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EFFECT OF MAGNETIC WATER AND UREA FERTILIZER ON SUGAR BEET YIELD AND QUALITY

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Abstract

The excessive use of nitrogen fertilizers causes irreversible environmental effects and affects negatively plants, from this point of view; magnetized irrigation water appears as a viable solution to minimize these effects. The agronomic advantages of using magnetized water for irrigation proposes will make the crops look more green, strong and healthy. So, this study was conducted to assess the impact of magnetic irrigation water on yield and quality of sugar beet (*Beta vulgaris* L.) and reducing the amount of applied urea to the field without a nitrogen deficiency. For this purpose, two field experiments were carried out at Tag El-Ezz Experimental Farm, Agricultural Research Station, Temi El-Amdid District, El-Dakahlia Governorate, Egypt, in 2017/18 and 2018/19 seasons to investigate the response of sugar beetplants were irrigated with magnetic and nonmagnetic water under different rates of urea fertilizer as a soil application (100, 75 and 50% of the urea recommended dose (URD) and various rates of urea fertilizer asa foliar application (0, 1, 2 and 3 % N). The used experimental design was a split-split plot design with three replicates for each treatment. Growth parameters, yield and its components characters, juice quality and chemical constituents of sugar beet plants were evaluated. Also, some soil properties were determined after harvest. The findings indicated that all growth parameters of sugar beet plant increased as a urea rate increased, where sugar beet plants under combination between urea as a soil application at rate of 100% of URD and urea as a foliar application at rate of 3% N was ranked as the first favorable treatments for the most studied attributes of growth, while the most of juice quality characters declined at this treatment. Also, the irrigation with magnetic water was better than nonmagnetic water. Thus, sugar beet plants sprayed with urea at a rate of (3% N) and fertilized by 75% of URD as soil application under irrigation with magnetic water is the best treatment for sugar beet. The irrigation by magnetic water had a positive effect on characters of sugar beet yield and quality. Also, spraying urea is more effective than soil application. Besides, the high rates of urea harmquality parameters of sugar beet.

Key words: Magnetic water, urea, soil and foliar application, sugar beet.

Introduction

Even though the nitrogen fertilizers are so important to plant growth because most of the Egyptian soils contain insufficient nitrogen in an available form, the continued use of nitrogen fertilizers causes environmental and health hazards like surface and ground water pollution by leaching of nitrate. So, reducing the amount of nitrogen fertilizers applied to the field without a nitrogen deficiency will be the main challenge in field management (Seadh, 2014). Foliar application of nitrogen is more effective than soil application due to the minimum losses involved in the foliar spray. Certain physical and chemical soil properties limit early plant growth and decrease its efficiency to absorb available nitrogen (Ayoub, 1982). Foliar spray of nitrogen fertilizer did not only improve the crop yields but also decreased the quantities of fertilizer applied through the soil. Also, the foliar application can reduce the lag time between application and uptake by the plant (Ahmad and Jabeen, 2005 and Veesar *et al.,* 2017). One of the possible options to reduce the nitrogen fertilizer usage could be the irrigating by magnetized water. The N-fertilization doses can be decreased by 20% with maintaining the production and the possibility of increasing it by irrigation with magnetic water (Mahmoud *et al.,* 2019). Water magnetization technology makes the nutrients in the soil easily absorbed by the plants. This technology is important in reducing the salinity impact in the irrigation water and soil due to the ability of magnetized water to leaching away of salts and washing of different anions from the soil (Ben, 2007). The subjecting water to a magnetic field causes modification of its characteristics, as it becomes more able to flow and more energetic. Magnetized water also prevents harmful metals from uptake by plant roots. However, it increases nutrients such as P and K. Irrigation plants with magnetized water dissolve more elements due to it lowers the water surface tension. Hence, this reduces the pH and leads to more nutrients to pass through the cell walls of plant roots. Magnetized water dissolves more elements into the root zone to become available, thus stimulate plant growth (Tai *et al.,* 2008; Mohamed and Ebead, 2013; Ali *et al.,* 2014; Shahin *et al.,* 2016 and Kanany *et al.,* 2017). Sugar beet (*Beta vulgaris* L.) has an important position in Egyptian crop rotation as a winter crop. Recently, the Egyptian Government encourages growers of sugar beet to increase the cultivated area for reducing the gap between consumption and production of sugar (Dewdar *et al.,,* 2018). Therefore, the objective of this study is to enhance yield and quality of sugar beet plants by irrigation with magnetized water as well as evaluation of application methods of urea fertilizer at different rates and find out the positive effect of these treatments on sugar beet plants growth because of its importance as a strategic crop in Egypt.

Materials and Methods

To achieve the goal of this investigation, a field trial was carried out at Tag El-Ezz Experimental Farm, Agricultural Research Station, Temi El-Amdid District, El-Dakahlia Governorate, Egypt (31°31' 47.64" N latitude and 30°56' 12.88" E longitude) during growing seasons of 2017/18 and 2018/19 to evaluate the influence of magnetized irrigation water, soil and foliar application of urea at different rates as well as their interactions on improving the yield and quality of sugar beet (*Betavulgaris* L.) and reducing the amount of applied urea fertilizer without a nitrogen deficiency. Twenty-four treatments (which were the simple possible combination between two irrigation water types, three rates of urea as soil application and four rates of urea as foliar application) were arranged in a split- split plot design. The irrigation water types (magnetic and nonmagnetic water) represented in the main plots and the urea soil applications (100, 75 and 50% of the Urea Recommended Dose (URD), equivalent to 80, 60 and 40 kg N fed^{-1}, respectively) were devoted in sub-plots, while the urea foliar applications (0, 1, 2 and 3 % nitrogen in the form of urea fertilizer) were allocated in the sub-sub plots. Each treatment was replicated three times. Thus, the total number of experimental units used for each season was 72. The sub-sub plot size was 14m^2 (3.5×4).

According to Dewis and Fertias (1970), the used soil was analyzed before sowing as a routine work. Table 1 showed some chemical and physical properties of experimental soil.Twenty-four soil samples were taken at harvest stage to determine the available N (mg kg^{-1}) and soil EC (dSm^{-1}). The magnetic water was the normal water (canal water) that had been exposed to a magnetic field by passing through, a magnetic water unit (2.0 inch diameter, 0.60 mT and supplied by Magnetic-Technologies Company LLC PO Box 27559, Dubai, UAE) before the application to the plants. The different analysis of the irrigation water before and after magnetizing was done by the standard methods (Richards, 1954) as the following in table 2.

