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EFFECT OF NANOTECHNOLOGY OF POTASSIUM FERTILIZER BY INJECTING MAGNETIZED WATER THROUGH DRIP IRRIGATION ON SUGAR BEET CROP

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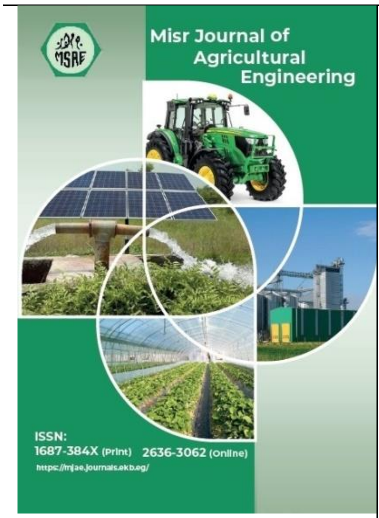

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Sugar beet**;**
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Magnetic water**;**
Nano-fertilizer

ABSTRACT

The field experiment was conducted in Wadi El Natrunq (latitude 30.23ºN, longitude 30.21ºE, and elevation 17.98 m above sea level), Beheira Governorate, Egypt, during the 2019-2020 and 2020-2021 growing seasons to study the productivity and quality of sugar beet crop under nano potassium magnetic water and drip irrigation system. The multi-embryo sugar beet variety "Fayrouz" was planted during the first week of October and harvested after 175 days. The field experiment treatments were studied for the effect of magnetic water (MW), and non-magnetic water (nMW). The second treatment used five percentages of potassium with nano potassium, which is (100% potassium, 75% potassium + 25% Nano potassium, 50% potassium + 50% Nano potassium, 25% potassium + 75% nano potassium and 100% nano potassium) respectively. The highest averages of sucrose remaining sugar in molasses, extracted sugar, and quality index were recorded (20.24, 2.27, 17.42, and 88.29) % respectively, with magnetic water by adding (75% potassium + 25% nano potassium). The highest productivity of root and the amount of sugar produced by the crop were (13.88 and 2.41) tons.fed^{-1}, with magnetic water and adding (75% potassium + 25% nano potassium). It was the highest efficiency (8.73, and 6.52) kg.m^{-3} for the first and second seasons, respectively, with magnetic water and the addition of (75% potassium + 25% nano potassium).

INTRODUCTION

Sugar beet is grown in different climates worldwide (FAO, 2020). Some studies have reported that sugar beet cultivation works to save water quantities by reducing the amount of irrigation water, depending on climatic and soil conditions (Azimi, 2016; Khozaei et al., 2020). Also, (Zhu et al., 2020) The effect of an extended seedling rearing period on sugar beet yield was found to be higher, with average yields ranging from 60.5 to 62.7 t ha^{-1}, 10.4–13.6% higher than that with 25-day seedling rearing period. They also showed that in the black soil area in Northeast China, sugar beet should be planted before April 8 and grown for 35–40 days in the greenhouse to obtain a significant increase in yield.

Sugar beet contributes about 30% of the world's sugar supply (Farhaoui et al., 2022). While sugarcane is the other major source of sugar, sugar beet thrives in more tropical climates and is emerging as a major sucrose crop in temperate regions (Jolayemi, 2019). The United States, Russia, Germany, and France are among the world's largest producers of sugar beet (FAO, 2020).

The plant follows a two-year cycle, developing a very sucrose-rich root in the first year and producing a flowering stalk in the second year. Sugar beet is currently mainly grown in temperate regions between 60° and 30° N, extending from Helsinki to Cairo (Haque et al.,2021; Zhang et al., 2016). The sugar concentration in the dry weight of sugar beetroot can reach about 75% (Farhaoui et al., 2023).

(Arroyo et al., 1999) compared the effects of drip (trickle) and sprinkler irrigation systems on yield and quality of sugar beet. Irrigation intensity was 50, 70 and 90% Epan (class A pan evaporation precipitation). Root yield under drip (77.4 ton/ha) or/and under sprinkler (79.2 ton/ha) did not vary significantly at 90% Epan, but drip irrigation resulted in significantly higher yields (80.8 and 73.2 ton/ha) than sprinkler irrigation (72.6 and 69.3 ton/ha) at 70 and 50% Epan, respectively. The highest sugar content was found at 90% Epan for drip irrigation and at 70% Epan for sprinkler irrigation.

