345.0
	S8	1060	890	1210	1060	1055.0
	S16	1200	960	1100	1050	1077.5
	Mean	1153	1020	1296	1166	1158.7
W80	FW	800	890	1110	830	907.5
	S8	830	1130	880	770	902.5
	S16	610	890	700	740	735.0
	Mean	746	970	896	780	848.0
W60	FW	1220	1120	870	820	1007.5
	S8	880	550	790	720	735.0
	S16	1000	990	670	560	805.0
	Mean	1033	887	777	700	849.2
LSD 0.05						
W, 22.6; S, 22.6; N, 39.2		WS, 26.2; WN, 45.4; SN, 45.4; WSN, 78.7				

FW, fresh water; S8, EC 8 dS m^{-1}; S16, EC 16 dS m^{-1}; W100, 100% ETc; W80, 80% ETc; W60, 60% ETc; N0, no nitrogen; N100, N80, N50, 100%, 80%, 50% of recommended rate

Nitrogen uptake by roots of plants irrigated with W100 tended to decrease with S8 salinity level, and then slightly increased with S16 salinity level. This was true under all nitrogen fertilization rates. Interaction between water salinity and N rates indicated the superiority of N80 over N50 and N100, respectively. In this regard, N80 was the best among N fertilization rates. Similar trend was noticed with W80 and W60 regimes but to somewhat lower extent. Interactions between the water and nitrogen regimes as affected by water salinity levels concluded the enhancement of nitrogen uptake by roots under W100 as compared to W80 and W60. Overall means of W80 and W60 were nearly closed to each other. Water salinity has a negative effect on N uptake values. Effect of N rates was significantly correlated to water regime. In this respect, N80 and N100 interacted with salinity levels resulted in the best values of N uptake by root under W100, W80 and W60, respectively.

On line, Hussein *et al*., (2015) found that interaction between water regime and nitrogenous fertilizer was significantly affected N content of sugar beet plants and in the same time urea form was found to be better than ammonium nitrate especially under 50% ETc water regimes. They attributed this phenomenon to continuous increase in urea fertilization in relation to the depression in water regime ETc percentage. Also, they detected an increase of N content under 50% ETc more than those of 75% or 100% Etc. In consistent, Abd El-Motagaly and Attia (2009) showed that N content and uptake by roots and foliage were significantly increased by increasing N fertilization over two seasons. Their data remarked that studied N content of foliage was higher than roots that are related to improvement of photosynthesis. This is on harmony with our presented data. Another researchers attributed the improvement of nitrogen uptake to K that helps in maintaining a normal balance between carbohydrates and proteins (Moustafa and Darwish, 2001; Monreal *et al*., 2007). Esmaeili (2011) found that root yield increased as nitrogen increased up to the highest level used. They found the lowest yield (50.28 t ha-1) with no N while the highest yield of 61.45t ha-1 induced by 150 kg N ha-1.

Nitrogen derived from fertilizer Ndff

Portions and absolute values of Ndff by shoot were listed in Table (4), revealed that percentages did not varied with salinity levels but absolute values showed slight increases of Ndff with S8 and S16 salinity levels over those recorded for fresh water (FW). Interaction between salinity levels and nitrogen rates under W100 regime indicated that N100 under FW recorded the highest Ndff value gained by shoot while under S8 and S16, the highest Ndff by shoot were recorded with N50 fertilization rate. This phenomenon was proved by mean average (875.6 mg pot-1), of S x N interaction. Reduction in water regime W80 resulted in decline of Ndff values than those recorded with W100 regime. Similarly, it decreases with S8 salinity level, and then increased with S16 under N100 rate. Reversible trend was noticed under N80 rate where it slightly increased with S8 but severely decreased with S16 salinity level. In case of N50 rate, Ndff values were tended to increase gradually with increasing water salinity levels where the highest Ndff value (818 mg pot-1) induced by S16 salinity level. Interaction of S x N under W80 reflected the superiority of N100 rate over those of N80 and N50 rates. Although the W60 regime subjected sugar beet plants to water scarcity, the mean average (716.6 mg pot-1) of Ndff increased again comparing to those recorded with W80 regime but still lower than those of W100 regime. Interaction of S x N showed that the highest Ndff value (764.1 mg pot-1) was resulted from application of N80 rate followed by those of N50 and those of N100 came to the next.

It could be concluded that Ndff by shoot tended to be reduced with irrigation water reduction up to W60 (water scarce). On the other hand, in most cases, Ndff values were increased with irrigation water salinity. It means that sugar beet as salinity tolerant plant acted well and able to gain more nitrogen from chemical fertilizer. More Ndff by shoot was gained when plants fertilized with either N80 or N50 rates.

Table 4. Nitrogen derived from fertilizer (% and mg pot^{-1}) by shoot and root of sugar beet as affected by irrigation water and N fertilizer management regimes.