Seeds of sugar beet (Finoget) will be obtained from Sugar Res. Institute, Agric. Res., Center, Giza, Egypt at two successive winter seasons. Sugar beet cultivated as a following crop after rice. Three-four seeds of sugar beet were sown in hill spaced 20 cm apart on one side of the ridge (60 cm apart) on 22th and 23th Octoberin 2017/18 and 2018/19 seasons, respectively. Plants were thinned twice, 30 days after planting and 15 days later to ensure one plant hill^{-1}. The experimental soil was prepared as usually and the irrigation was immediately after sowing, where the half of treatments was irrigated with magnetic water and the other half was irrigated with nonmagnetic water. In this experiment urea (46.5%N) as a source of nitrogen was applied. Urea was applied through the soil

Table 1: Experimental soil characteristics before cultivating (mixed soil sample were taken of the two seasons).

Particle size distribution (%)				**Texturalclass class**	**EC, dSm^{-1}***	**pH ****	**$CaCO_3$**	**O.M**	**F.C**	**SP**
C.sand sand	**F.sand**	**Silt**	**Clay**	**Clay**	**(%)**					
3.72	12.15	36.74	47.39		4.10	7.9	4.82	1.70	41.82	83.65
Soluble cations and anions (meq 100 g soil $^{-1}$)								Available element, mg kg^{-1}		
Soluble cations				Soluble anions						
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K
0.67	0.50	2.24	0.014	-	0.26	2.28	0.88	47.4	9.00	225.7

*Soil Electrical Conductivity (EC) and soluble ions were determined in saturated soil paste extract. ** Soil pH was determined in soil suspension (1: 2.5).

Table 2: Chemical analysis of irrigation water before and after magnetizing according to the standard methods.

Parameter	Non magnetizing Water	Magnetizing Water
pH	7.42	7.48
EC (dSm^{-1})	0.76	0.69
**SAR	2.32	1.62
Soluble Cations (meq L^{-1})		
Ca^{+2}	2.50	2.53
Mg^{+2}	1.44	1.71
Na^{+}	3.26	2.36
K^{+}	0.40	0.30
Soluble Anions (meq L^{-1})		
CO_3^{-2}	—	—
HCO_3^{-}	4.25	4.50
Cl^{-}	1.73	1.62
SO_4^{-2}	1.62	0.78

*The mean values of the number of irrigation during the season.

**SAR = Na/SQRT (Ca^{+2} + Mg^{+2}) / 2

with the above-mentioned rates at two equal doses the first after thinning and the second after one month later. Also, the spraying urea with the above-mentioned rates was repeated 2-times at the same time as a soil application. K as potassium sulphate (48% K_2O) was added at the rate of 50kgfed-1 according to the recommended by the Ministry of Agriculture and Soil Reclamation (MASR) and P as mono calcium phosphate (15.5% P_2O_5) was added at the rate of 150 kg fed^{-1} before planting for all plots of the experiment. All other cultural practices were done as recommended and the irrigation was done as the plants needed.

As ample of five plants from every treatment was randomly chosenat 100 days from sowing to evaluate growth parameters *i.e.* shoot fresh and dry weights ($gplant^{-1}$), shoot length (cm), number of leaves $plant^{-1}$ as criteria of sugar beet plants growth. Also mineral content of shoots *i.e.* N, P, K and Na (%) as well as chlorophyll a, b and chlorophyll (a+b) (mg/g F.W) at this growth stage (100 days from sowing) were determined.

At harvest time (after 180 days from planting), five guarded plants were taken at random from the middle rows of each treatment and carefully uprooted in the two seasons to determined root length and diameter (cm) as well as root fresh and dry weights (g $plant^{-1}$). Plant samples were transferred to laboratory, washed with tab water then by distilled water. Then roots and shoots were separated and weighed in kilograms to estimated root and top yield (ton fed^{-1}), also N and P % were determined in roots. Extracted sugar yield ($tonfed^{-1}$), which was calculated according to the following equation:Extracted sugar yield (ton fed^{-1}) = root yield (ton fed^{-1}) x extracted sugar (%).

Root quality and impurity parameters: A sample of 10 kg of roots was taken from each treatment randomly and was send to the Beet Laboratory at Dakahlia sugar Factory to estimate root quality.

- Sucrose % (Pol %), which was estimated in fresh samples of sugar beet roots, using "Saccharometer" according to the procedure of the El- Dakahlia Sugar company of Le-Docte, (1972).

- Extracted sugar (%), which was calculated using the following equation according to the following equation of Cooke and Scott (1993):

Extracted sugar% = Pol % - 0.343*(K + Na) – ±-amino N* (0.0939) – 0.29

- Sugar lost to molasses (SLM; %) = sucrose (%) - extracted sugar (%) - 0.6.

- Juice quality index was calculated using the following equation of Cooke and Scott(1993) :

QI (%) = Extracted sugar (%) x100/pol (%)

- Impurities (±-amino N, Na and K contents in juice) were estimated according to the procedures of Sugar Company by Automated Analyzer as described by Cooke and Scott (1993).

- Alpha amino nitrogen (±-amino N) percentages (expressed as a mill equivalent 100 g^{-1} of beet) was determined using ninhydrin according to the methods of Carruthers and Oldfield (1962).

- Total soluble solids percentage (TSS; %) was determined using hand refractometer method according to Snedecor and Cochran (1980).

- K and Na (%) were determined using flame photometer according to Peters *et al.,* (2003).

Total nitrogen in plant organs was determined by completely wet digested sample using Kjeldahl method according to Jones *et al.,* (1991), while total phosphorus was determined spectrophotometrically as described by Peters *et al.,* (2003). Chlorophyll content was estimated on 4^{th} leaves from the plant apix according to Sadasivam and Manickam, (1996).

Statistical analysis: Data were statistically analyzed using MSTAT-C computer package (Freed *et al.,* 1989). The least significant difference (LSD at 5%) test was done to compare among the means.