(Sharmasarkar et al., 2001) compared drip and furrow irrigation on sugar beet grown in sandy loam soil. They reported that sugar beet yield and sucrose content were greater under drip irrigation than under furrow irrigation.

(Wang et al., 2015) confirmed that potassium (K) is the third most important nutrient for plant growth and development, and its importance in agriculture has been proven comprehensively as it is an essential nutrient required in larger quantities for plant metabolism, especially for photosynthesis and transport assimilation. Studies have also indicated that using potassium and nitrogen has improved the quality and productivity of sugar beet (Etemadi, 2000).

(Brien et al., 2012) mentioned that using fast action and alternatives such as nano fertilizers have many benefits for plants compared with mineral fertilizers because they reduce environmental pollution, increase crop yields, decrease production cost per unit area, and make storage easy. Moreover, nano-fertilizers can enhance growth parameters such as plant height, chlorophyll production, and the rate of photosynthesis, which results in more production of the plants (Manjunatha et al., 2016).

(Zangeneh and Rasouli, 2018) reported that the application of 1000 ppm nano-K increased chlorophyll content. Likewise, (Jasim et al., 2020) said that spraying leaves of maize with 500 ppm of nano-K + 150 kg/ha of potassium sulfate fertilizer was superior for yield.

Research on magnetically treated irrigation water began in the 1960s as an approach to reducing salt stress, and studies have shown that magnetically treated saline water can improve water quality in agricultural irrigation (Da Silva and Dobranszki, 2014; Da Silva and Dobranszki, 2016; Selim and El-Nady, 2011). Magnetically treated water can also improve the physical and chemical properties of water by reducing the surface tension coefficient and viscosity coefficient, which helps improve wettability, conductivity, pH, osmotic pressure, and dissolved oxygen content (Amiri and Dadkhah, 2006; Ding et al., 2011; Esmaeilnezhad et al., 2017; Toledo et al., 2008).

Therefore, the research aims to investigate the effect of using saline irrigation water treated magnetically by injecting different levels of potassium and nano-potassium fertilizer on the productivity of sugar beet under drip irrigation system.

MATERIALS AND METHODS

All experimental fields were located at the farm of Wadi El-Natrun (Lat. 30.23º N, long 30.21º E, and 17.98 m above sea level) in El-Beheira Governorate, Egypt, in the 2019/2020 and 2020/2021 growing seasons.

A. The materials.

1- Soil analysis.

A physical and chemical soil analysis was carried out at different depths from 0 cm to 60 cm (every 20 cm). The analysis was carried out in the Central Laboratory of the Faculty of Agriculture, Ain–Shams University. Shoubra El-Khaima, Qalyubia Governorate. Some soil's physical and chemical properties are presented in Tables (1 and 2).

Table 1: Some physical properties of soil (average of the two seasons).

Soil layer	Particle size distribution (%)			Texture class	Moisture content (%)		
(cm)	Sand	Silt	Clay		F.C	W. P	A. W
0-20	91.50	6.50	2.00		13.21	7.38	5.83
20-40	94.00	4.30	1.70	Sandy	8.65	4.12	4.53
40-60	95.20	3.50	1.30		6.11	3.42	2.69

Table 2: Some chemical properties of soil (average of the two seasons).

Soil layer	SAR	pH	EC	Soluble anions (meq. l^{-1})				Soluble cations (meq. l^{-1})			
(cm)			(dS/m)	$CO3^{=}$	$HCO3^{-}$	Cl^{-}	$SO4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
0-20	0.95	7.9	0.5	0.1	0.5	3.5	0.98	1.6	0.5	2.85	0.13
20-40	1.23	8.1	0.32	0.1	0.5	2.0	0.68	1.1	0.5	1.6	0.08
40-60	1.52	8.0	1.6	0.1	1.0	10.5	4.48	4.53	2.51	8.72	0.32

2- Irrigation water analysis.

Irrigation was carried out with water extracted from an artesian well, 85 m depth, the water source is 300 meters away from the experimental plot. A water sample was taken to carry out some chemical properties, which are presented in Table (3).