Water Regime	Water salinity (dS m^{-1})	Nitrogen fertilizer rate mg pot^{-1}							
		N_{100}		N_{80}		N_{50}		Mean	
		Shoot							
Ndff values		%	mg	%	mg	%	mg	%	Mg
W100	FW	54.8	838.4	54.9	724.7	55.1	743.9	54.9	769.0
	S8	53.8	823.1	54.3	857.9	54.5	953.8	54.2	878.3
	S16	55.2	844.6	55.0	841.5	55.3	929.0	55.2	871.7
	Mean	54.6	835.4	54.7	808.0	55.0	875.6	54.8	839.7
W80	FW	54.4	636.5	53.8	726.3	54.8	591.8	54.3	651.5
	S8	54.5	588.6	54.2	742.5	55.3	619.4	54.7	650.2
	S16	54.7	919.0	53.3	559.7	54.9	818.0	54.3	765.6
	Mean	54.5	714.7	53.8	676.2	55.0	676.4	54.4	689.1
W60	FW	53.9	533.6	53.9	646.8	54.9	746.6	54.2	642.3
	S8	55.2	695.5	53.8	742.4	54.5	746.7	54.5	728.2
	S16	55.3	768.7	54.4	903.0	54.6	666.1	54.8	779.3
	Mean	54.8	665.9	54.0	764.1	54.7	719.8	54.8	716.6
		Root							
W100	FW	60.2	728.4	61.5	971.7	65.0	903.5	62.2	867.9
	S8	54.9	488.6	55.0	665.5	65.0	689.0	58.3	614.4
	S16	60.0	576.0	59.5	654.5	64.9	681.5	61.5	637.3
	Mean	58.4	597.7	58.7	763.9	65.0	758.0	60.7	706.5
W80	FW	59.4	528.7	54.9	609.4	64.8	537.8	59.7	558.6
	S8	53.4	603.4	60.2	529.8	54.8	422.0	56.1	518.4
	S16	55.3	492.2	53.8	376.6	55.1	407.7	54.7	425.5
	Mean	56.0	541.4	56.3	505.3	58.2	455.8	56.8	500.8
W60	FW	55.2	618.2	53.4	464.6	65.0	533.0	57.9	538.6
	S8	60.8	334.4	61.1	482.7	59.5	428.4	60.5	415.2
	S16	55.1	545.5	54.4	364.5	60.3	337.7	56.6	415.9
	Mean	57.0	499.4	56.3	437.3	61.6	433.0	58.3	456.6

FW, fresh water; S8, EC 8 dS m^{-1}; S16, EC 16 dS m^{-1}; W100, 100% ETc; W80, 80% ETc; W60, 60% ETc; N0, no nitrogen; N100, N80, N50, 100%, 80%, 50% of recommended rate

On the contrary, nitrogen derived from fertilizer by root under W100 regime tended to declines with increasing water salinity up to S16. Similar trend, but to somewhat lower extent, was noticed with W80 and W60 water regime, respectively. Under this regime, Ndff values were increased with lower N rates (N80 and N50). It is worthy to mention that Ndff percentages recorded with root were to some extent higher than those of Ndff by shoot. In conclusion, Ndff by root was negatively affected by reduction of water requirement and declined with increasing water salinity but enhanced with low rate of chemical fertilizer added especially at W100 regime.

Nitrogen use efficiency (%NUE)

Efficient use of chemical fertilizer by shoot of plants irrigated with W100 regime was enhanced with low rates of addition (N80 and N50) (Table 5). This phenomenon, with slight decrease, was noticed with W80 and W60 regimes. Interaction of S x N indicated the increase of %NUE with S8 and S16 salinity levels comparing to fresh water. This was true, but in low extent, with W80 and W60 water regimes.

Table 5. Nitrogen use efficiency (%NUE) by shoot and root of sugar beet as affected by irrigation water and N fertilizer management regimes.

Water Regime	Water salinity (dS m^{-1})	N fertilizer (%) of recommended rates							
		N_{100}	N_{80}	N_{50}	Mean	N_{100}	N_{80}	N_{50}	Mean
		Shoot				Root			
W100	FW	27.9	30.2	49.6	35.9	24.3	40.5	60.2	41.7
	S8	27.4	35.7	63.6	42.2	16.3	27.7	45.9	30.0
	S16	28.2	35.1	61.9	41.7	19.2	27.3	45.4	30.6
	Mean	27.8	33.7	58.4	40.0	19.9	31.8	50.5	34.1
W80	FW	21.2	30.3	39.5	30.3	17.6	25.4	35.9	26.3
	S8	19.6	30.9	41.3	30.6	20.1	22.1	28.1	23.4
	S16	30.6	23.3	54.5	36.1	16.4	15.7	27.2	19.8
	Mean	23.8	28.2	45.1	32.4	18.0	21.1	30.4	23.2
W60	FW	17.8	27.0	49.8	31.5	20.6	19.4	35.5	25.2
	S8	23.2	30.9	49.8	34.6	11.1	20.1	28.6	19.9
	S16	25.6	37.6	44.4	35.9	18.2	15.2	22.5	18.6
	Mean	22.2	31.8	48.0	34.0	16.6	18.2	28.9	21.2

Similar trend, but to somewhat lower extent, was noticed with NUE of root. The highest %NUE was recorded with N50 interacted with FW under W100. It is obvious that N utilized by root was severely negatively affected by water regime and salinity levels while it enhanced with reduction in N fertilizer rates. It means that these rates meet the plant demand resulted in the most benefits from the added doses.