Results and Discussion

Growth criteria, photosynthetic pigment and

chemical content in shoots at 100day from sowing

Tables 3, 4 and 5 showed the effect of magnetized irrigation water, soil and foliar applications of urea at different rates as well as their interactions on growth criteria (*i.e.*shoot fresh and dry weights (g plant^{-1}) shoot length (cm) and No. of leaves plant^{-1}), photosynthetic pigments (*i.e.* chlorophyll a, b and chlorophyll (a+b) mg/ g fw) and chemical content in shoots (*i.e.* N, P, K and Na; %) of sugar beet plant at 100 days from sowing (the displayed parameters' values were mean of the two seasons). It is clearthat; irrigation of sugar beet plants with magnetic water increased significantly all aforementioned traits, except No. of leaves plant^{-1}, as compared with sugar beet plants irrigated with nonmagnetic water. This may be due to the changes of some physical and chemical characters of the magnetic water *i.e.* viscosity, hydrogen bonding, polarity and surface tension which increased sugar beet plant growth. Harmony results were reported by El-Shokali *et al.,* (2015) who concluded that magnetic water had a positive enhancing impact on different plants. Also, Otsuka and Ozeki (2006) reported that magnetic water has changed some of its properties mainly surface tension, hydrogen bonding, polarity, pH, conductivity and solubility of salts. These changes in water characters capable to affect the growth of plants. Concerning the individual influence of urea fertilizer as soil application at different rates, data showed that the highest values of above-mentioned traits were recorded when sugar beet plants treated with urea fertilizer as soil application at 100% of URD compared to other treatments. The soil application of 75% of URD came in the second order, then 50% of URD. Regarding the individual effect of urea foliar spraying, the values of all aforementionedtraits were significantly increased as the rates of sprayed urea were increased. In this connect; the highest values were recorded for the sugar beet plants treated with urea foliar spraying at rate of 3%N while, the lowest one was obtained for untreated plants (0% N). Generally, sequence of foliar urea treatments from top to less was the 3%N> 2%N> 1%N> 0%N (untreated plant). This trend was found for the two

Table 3: Effect of irrigation treatments, soil and foliar applications of ureaas well as their interaction on growth criteria (combined data over both seasons)of sugar beet plants at 100 days from sowing.

Treatments			Weight (g plant^{-1}) Fresh shoot	Dry shoot	Plant height (cm)	No. of leaves plant^{-1}
Irrigation water						
Magnetic water			598.78	58.30	51.92	38.53
Nonmagnetic water			555.72	53.39	50.29	37.78
F. significance			**	*	*	n.s
Different rates of URD as soil application						
Soil application of 100% URD			732.25	73.00	56.95	40.96
Soil application of 75% URD			682.67	67.46	55.04	40.46
Soil application of 50% URD			316.83	27.08	41.33	33.04
LSD $_{at 5\%}$			2.91	0.40	0.36	1.25
Different rates of URD as foliar application						
Urea foliar application (0% N)			413.72	37.72	45.00	34.83
Urea foliar application (1% N)			525.11	49.74	48.99	37.33
Urea foliar application (2% N)			631.22	61.96	53.21	39.28
Urea foliar application (3% N)			738.94	73.96	57.23	41.17
LSD $_{5\%}$			2.41	0.32	0.29	0.77
Interaction						
Magnetic water	Soil application of 100% URD	Urea foliar application (0% N)	560.00	54.10	50.37	38.00
		Urea foliar application (1% N)	695.33	68.47	55.40	39.67
		Urea foliar application (2% N)	820.67	83.43	60.60	42.67
		Urea foliar application (3% N)	951.00	97.10	65.20	45.00
	Soil application of 75% URD	Urea foliar application (0% N)	494.67	46.43	48.03	37.00
		Urea foliar application (1% N)	627.67	61.27	52.83	39.00
		Urea foliar application (2% N)	787.67	79.60	59.10	42.00
		Urea foliar application (3% N)	917.33	93.73	64.07	44.33
	Soil application of 50% URD	Urea foliar application (0% N)	235.00	18.03	38.03	31.33
		Urea foliar application (1% N)	302.33	25.23	40.73	33.33
		Urea foliar application (2% N)	364.33	32.53	43.07	34.33
		Urea foliar application (3% N)	429.33	39.70	45.60	35.67
Nonmagnetic water	Soil application of 100% URD	Urea foliar application (0% N)	527.67	50.17	49.17	37.33
		Urea foliar application (1% N)	662.33	64.83	54.03	39.33
		Urea foliar application (2% N)	755.67	75.70	57.97	41.67
		Urea foliar application (3% N)	885.33	90.17	62.87	44.00
	Soil application of 75% URD	Urea foliar application (0% N)	462.33	43.07	46.57	36.33
		Urea foliar application (1% N)	592.67	56.87	51.60	40.67
		Urea foliar application (2% N)	724.67	71.63	56.63	41.33
		Urea foliar application (3% N)	854.33	87.10	61.47	43.00
	Soil application of 50% URD	Urea foliar application (0% N)	202.67	14.53	37.83	29.00
		Urea foliar application (1% N)	270.33	21.77	39.33	32.00
		Urea foliar application (2% N)	334.33	28.87	41.90	33.67
		Urea foliar application (3% N)	396.33	35.93	44.17	35.00
LSD $_{5\%}$			5.92	0.78	0.72	1.88

studied seasons. The increases of growth parameters of sugar beet plants due to increasing urea fertilizer rates may be attributed to the favorable impacts of N on increasing size and No. of leaves which led to increasing leaf area per plant which, in turn, led to higher photosynthetic activities resulted in increasing of leaves (Abdel-Motagally and Attia, 2009, on sugar beet). Concerning the interaction effect between the treatments under investigation, it could be observed that the values of above-mentioned traits were significantly affected due to the application of all investigated treatments, where the sugar plants irrigated with magnetic water, fertilized with 100% of URD as soil application and sprayed with 3 % nitrogen in the form of urea fertilizer produced higher values, while the lowest values were recorded when the sugar plants irrigated with nonmagnetic water and fertilized with 50% of URD as soil application without urea spraying (0% of nitrogen as foliar application). On the other hand, spraying sugar beet plants with urea at rates of 1, 2 and 3%N under fertilizing by 75% of URD as soil application gave better results than sugar beet plants treated only with 100% of URD as a soil application. Also, spraying sugar beet plants with urea at rate of 3%N under fertilizing by 75% of URD as soil application gave better results than sugar beet plants treated with 100% of URD as a soil application with spraying foliar of urea at rate of 0, 1 and 2%N. This may be attributed to the effectiveness of foliar application than soil application, where the foliar application can reduce the lag time between application and uptake by the plant (Ahmad and Jabeen, 2005 and Veesar *et al.,* 2017). Also, the sugar beet plants irrigated with magnetic or nonmagnetic water appeared the same trend as for application methods of urea but the values with irrigation by magnetic water were better than nonmagnetic water. Several data proved that irrigation with magnetized water enhanced growth of plants (Midan and Tantawy 2013; Hozayn and Abeer 2019; Hozayn *et al.,* 2013, 2019; Hanen ben hassen *et al.,* 2020 and El-Shokali *et al.,* 2015).