Table 3: Chemical analysis of irrigation water.

pH	SAR	EC	Soluble anions (meq. l^{-1})				Soluble cations (meq. l^{-1})			
		(dS/m)	$CO3^{=}$	$HCO3^{-}$	Cl^{-}	$SO4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
7.3	6.06	2.15	0.1	6.40	6.19	4.85	6.8	2.2	9.8	0.73

3- Irrigation network.

- U.P.V.C Pipes 50 mm (OD) -1000 kPa.
- Polyethylene (P.E.) hoses, outer diameter 16 mm.
- L.D.P.E. Dripline (inline), outer diameter 16 mm, discharge 12 l/h/m. The distance between the exits is 0.33 m at 150 kPa.
- P.E. Venture 0.5"/16 mm.

4 - Magnetic device.

Magnetized irrigation water was obtained by passing water through a magnetizing device fixed to the submain irrigation pipeline (50 mm). The properties of the magnetization unit are shown in Table (4).

Table 4: Some properties of magnetic device.

Diameter Size, inch.	Flow rate, m^3/h.	Pressure, kPa.	Temperature, C°	Capability, Gause.
1	12	(up to): 700	(up to): 80°	14500

B. Calculation methods.

1 - Quality analysis of sugar beet roots:

Quality analysis was done on fresh samples of sugar beet roots (multi-germ sugar beet variety "Fayroz"), Figure (1) at the Laboratory of Noubaria Sugar Factory, Egypt. The sugar beet was sown during the 1st week of October 2019 and 2020 for the two agricultural seasons. While harvesting was done after 175 days.

Fig. 1: Sugar beet plant.

1 – 1 Sucrose percentage (%).

Sucrose percentage was determined in fresh macerated root according to (Le-Docte, 1977), method using an automatic saccharimeter on a lead acetate basis according to the procedure of Noubaria Sugar Company.

1 – 2 Sugar loss to molasses percentage (SLM%).

The **s**ugar loss to the masses percentage was calculated (Devillers, 1988) Equation:

$$\mathbf{SLM = 0.14\ (Na + K) + 0.25\ (\alpha\text{–amino N}) + 0.5}$$

Where:

Na: Sodium content in molasses (%).
K: Potassium content in molasses (%).
α–amino N: Alpha amino nitrogen content in molasses (%).

1 – 3 Extractable sugar percentage (ES %).

The extractable sugar percentage was calculated using the following equation (Dexter et al., 1967):

$$\mathbf{ES\% = sucrose\ \% - SLM\ \% - 0.6}$$

1 – 4 Quality index (QI).

The quality index was calculated according to (Cooke et al., 1993) equation as follows:

$$QI = \frac{extracted\ sugar\ \%}{sucrose\ \%} x\ 100$$

2 - Yields.

The root crop yield of sugar beet and the amount of sugar produced for the experiment were measured and calculated.

2 – 1 Root yield (ton. Fed^{-1}).

The root yield of all plants under each treatment was weighed on the field, and calculated per fed.

2 – 2 Sugar yield (ton. fed^{-1}).

The sugar produced was calculated according to the following equation:

Sugar yield (ton. Fed^{-1}) = root yield (ton. Fed^{-1}) x extractable sugar (%).

3 –Water use efficiency (WUE).

The experimental plot was irrigated twice a week until the time of the harvest, The Reference Evapotranspiration (ETo) was calculated using the CROPWAT 8.0 program. Climate data for the Wadi El-Natrun region has been obtained by using (FAO AQUASTAT 2021).

Water use efficiency (WUE) has been calculated using water consumption of sugar beet which was calculated using an average Reference Evapotranspiration (ETo) Table (5), and the crop coefficients (Kc) Table (6), by the following equations:

$$ETc = ET_{\circ}\ x\ Kc$$

Where:

ETc: Water consumption of sugar beet, was calculated by using CROPWAT 8.0 (a computer program for irrigation) version (3.2).

ETo: Reference evapotranspiration, was calculated by using CROPWAT 8.0 (a computer program for irrigation) version (3.2).