Our results of Ndff and %NUE are in consistent with those reported earlier by Aly *et al.*, (2005) who found that aerial green parts (leaves) of sugar beet were more effective in utilizing the N derived from fertilizer. This effective source of N derived by green parts was responded well to increase water regime and splitting of N-fertilizer additions. They reported similar trend of salinity effect on %Ndff by roots which was noticed under WII water regime. Also, the highest percent of N derived from fertilizer was recorded with the higher salinity level of 12 dS m^{-1} (84.2%) under NI, and (85.7%) under NII treatments. Contrary, the absolute values reflected that the amounts of N derived from fertilizer were higher in case of 4 and 8 dS m^{-1} levels than the 12 dS m^{-1} level. In this respect, the highest amount of Ndff was recorded with 4 dS m^{-1} level (0.69 g L^{-1}) under NII and WII treatments.

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الاستخدام الكفوء للنيتروجين بواسطة بنجر السكر المروى بالماء المالح تحت معدلات سمادية و حمية مائية باستخدام تقنية اقتفاء الأثر- ن^{15}

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أجريت تجربة أصص تحت ظروف البيت الزجاجي بقسم بحوث الأراضي والمياه، مركز البحوث النووية، ابو زعبل، مصر خلال شتاء 2016. أتبعت ادارة التسميد النيتروجيني مع حمية ماء الري كمعاملات حقلية بغرض تحسين انتاجية بنجر السكر تحت ظروف الاجهاد الملحي. رويت نباتات بنجر السكر بالماء المالح عند مستويي 8 و 16 ديسيسيمنز/م بمعدلات ري 100%، 80%، 60% من السعة الحقلية كما سمدت النباتات بمعدلات 100%، 80%، 50% من المعدل الموصي به من الآزوت الكيماوي. لم يتأثر الوزن الجاف للسيقان بالعوامل التجريبية تحت الدراسة بينما تأثر الوزن الجاف للجذور سلبيا بالانخفاض في مقننات الري مع زيادة مستوى ملوحة المياه. في اتجاه آخر، تفوقت أوزان الجذور الجافة للنباتات المعاملة بنسبة 50% من السماد الكيماوي على المعدلات الأخرى وخاصة مع معدلات الري 80% و60% حمية مائية. النيتروجين الممتص بواسطة السيقان والجذور تأثر معنويا بحميات الماء والنيتروجين في ظل مستويات الملوحة المختلفة. أوضحت المتوسطات أن حمية الماء 100% و النيتروجين 50%، 100% كانت الأفضل عندما تفاعلت مع مستويات الملوحة. بصفة عامة، تأثر النيتروجين الممتص سلبيا بالنقص في كميات مياه الري (الحمية). أعلى قيم للنيتروجين الممتص بواسطة سيقان النباتات المروية بمياه مالحة 8 و 16 ديسيسيمنز والتي رصدت عند اضافة 50% معدل سمادي. تفاعل معدلي 80% و 100% من السماد الكيماوي مع مستويات الملوحة نتج عنه أفضل امتصاص للنيتروجين بواسطة الجذور تحت حميات الري 100%، 80%، 60% على الترتيب. النيتروجين المستمد من السماد الكيماوي بواسطة الجذور مال الى النقص مع تناقص معدلات مياه الري حتى 60%. من جهة أخرى، تزايدت قيم النيتروجين المستمد من السماد الكيماوي، في معظم الحالات، مع ملوحة مياه الري. وهذا يعنى أن بنجر السكر كنبات مقاوم للملوحة تصرف بشكل جيد وكانت له القدرة على امتصاص الآزوت من مصدره الكيماوي. كثير من النيتروجين المستمد من السماد الكيماوي بواسطة السيقان امتص بواسطة النباتات المسمدة بمعدل 80% أو 50%. تأثر النيتروجين المستمد من السماد الكيماوي بواسطة الجذور سلبيا مع انخفاض معدلات الري وتناقص مع زيادة الملوحة ولكنه تحسن مع المعدل المنخفض من السماد الكيماوي وخاصة في ظل اضافة 100% حمية مائية. التفاعل بين مستويات الملوحة مع معدلات النيتروجين اشار الى زيادة كفاءة استخدام السماد الكيماوي عند مستويات الملوحة 8 و 16 ديسيسيمنز/م مقارنة مع المياه العذبة. تحقق ذلك ايضا، ولكن في مدى أقل، مع الحمية 80% و 60%. أعلى قيمة لكفاءة استخدام النيتروجين السمادى بواسطة الجذور تم رصدها مع معدل النيتروجين 50% في حالة المياه العذبة المضافة بمعدل 100%. وهذا يعنى أن معدل النيتروجين السمادى 50% يوفى باحتياجات النبات في الوقت المناسب محققا أفضل استفادة من المعدلات المضافة.