Table 4: Effect of irrigation treatments, soil and foliar applications of urea as well as their interaction on chlorophyll (a), chlorophyll (b) and chlorophyll (a+b) content (mg/g FW)(combined data over both seasons)of sugar beet shoots at 100 days from sowing.

Treatments			**Chlorophyll (mg g fresh weight^{-1})**		
			Chl. a	**Chl. b**	**Chl. (a+b)**
Irrigation water					
Magnetic water			0.499	0.368	0.867
Nonmagnetic water			0.476	0.351	0.826
F. significance			**	**	**
Different rates of URD as soil application					
Soil application of 100% URD			0.577	0.422	0.998
Soil application of 75%URD			0.552	0.402	0.954
Soil application of 50% URD			0.334	0.255	0.588
$LSD_{5\%}$			0.001	0.003	0.004
Different rates of URD as foliar application					
Urea foliar application (0%N)			0.391	0.293	0.684
Urea foliar application (1% N)			0.454	0.337	0.791
Urea foliar application (2% N)			0.519	0.382	0.900
Urea foliar application (3% N)			0.587	0.426	1.012
$LSD_{5\%}$			0.003	0.003	0.004
Interaction					
Magnetic water	Soil application of 100% URD	Urea foliar application (0% N)	0.478	0.352	0.830
		Urea foliar application (1% N)	0.551	0.405	0.956
		Urea foliar application (2% N)	0.628	0.457	1.085
		Urea foliar application (3% N)	0.705	0.511	1.216
	Soil application of 75% URD	Urea foliar application (0% N)	0.440	0.326	0.766
		Urea foliar application (1% N)	0.515	0.379	0.895
		Urea foliar application (2% N)	0.610	0.445	1.056
		Urea foliar application (3% N)	0.686	0.498	1.184
	Soil application of 50% URD	Urea foliar application (0% N)	0.281	0.219	0.500
		Urea foliar application (1% N)	0.323	0.249	0.572
		Urea foliar application (2% N)	0.368	0.275	0.643
		Urea foliar application (3% N)	0.403	0.301	0.704
Nonmagnetic water	Soil application of 100% URD	Urea foliar application (0% N)	0.460	0.341	0.801
		Urea foliar application (1% N)	0.535	0.391	0.925
		Urea foliar application (2% N)	0.590	0.432	1.022
		Urea foliar application (3% N)	0.666	0.485	1.151
	Soil application of 75% URD	Urea foliar application (0% N)	0.421	0.315	0.735
		Urea foliar application (1% N)	0.495	0.366	0.861
		Urea foliar application (2% N)	0.570	0.418	0.988
		Urea foliar application (3% N)	0.674	0.471	1.145
	Soil application of 50% URD	Urea foliar application (0% N)	0.263	0.205	0.468
		Urea foliar application (1% N)	0.302	0.235	0.537
		Urea foliar application (2% N)	0.345	0.263	0.608
		Urea foliar application (3% N)	0.385	0.288	0.674
$LSD_{5\%}$			0.006	0.007	0.009

Yield and its components characters, juice quality and chemical constituents at maturity stage (180 days from planting)

In Egypt, sugar beet quality and yield are essential issues for farmer's income. Recently, the major purpose to cultivate sugar beet plant is the production of a maximum amount of sugar. The sucrose percentage in sugar beet is the main factor affecting the sugar yield. Also, by products of sugar beet like top yield are considered a good feed source for livestock. Mentioned parameters could be considered as major factors affecting on yield and quality of sugar beet root. Statistical analysis of the data presented in tables 6, 7 and 8 indicated the values of yield components characters [*i.e.* root diameter (cm), root length (cm) root fresh and dry weights (g plant^{-1})], yield characters [*i.e.* root yield, top yield and extracted sugar yield (ton fed^{-1})] and root quality characters [*i.e.* sucrose, TSS, impurity, extracted sugar, sugar lost to molasses, quality index, ± amino N, N, P, K and Na (%)] of sugar beet plant as affected by the different types of irrigation water (magnetic and non-magnetic water), soil application of urea at different rates (100, 75 and 50% of URD), foliar application of urea at different rates (0, 1, 2 and 3%N) and their interactions at harvest time during the seasons of (2017/18) and (2018/19) (the displayed parameters' values were mean of the two seasons). It is quite obvious from the data presented in tables 6, 7 and 8 that, magnetic water significantly affected all aforementioned traits except extracted sugar (%). Data in the same tables illustrated that; the highest values of most above-mentioned traits, except quality index (%), were realized when sugar beet plants irrigated with magnetic water, while the irrigation with nonmagnetic water gave the lowest values. On the contrary, irrigation of sugar beet plants with magnetic water reduced significantly quality index% table 7 as compared with sugar beet plants irrigated with nonmagnetic water. These results may be correlated to the increment in sucrose % due to irrigation with magnetic water. The increase in sugar yield could be attributed to the role of magnetic water in increasing sucrose substances and proteins (Hozaynand Amera, 2010a, b). Hozayn *et al.,* (2013; 2015a & b; 2016a & b) illustrated the beneficial impacts of the magnetic field on yield and some features of the quality of sugar beet roots. Data also indicated that applying urea through the soil at a rate of 100, 75 and 50% of URD pronouncedly affected the values of all aforementioned traits. The values of most investigated parameters significantly

Table 5: Effect of irrigation treatments, soil and foliar applications of urea as well as their interaction on N, P, K and Na (%) (combined data over both seasons)of sugar beet shoots at 100 days from sowing.