Kc: Crop coefficient (FAO, 2020).

$$\mathrm{WUE} = \frac{\mathrm{RY}}{ETc}$$

Where:

WUE: Water use efficiency (kg.m^{-3}).

RY: Root yield (kg.fed^{-1}).

ETc: Water consumption of sugar beet (m^3.fed^{-1}), Table (7).

Table 5: The average reference evapotranspiration for Wadi El-Natrun.

ETo, mm.day^{-1}	Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
	1st season	4.91	3.67	2.68	2.45	3.10	4.83	5.88	7.86
	2nd season	4.91	3.32	2.58	2.80	3.30	4.53	6.63	8.80

Table 6: The average crop coefficients (Kc) for sugar beet (FAO, 2020).

Growth periods	Init.	Dev.	Mid.	Late.	Total.
Days	35	40	40	60	175
KC	0.35	0.71	1.22	0.98	

Table 7: Water consumption of sugar beet during the stages of growth.

Months	Weeks	1st season			2nd season		
		Eto mm/day	Kc	Etc mm/day	Eto mm/day	Kc	Etc mm/day
Oct.	3	5.59	0.35	1.96	5.90	0.35	2.07
	4	4.23	0.35	1.48	4.60	0.35	1.61
Nov.	1	3.70	0.35	1.30	4.40	0.35	1.54
	2	3.82	0.35	1.34	3.60	0.35	1.26
	3	4.16	0.35	1.46	3.30	0.35	1.16
	4	3.52	0.40	1.41	2.80	0.40	1.12
	5	3.17	0.47	1.49	2.50	0.47	1.18
Dec.	1	2.50	0.55	1.38	2.70	0.55	1.49
	2	2.85	0.63	1.80	2.90	0.63	1.83
	3	2.36	0.71	1.68	2.30	0.71	1.63
	4	3.01	0.79	2.38	2.40	0.79	1.90
Jan.	1	2.60	0.87	2.26	2.40	0.87	2.09
	2	2.10	0.95	2.00	3.20	0.95	3.04
	3	2.60	1.03	2.68	2.80	1.03	2.88
	4	2.50	1.11	2.78	2.80	1.11	3.11
Feb.	1	2.50	1.18	2.95	3.50	1.18	4.13
	2	3.10	1.20	3.72	3.00	1.20	3.60
	3	3.00	1.20	3.60	3.10	1.20	3.72
	4	3.80	1.20	4.56	3.60	1.20	4.32
Mar.	1	4.50	1.20	5.40	4.60	1.20	5.52
	2	4.30	1.20	5.16	4.40	1.20	5.28
	3	4.60	1.20	5.52	4.80	1.20	5.76
	4	5.90	1.20	7.08	4.30	1.20	5.16
Apr.	1	5.70	1.20	6.84	5.60	1.20	6.72
	2	5.10	1.20	6.12	5.50	1.20	6.60
	3	6.40	1.20	7.68	7.70	1.20	9.24
	4	6.30	1.20	7.56	7.70	1.20	9.24
May.	1	6.40	1.20	7.68	8.90	1.20	10.68
	2	7.20	0.70	5.04	8.00	0.70	5.60
	3	9.20	0.70	6.44	8.80	0.70	6.16
	4	8.50	0.70	5.95	8.90	0.70	6.23
	5	8.00	0.70	5.60	9.40	0.70	6.58

4- **Statistical analysis.**

The data were analyzed using the analysis of variance (ANOVA) for the strip-plot design as published by (Gomez and Gomezz, 1984). The least significant difference (LSD) method was used to test the differences between treatment means at the 5% level of probability as described by (Snedecor and Cochran,1980).

c. Experimental design and treatments.

1- Experimental design.

The plot area (10 x 30) m^2 for the drip irrigation system was selected for carrying out the experiments. The distance between the cultivation lines is 0.5 meter and the number of planting lines is 20 lines and the distance between the plants on one line is 0.2 meter and the number of plants on the line is 150.

2- Experimental treatments layout.

The analysis of variance (ANOVA) was used to measure the significance of the coefficients. The two factors used in the statistical design were irrigation water [non-magnetic water (NMW) – magnetic water (MW)], and different levels of potassium and nano potassium fertilization.

By adding five weight ratios at [100% K_2O (F_1), 75% K_2O + 25% nano K (F_2), 50% K_2O + 50% nano K (F_3), 25% K_2O + 75% nano K (F_4) and 100% nano K (F_5)]. Vertical plots were filled with magnetized irrigation water treatments (NMW and MW). Horizontal plots were allocated to potassium fertilization treatments. The treatments were distributed as shown in Figure (2). A magnetizing device was used to treat the water magnetically by passing the water through the device installed on the main irrigation line (50 mm OD).

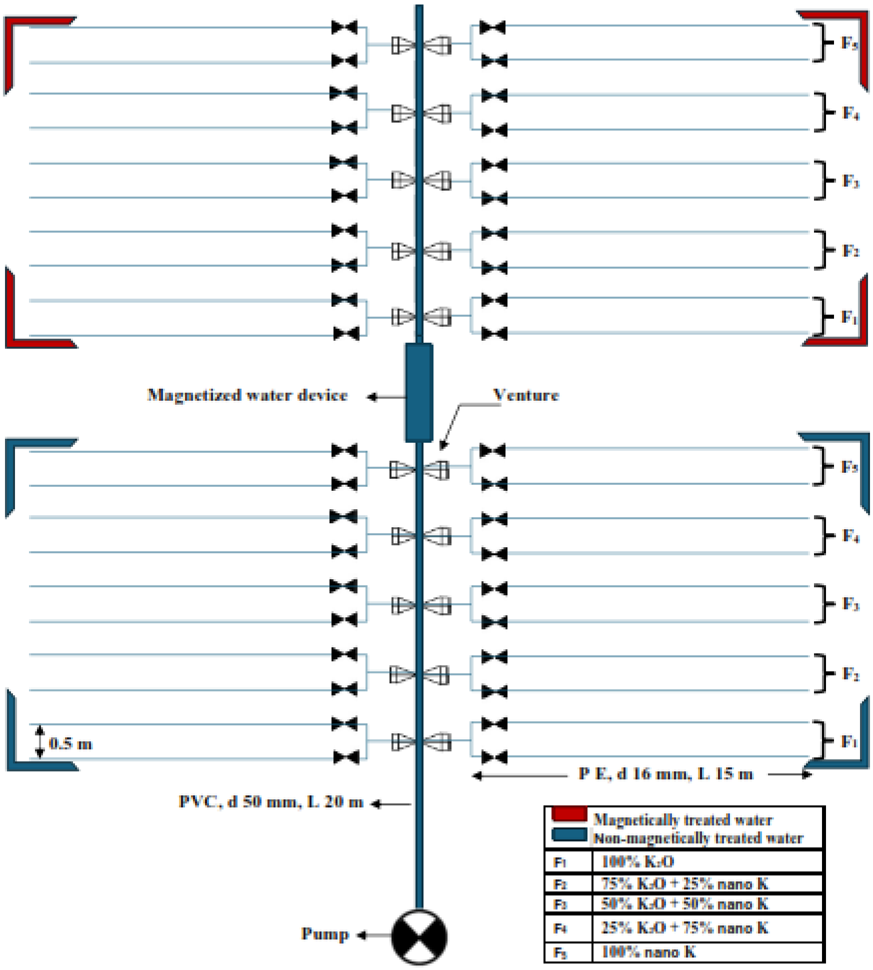

Fig. 2: The prototype of the experiment design.

The experimental plot included four irrigation lines of 15 m length each and the distance between lines was 0.5 m. Fertilizers were added through the irrigation network in the middle of the irrigation time by using a venture at every treatment. It was done in four doses of nitrogen and potassium fertilizer. Phosphorus was added to the soil only once before planting in the form of calcium superphosphate (15.5% P_2O_5) at a rate of 30 kg P_2O_5/fed., nitrogen fertilizer was added in the form of ammonium nitrate (33.5% NH_4NO_3) at a rate of 120 kg NH_4NO_3/fed., potassium for mineral fertilizer in the form of K_2O (100% K_2O) recommended rate at a rate of 48 kg K_2O/fed. And nano potassium (100% of potassium) at a rate of 1500 ppm. The first dose of nitrogen and potassium fertilizer was added after a month of planting (after the thinning process), and three other doses later every two weeks, until the end of the vegetative growth stage. Other field practices were carried out according to the recommendations of the Sugar Crops Research Institute, Agricultural Research Center, Egypt, such as the initial additions in the season, which have a positive effect on productivity, cannot be neglected, such as the added superphosphate and ammonium nitrate.