Treatments			Macro-elements (%) N	P	K	Na
Irrigation water						
Magnetic water			2.20	0.278	4.08	2.42
Nonmagnetic water			2.07	0.271	3.86	2.27
F. significance			**	**	**	**
Different rates of URD as soil application						
Soil application of 100% URD			2.56	0.304	4.75	2.84
Soil application of 75% URD			2.42	0.295	4.49	2.69
Soil application of 50% URD			1.42	0.225	2.67	1.51
$LSD_{5\%}$			0.02	0.002	0.02	0.03
Different rates of URD as foliar application						
Urea foliar application (0% N)			1.68	0.245	3.16	1.85
Urea foliar application (1% N)			1.98	0.264	3.71	2.17
Urea foliar application (2% N)			2.27	0.285	4.24	2.50
Urea foliar application (3% N)			2.60	0.305	4.78	2.86
$LSD_{5\%}$			0.03	0.002	0.02	0.02
Interaction						
Magnetic water	Soil application of 100% URD	Urea foliar application (0% N)	2.06	0.273	3.90	2.30
		Urea foliar application (1% N)	2.52	0.296	4.55	2.75
		Urea foliar application (2% N)	2.81	0.321	5.20	3.10
		Urea foliar application (3% N)	3.18	0.342	5.85	3.55
	Soil application of 75% URD	Urea foliar application (0% N)	1.89	0.260	3.56	2.10
		Urea foliar application (1% N)	2.24	0.285	4.22	2.51
		Urea foliar application (2% N)	2.70	0.314	5.03	2.98
		Urea foliar application (3% N)	3.09	0.337	5.68	3.45
	Soil application of 50% URD	Urea foliar application (0% N)	1.20	0.210	2.27	1.32
		Urea foliar application (1% N)	1.36	0.220	2.61	1.43
		Urea foliar application (2% N)	1.56	0.235	2.91	1.64
		Urea foliar application (3% N)	1.72	0.248	3.23	1.86
Nonmagnetic water	Soil application of 100% URD	Urea foliar application (0% N)	1.97	0.268	3.72	2.19
		Urea foliar application (1% N)	2.34	0.290	4.40	2.62
		Urea foliar application (2% N)	2.60	0.310	4.85	2.88
		Urea foliar application (3% N)	3.01	0.333	5.51	3.32
	Soil application of 75% URD	Urea foliar application (0% N)	1.80	0.254	3.38	1.98
		Urea foliar application (1% N)	2.15	0.279	4.04	2.40
		Urea foliar application (2% N)	2.50	0.303	4.70	2.86
		Urea foliar application (3% N)	2.95	0.327	5.35	3.21
	Soil application of 50% URD	Urea foliar application (0% N)	1.13	0.203	2.12	1.19
		Urea foliar application (1% N)	1.29	0.215	2.44	1.32
		Urea foliar application (2% N)	1.47	0.229	2.74	1.55
		Urea foliar application (3% N)	1.65	0.241	3.05	1.75
$LSD_{5\%}$			0.08	0.005	0.05	0.05

increased with the increase of added urea rate through soil, where the highest values were realized due to fertilizing with 100% of URD as soil application followed by 75% of URD and lately 50% of URD, respectively. Regarding the individual effect of urea foliar spraying, data in the same tables 6, 7 and 8 indicated that the values of most aforementioned traits were significantly increased as the rates of sprayed urea were increased, where the highest results for the most investigated parameters of sugar beet plants were recorded with urea foliar spraying at rate of 3% N. As for sucrose (%), quality index (%) and extracted sugar (%), the values were significantly

Table 6: Effect of irrigation treatments, soil and foliar applications of urea as well as their interaction on yield and characters of its components(combined data over both seasons)of sugar beet plants at harvest stage.

Treatments			Root diameter(cm)	Root length(cm)	Weight (g plant^{-1}) Fresh root	Weight (g plant^{-1}) Dry root	Yield (ton fed^{-1}) Root	Yield (ton fed^{-1}) Top	Yield (ton fed^{-1}) Extracted sugar
Irrigation water									
Magnetic water			11.65	43.61	1540.94	324.50	25.22	9.48	349.79
Nonmagnetic water			11.22	42.26	1439.42	303.03	24.32	9.15	337.40
F. significance			**	**	**	**	**	**	**
Different rates of URD as soil application									
Soil application of 100% URD			13.07	47.99	1911.42	388.67	27.91	10.51	360.62
Soil application of 75% URD			12.43	46.30	1777.79	364.63	26.94	10.13	356.72
Soil application of 50% URD			8.81	34.52	781.33	188.00	19.46	7.31	313.45
LSD $_{at\,5\%}$			0.30	0.31	24.55	1.97	0.11	0.03	1.70
Different rates of URD as foliar application									
Urea foliar application (0% N)			9.73	37.57	1033.78	233.78	21.40	8.05	326.83
Urea foliar application (1% N)			10.90	41.18	1353.72	287.06	23.70	8.90	340.85
Urea foliar application (2% N)			12.12	44.81	1638.67	340.67	25.89	9.74	351.04
Urea foliar application (3% N)			12.99	48.19	1934.56	393.56	28.08	10.58	355.66
LSD $_{5\%}$			0.22	0.23	24.79	2.37	0.11	0.02	1.43
Interaction									
Magnetic water	Soil application of 100% URD	Urea foliar application (0% N)	11.05	42.13	1456.33	304.67	24.38	9.16	353.00
		Urea foliar application (1% N)	12.82	46.85	1800.67	370.33	27.10	10.21	365.09
		Urea foliar application (2% N)	14.35	51.00	2148.67	432.33	29.78	11.21	379.67
		Urea foliar application (3% N)	15.13	55.04	2500.33	496.00	32.43	12.24	371.59
	Soil application of 75% URD	Urea foliar application (0% N)	10.52	40.12	1281.33	273.67	23.06	8.66	345.80
		Urea foliar application (1% N)	11.65	44.16	1631.00	335.33	25.74	9.66	359.18
		Urea foliar application (2% N)	13.69	49.94	2064.33	415.67	29.12	10.96	375.57
		Urea foliar application (3% N)	14.76	54.02	2414.67	480.67	31.77	11.98	370.17
	Soil application of 50% URD	Urea foliar application (0% N)	8.09	31.98	390.33	150.00	17.79	6.70	299.34
		Urea foliar application (1% N)	8.66	34.01	761.33	179.33	19.28	7.19	317.80
		Urea foliar application (2% N)	9.25	36.04	933.67	213.00	20.45	7.68	326.76
		Urea foliar application (3% N)	9.78	38.05	1108.67	243.00	21.74	8.16	333.53
Nonmagnetic water	Soil application of 100% URD	Urea foliar application (0% N)	10.82	41.13	1371.67	288.00	23.70	8.91	340.10
		Urea foliar application (1% N)	12.45	45.87	1714.33	353.00	26.43	9.95	351.00
		Urea foliar application (2% N)	13.42	48.93	1974.67	400.67	28.44	10.71	355.24
		Urea foliar application (3% N)	14.52	52.99	2324.67	464.33	31.07	11.72	369.25
	Soil application of 75% URD	Urea foliar application (0% N)	10.15	39.08	1193.67	256.33	22.39	8.42	331.26
		Urea foliar application (1% N)	11.42	43.17	1540.33	320.33	25.22	9.42	349.41
		Urea foliar application (2% N)	13.05	47.92	1861.33	385.33	27.78	10.46	354.43
		Urea foliar application (3% N)	14.18	51.99	2235.67	449.67	30.41	11.48	367.94
	Soil application of 50% URD	Urea foliar application (0% N)	7.75	31.01	509.33	130.00	17.10	6.44	291.52
		Urea foliar application (1% N)	8.42	33.01	674.67	164.00	18.46	6.95	302.63
		Urea foliar application (2% N)	8.93	35.03	849.33	197.00	19.81	7.44	314.55
		Urea foliar application (3% N)	9.58	37.05	1023.33	227.67	21.07	7.91	321.47
LSD $_{5\%}$			0.04	0.05	0.55	0.57	60.72	0.05	3.51