RESULTS AND DISCUSSION

1 - Quality analysis.

1 – 1 Sucrose percentage (%).

Table (8) showed a significant effect of irrigation treatments on sucrose percentage in both seasons, and preference was given to magnetic water, as the average sucrose percentages were (19.51 and 17.21) % in both seasons, respectively. Also, potassium fertilization levels had a significant effect on sucrose percentages, the highest average value of sucrose percentages were (19.49, and 17.76) % in both seasons, respectively, with 75% K_2O and 25% nano K. This effect is due to the importance of potassium in stimulating the activity of meristematic cells and elongation of plant cells, these results agree with (Hafsi et al., 2014).

The interaction between irrigation treatments and fertilization levels showed a significant effect on sucrose percentage in the first season only, Table (8). The highest sucrose averages (20.24%) were recorded in magnetized irrigation adding 75% K_2O and 25% nano K in the first season. The lowest value was 15.6% in non-magnetized at 100% nano K in the second season.

Table 8: Effect of irrigation water treatments and potassium fertilizer levels on sucrose percentage and sugar loss to molasses percentage.

Potassium fertilizer (K)	Sucrose percentage (%)						Sugar lost to molasses percentage (SLM%)					
	1st season			2nd season			1st season			2nd season		
	Irrigation treatment (IR)											
	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
F1	18.40	19.75	19.07	16.70	17.57	17.14	2.06	2.08	2.07	1.64	1.50	1.57
F2*	18.75	20.24	19.49	17.33	18.18	17.76	2.27	2.23	2.25	1.74	1.57	1.65
F3	18.16	19.48	18.82	16.35	17.09	16.72	1.92	1.93	1.92	1.56	1.43	1.50
F4	17.98	19.25	18.61	16.23	16.80	16.52	1.82	1.79	1.81	1.50	1.37	1.43
F5	17.29	18.82	18.05	15.60	16.43	16.02	1.73	1.73	1.73	1.47	1.33	1.40
Mean	18.11	19.51	18.81	16.44	17.21	16.83	1.96	1.95	1.96	1.58	1.44	1.51
LSD	at 0.05											
IR			0.57			0.41			NS			0.09
K			0.22			0.14			0.02			0.02
IRxK			0.26			NS			NS			NS

NS: Not significant, *: Best treatment.

1 – 2 Sugar lost to molasses percentage (SLM%).

Irrigation treatments had a significant effect on the percentage of sugar lost in molasses in the second season only. Its percentage was 1.58% with non-magnetized water. Also, fertilization levels had a significant effect in both seasons on the percentage of sugar loss in molasses, where the highest average value was (2.25, and 1.65%) at 75% K_2O and 25% nano K in the first and second seasons, respectively. The results showed no significant effect in the interaction between irrigation treatments and fertilization levels on the percentage of sugar loss in molasses in both seasons, Table (8). The highest average value of sugar loss in molasses was (2.27%) with magnetized irrigation at 75% K_2O and 25% nano K in the first season, and the lowest value was 1.33% with magnetized at 100% nano K in the second season.

1 – 3 Extractable sugar percentage (ES %).

The extractable sugar percentage was significantly affected by irrigation treatments in both seasons as shown in Table (9), where the average value of the extractable sugar percentage was (16.96 and 15.18) % with magnetic irrigation for the two seasons respectively. The extractable sugar percentage was also significantly affected by fertilization treatments, where the highest average value was (16.72 and 15.50) % with the addition of 75% K_2O and 25% nano K for both seasons respectively.

According to Table (9), there was no significant effect between irrigation treatments and fertilization levels on the percentage of extractable sugar in both seasons. The highest value was 17.42% with magnetized irrigation at 75% K_2O and 25% nano K in the first season, and the lowest value was 13.53% with non-magnetized irrigation when adding 100% nano K in the second season.

1 – 4 Quality index (QI).