decreased as the rates of applied urea were increased under both application methods of urea (either foliar or through the soil), where the highest values under the urea as soil application were recorded with the rate of 50% of URD. Also, the highest values under the foliar application were recorded with the rate of 0%N (untreated plants). The obtained results are in agreement with Hassanein and Elayan, (2000) who stated that sucrose yield decreased by over fertilizing sugar beet with more N than needed for maximum sucrose production. Hozayn

Table 7: Effect of irrigation treatments, soil and foliar applications of urea as well as their interaction on some yield quality parameters(combined data over both seasons)of sugar beet plants at harvest stage.

Treatments			Quality parameters (%)						
			Sucrose	**TSS**	**Impurity**	**Extracted sugar**	**Sugar lost to molasses**	**Quality index**	**α amino N**
Irrigation water									
Magnetic water			15.95	23.83	6.62	14.19	1.16	88.64	3.20
Nonmagnetic water			15.85	23.10	6.24	14.17	1.08	89.14	3.03
F. significance			**	**	**	ns	**	**	**
Different rates of URD as soil application									
Soil application of 100% URD			15.10	25.15	8.09	13.02	1.48	86.11	3.96
Soil application of 75% URD			15.32	24.60	7.45	13.38	1.35	87.14	3.61
Soil application of 50% URD			17.28	20.64	3.75	16.15	0.53	93.43	1.78
$LSD_{5\%}$			0.02	0.03	0.14	0.02	0.01	0.07	0.16
Different rates of URD as foliar application									
Urea foliar application (0% N)			16.75	21.75	4.63	15.41	0.74	91.93	2.18
Urea foliar application (1% N)			16.18	22.98	5.92	14.57	1.01	89.88	2.85
Urea foliar application (2% N)			15.64	24.19	7.02	13.79	1.24	87.98	3.43
Urea foliar application (3% N)			15.04	24.94	8.15	12.95	1.49	85.79	4.00
$LSD_{5\%}$			0.01	0.02	0.16	0.02	0.02	0.10	0.16
Interaction									
Magnetic water	Soil application of 100% URD	Urea foliar application (0% N)	16.15	23.40	6.26	14.48	1.07	89.63	3.07
		Urea foliar application (1% N)	15.45	24.86	7.62	13.47	1.38	87.21	3.73
		Urea foliar application (2% N)	15.03	26.35	9.00	12.75	1.68	84.85	4.42
		Urea foliar application (3% N)	14.02	27.81	10.34	11.46	1.96	81.72	5.11
	Soil application of 75% URD	Urea foliar application (0% N)	16.46	22.67	4.91	14.99	0.86	91.11	2.05
		Urea foliar application (1% N)	15.77	24.15	6.92	13.95	1.22	88.45	3.39
		Urea foliar application (2% N)	15.10	25.97	8.68	12.90	1.60	85.40	4.27
		Urea foliar application (3% N)	14.15	27.46	10.01	11.65	1.89	82.37	4.94
	Soil application of 50% URD	Urea foliar application (0% N)	17.74	19.74	2.88	16.83	0.34	94.69	1.34
		Urea foliar application (1% N)	17.58	20.46	3.57	16.49	0.49	93.78	1.69
		Urea foliar application (2% N)	17.22	21.17	4.26	15.98	0.64	92.79	2.05
		Urea foliar application (3% N)	16.72	21.94	4.92	15.34	0.78	91.72	2.38
Nonmagnetic water	Soil application of 100% URD	Urea foliar application (0% N)	15.95	23.03	5.91	14.35	1.00	89.97	2.88
		Urea foliar application (1% N)	15.29	24.52	7.60	13.28	1.40	86.89	3.58
		Urea foliar application (2% N)	14.61	25.61	8.30	12.49	1.52	85.49	4.08
		Urea foliar application (3% N)	14.30	25.61	9.67	11.89	1.82	83.10	4.77
	Soil application of 75% URD	Urea foliar application (0% N)	16.25	22.30	5.24	14.79	0.85	91.06	2.55
		Urea foliar application (1% N)	15.60	23.77	6.59	13.86	1.15	88.80	3.22
		Urea foliar application (2% N)	14.80	25.24	7.95	12.76	1.44	86.20	3.90
		Urea foliar application (3% N)	14.45	25.24	9.33	12.10	1.75	83.74	4.58
	Soil application of 50% URD	Urea foliar application (0% N)	17.92	19.36	2.58	17.04	0.28	95.10	1.19
		Urea foliar application (1% N)	17.41	20.10	3.23	16.39	0.42	94.15	1.52
		Urea foliar application (2% N)	17.05	20.81	3.91	15.88	0.57	93.16	1.87
		Urea foliar application (3% N)	16.57	21.56	4.60	15.26	0.71	92.08	2.23
$LSD_{5\%}$			0.04	0.05	0.38	0.05	0.04	0.24	0.39

et al., (2014) and Nemeata Alla, (2016) reported that an adequate supply of N is essential for optimum yield but excess N may result in an increase in yield of roots with lower sucrose content and juice purity. Yield increased with applied but sucrose (%), purity (%) and extracted sugar (%) were significantly decreased as N level increased. Generally, it could be noticed that increasing urea application rates either as through the soil or as foliar spraying significantly increased the most characters of growth and yield of sugar beet roots table 6. These results may be attributed to the role of N in enhancing root dimensions by increased elongation and/or cell division (Abdel-Motagally and Attia, 2009). The positive impact of urea might be due to the increased efficiency of urea (46.5 N%) in building upmetabolites translocations from leaves to developing roots, hence increasing dry matter accumulation (El-Shahawy *et al.,* 2002). This reflected in greater root, also increasing urea rate either as soil application or as foliar spraying had a significant influence on elements content of sugar beetroots table 8. Similar results were reported by Zalat and Youssef (2001). Most ofthe yield quality characters were significantly declined by raising urea rates, where higher rates of urea had a significant impact on Na and ±- amino-N content tables 7 and 8. These may be due to that high rate of urea increased impurities and they interfere with sugar extraction. This was reflected by raising the sugar losses to molasses (%), thus reducing extracted sugar (%). Also, higher rates urea led to increasing in the content of water in fresh sugar beet roots, which diluted the concentration of sucrose. These results are in agreement with the results of Abdel-Motagally and Attia (2009) who reported that the increased cations contents might be associated with a decrease in sucrose percentage. This was further associated with an increase in water content in fresh roots of sugar beet, which diluted the sucrose concentration. Thus, not only sucrose % but also juice purity might be expected to increase as the amount of cations decreases. Also, Nemeata Alla, (2016) reported that sucrose (%) in sugar beet roots increased with nitrogen deficiency. Concerning the interaction effect, magnetic water and urea rates as soil applications as well as urea rates as foliar

Table 8: Effect of irrigation treatments, soil and foliar applications of urea as well as their interaction on N, P, K and Na (%)(combined data over both seasons)of sugar beet roots at harvest stage.

Treatments			Macro-elements in root at harvest (%)			
			N	P	K	Na
Irrigation water						
Magnetic water			0.81	0.186	1.13	2.28
Nonmagnetic water			0.77	0.178	1.06	2.15
F. significance			**	**	**	**
Different rates of URD as soil application						
Soil application of 100% URD			0.93	0.212	1.33	2.80
Soil application of 75%URD			0.89	0.203	1.25	2.59
Soil application of 50% URD			0.56	0.131	0.70	1.26
LSD at 5%			0.01	0.001	0.02	0.01
Different rates of URD as foliar application						
Urea foliar application (0% N)			0.65	0.150	0.84	1.61
Urea foliar application (1% N)			0.74	0.172	1.02	2.05
Urea foliar application (2% N)			0.84	0.194	1.17	2.41
Urea foliar application (3% N)			0.94	0.213	1.35	2.79
LSD 5%			0.01	0.002	0.02	0.01
Interaction						
Magnetic water	Soil application of 100% URD	Urea foliar application (0% N)	0.79	0.179	1.07	2.12
		Urea foliar application (1% N)	0.89	0.206	1.27	2.62
		Urea foliar application (2% N)	1.00	0.228	1.47	3.11
		Urea foliar application (3% N)	1.12	0.253	1.68	3.55
	Soil application of 75% URD	Urea foliar application (0% N)	0.73	0.166	0.96	1.90
		Urea foliar application (1% N)	0.85	0.192	1.17	2.36
		Urea foliar application (2% N)	0.98	0.225	1.40	3.01
		Urea foliar application (3% N)	1.09	0.246	1.63	3.45
	Soil application of 50% URD	Urea foliar application (0% N)	0.49	0.113	0.57	0.97
		Urea foliar application (1% N)	0.54	0.128	0.68	1.20
		Urea foliar application (2% N)	0.61	0.143	0.79	1.43
		Urea foliar application (3% N)	0.67	0.155	0.87	1.66
Nonmagnetic water	Soil application of 100% URD	Urea foliar application (0% N)	0.76	0.172	1.02	2.01
		Urea foliar application (1% N)	0.87	0.198	1.23	2.79
		Urea foliar application (2% N)	0.95	0.219	1.35	2.87
		Urea foliar application (3% N)	1.07	0.241	1.57	3.32
	Soil application of 75% URD	Urea foliar application (0% N)	0.69	0.161	0.91	1.78
		Urea foliar application (1% N)	0.81	0.185	1.12	2.24
		Urea foliar application (2% N)	0.91	0.214	1.30	2.75
		Urea foliar application (3% N)	1.03	0.235	1.53	3.22
	Soil application of 50% URD	Urea foliar application (0% N)	0.45	0.106	0.51	0.88
		Urea foliar application (1% N)	0.51	0.120	0.62	1.09
		Urea foliar application (2% N)	0.57	0.135	0.73	1.31
		Urea foliar application (3% N)	0.65	0.148	0.83	1.55
LSD 5%			0.03	0.004	0.04	0.04

applications played an effective role in these characters. It could be observed that; the values of root diameter (cm), root length (cm), root fresh and dry weights (g plant^{-1}), root yield (ton fed^{-1}), top yield (ton fed^{-1}), extracted sugar yield (ton fed^{-1}) as well as ± amino N, N, P, K and Na (%)were significantly affected due to the application of all investigated treatments. On the other hand, spraying sugar beet plants with urea at 1, 2 and 3% N under fertilizing by 75% of URD as soil application gave better results for most studied parameters than sugar beet plants treated only with 100% of URD as a soil application. As we mentioned before, This may be attributed to the effectiveness of foliar application than soil application as well as magnetic water had a positive enhancing impact on yield root of sugar beet plants (Midan and Tantawy 2013; Hozayn *et al.,* 2013 and El-Shokali *et al.,* 2015). Also, the data showed that; under all urea soil application treatments, the values of sucrose, extracted sugar and quality index percentages (%) of roots juice were decreased as the rates of sprayed urea were increased. Also, under all urea foliar application treatments, the values of sucrose, extracted sugar and quality index percentages (%) of roots juice were decreased as the rates of applied urea through soil were increased. It must avoid raising the nitrogen rate to overcome the high rate Alpha-amino N% because of its harmful effect on the quality and price of sugar beet plants. These results are in accordance with those of Nemeata Alla (2016) who reported that increasing N level up to 90 kg N fad^{-1} has a negative effect in sucrose %, extractable sugar, extractability % and sugar losses percentages. Also, the purity % has negative effective with increasing N dose from 75 to 95 kg N fad^{-1}.

Soilelectric conductivity (EC) and available N in soil at harvesting date

Data illustrated in table 9 detected the effect of different types of irrigation water (magnetic and non-magnetic water), soil application of urea at different rates (100, 75 and 50% of the URD) and foliar spraying of urea at different rates (0, 1, 2 and 3%N) on the average values of soil EC (dSm^{-1}) and available nitrogen (mg kg^{-1}) in the soil after harvesting of sugar beet crops (the displayed parameters' values were mean of the two seasons). The average values of soil EC (dSm^{-1}) under irrigating with magnetic water were less than that under irrigating with nonmagnetic water at all different rates of urea (either soil or foliar application). This may be due to declining soluble cations concentration because of magnetizing the water. In respect to urea rates, the findings also illustrated that different urea rates under both application methods (either soil or foliar) slightly increased soil EC (dSm^{-1}) under irrigation by magnetic and nonmagnetic water after harvesting. Generally, the highest value of soil EC (dSm^{-1}) were observed with combination of 100% of the URD as soil application and foliar application of urea at rate of (3%N) under irrigating by nonmagnetic water (5.85 dSm^{-1}), while the lowest value of soil EC (dSm^{-1}) were observed with combination of 50% of the URD as soil application without foliar application of urea under irrigating by magnetic water (4.20 dSm^{-1}). Similar findings were found by Ahmed (2013) who reported that magnetized water had a slightly significant impact in declining soil EC values after harvesting plants. Also, Ben, (2007) indicated that the benefits of magnetic irrigation water include reduced salts amount in various soil depths owing to leaching away of salts during watering soil with magnetic water and washing of different anions from the

Table 9: Average soil EC (dSm^{-1}) and available N in soil (mg kg^{-1}) (combined data over both seasons)after harvesting as affected by irrigation treatments, soil and foliar applications at different rates of urea.

Treatments			Soil EC (dSm^{-1})	N (mg kg^{-1})
Interaction				
Magnetic water	Soil application of 100% URD	Urea foliar application (0% N)	5.13	84.30
		Urea foliar application (1% N)	5.19	87.50
		Urea foliar application (2% N)	5.25	90.40
		Urea foliar application (3% N)	5.30	93.50
	Soil application of 75% URD	Urea foliar application (0% N)	4.75	57.60
		Urea foliar application (1% N)	4.89	60.70
		Urea foliar application (2% N)	4.95	64.10
		Urea foliar application (3% N)	5.05	66.80
	Soil application of 50% URD	Urea foliar application (0% N)	4.20	44.30
		Urea foliar application (1% N)	4.30	48.59
		Urea foliar application (2% N)	4.50	51.40
		Urea foliar application (3% N)	4.60	54.60
Nonmagnetic water	Soil application of 100% URD	Urea foliar application (0% N)	5.50	86.00
		Urea foliar application (1% N)	5.55	88.80
		Urea foliar application (2% N)	5.67	91.80
		Urea foliar application (3% N)	5.85	95.00
	Soil application of 75% URD	Urea foliar application (0% N)	5.20	59.20
		Urea foliar application (1% N)	5.25	62.30
		Urea foliar application (2% N)	5.36	65.50
		Urea foliar application (3% N)	5.40	82.80
	Soil application of 50% URD	Urea foliar application (0% N)	4.60	47.40
		Urea foliar application (1% N)	4.75	50.10
		Urea foliar application (2% N)	4.95	52.80
		Urea foliar application (3% N)	5.00	56.10

soil. Also, available nitrogen (mg kg^{-1}) status at the root zone pronouncedly differed after harvest of sugar beet crop. Magnetic water caused decrease average available nitrogen (mg kg^{-1}) in the soil after harvesting due to improved plant growth by magnetic irrigation water, thus absorbed more N which reduced the residual from the urea fertilizer in the soil. Similar results were reported by Hameda (2015) who reported that magnetic water improved growth of plants. In respect to urea rates, the findings showed that different urea rates under both application methods (either soil or foliar) pronouncedly affected available residual N in the soil after harvesting. Generally, the highest value of available nitrogen (mg kg^{-1}) in the soil after harvesting was observed with combination of 100% of the URD as soil application and foliar application of urea at rate of (3%N) under irrigating by nonmagnetic water (95.00mg kg^{-1}), while the lowest value was recorded with combination of 50% of the URD as soil application without urea foliar application under irrigating by magnetic water (44.30mg kg^{-1}). Generally, average values of soil EC (dSm^{-1}) and residual N (available nitrogen mg kg^{-1}) in the soil at harvest stage after irrigation with magnetic water were less than that after irrigation with nonmagnetic irrigation water under different combinations of all rates of urea either soil application or foliar urea. For example, under foliar application of urea at rate of 3%N and irrigation with magnetic water under fertilizing with 75% of URD as soil application, the average values of soil EC (dSm^{-1}) and residual N (mg kg^{-1}) were (5.05 dSm^{-1} and 66.80 mg N kg^{-1}, respectively), while the values were (5.40 dSm^{-1} and 82.80 mg N kg^{-1}, respectively) with nonmagnetic water under the same rates of urea. This is owing to the positive role of magnetic water in improving sugar beet growth and enhancing soil properties. Finally, the findings showed that the irrigation with magnetic water positively affected both soil EC (dSm^{-1}) and available nitrogen (mg kg^{-1}) in soil and made their values low compared to irrigation with non-magnetic water. This result is harmony with those obtained by Agbede *et al.,* (2010) and Abou El-Yazied *et al.,* (2012) Mohamed *et al.,* 2015; Ben Hassen *et al.,* 2020; Hozayn *et al.,* 2015a & b; Hozayn *et al.,* 2016a & b; Hozayn and Abeer 2019; Hozayn *et al.,* 2019).

Conclusion

This investigation discovered that, although high rates of nitrogen fertilization increased the growth of sugar beet shoot and root during the growth period, it negatively affected quality yield parameters such as alpha-amino N (%), sucrose (%), extracted sugar and sugar losses percentages. Also, magnetic water had a positive role in improving sugar beet growth and enhancing soil properties. Finally, based on the obtained results of this study, it could be detected that irrigation sugar beet plants with magnetic water and spraying it with urea at rate of (3%N) under fertilizing by 75% of urea recommended dose as soil application is the best treatment for sugar beet in Delta area and other regions with similar agro-climate conditions. Also, with this treatment, reducing the amount of urea applied to the field without a nitrogen deficiency happened.

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