Statistical analysis did not show any significance for irrigation treatments on the quality index in the first season, unlike the second season, where the effect was significant. The average value of the quality index was 88.16% with magnetic water, Table (9). Fertilization levels also affected the quality index in both seasons. The highest value was (87.05 and 87.67) % when adding 75% K_2O and 25% nano K in both seasons, respectively. The interaction between irrigation treatments and fertilization levels showed a significant effect in the second season only, where the highest average value of the quality index was 88.29% with magnetic irrigation when adding 75% K_2O and 25% nano K in the first season, and the lowest value was 84.68% with non-magnetic irrigation when adding 100% nano K in the first season.

Table 9: Effect of irrigation water treatments and potassium fertilizer levels on extractable sugar percentage and quality index.

Potassium fertilizer (K)	Extractable sugar percentage (ES %)						Quality index (QI %)					
	1st season			2nd season			1st season			2nd season		
	Irrigation treatment (IR)											
	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
F1	15.73	17.07	16.40	14.47	15.48	14.97	85.52	86.44	85.98	86.61	88.07	87.34
F2*	16.03	17.42	16.72	15.00	16.01	15.50	86.50	86.02	87.05	86.52	88.29	87.67
F3	15.64	16.95	16.30	14.19	15.06	14.63	86.14	87.00	86.57	86.81	88.10	87.45
F4	15.56	16.86	16.21	14.13	14.83	14.48	84.68	87.58	85.35	87.06	88.06	87.29
F5	14.95	16.48	15.72	13.53	14.51	14.02	86.50	87.59	87.04	86.73	88.27	87.50
Mean	15.58	16.96	16.27	14.26	15.18	14.72	85.87	86.93	86.40	86.74	88.16	87.45
LSD	at 0.05											
IR			0.64			0.32			NS			0.26
K			0.23			0.14			0.12			0.12
IRxK			NS			NS			NS			0.31

2 - Yields.

2 – 1 Root yield (ton. fed^{-1}).

Water treatments had a significant effect on the root crop productivity of sugar beet in the second season only, Table (10), where the average value with magnetized water was 11.72

tons.fed^{-1}. Different fertilization treatments also had a significant effect in both seasons on root productivity, where the highest average value of root productivity was (13.30 and 11.45) tons.fed^{-1} at 75% K_2O and 25% nano K in both seasons respectively. The effect of the interaction between irrigation treatments and different fertilization levels on root productivity was significant in both seasons and the highest average value of root productivity was (13.88 and 12.10) tons.fed^{-1} with magnetized irrigation water with the addition of 75% K_2O and 25% nano K for both seasons respectively. The lowest average value was (11.83 and 9.93) ton.fed^{-1}. with non-magnetized water with the addition of 100% nano K for both seasons respectively. This is due to Nano fertilizers allowing for increased surface area and improved absorption by plant roots. Also, the small size of nano potassium fertilizers allows for better penetration into plant tissues and more efficient uptake compared to conventional fertilizers (El-Saadony et al., 2021).

This can lead to higher yields. Moreover, magnetic water treatment may alter the physical and chemical properties of water and may improve root development, and nutrient uptake efficiency (Surendran et al., 2016).

2 – 2 Sugar yield (ton.fed^{-1}).

Sugar productivity was significantly affected by irrigation treatments in the second season only. The mean value of sugar productivity was 1.78 tons.fed^{-1} with magnetized irrigation water, Table (10). Also, fertilization levels were significantly affected in both seasons, and the highest mean value was (2.21 and 1.78) ton.fed^{-1} with 75% K_2O and 25% nano K in the first and second seasons, respectively. There was a significant effect in the interaction between irrigation treatments and fertilization levels on sugar productivity in both seasons. The highest mean value of sugar productivity was (2.41 and 1.93) tons.fed^{-1} with magnetized water at 75% K_2O and 25% nano K for both seasons, respectively. The lowest mean values were (1.77 and 1.34) tons.fed^{-1} with non-magnetized irrigation water with the addition of 100% nano K in both seasons, respectively. This is due to the application of nano potassium fertilizer results in higher root biomass and sugar content in sugar beets compared to traditional fertilization methods (Dewdar et al., 2018). When combined with magnetic water irrigation, these benefits can be amplified due to improved nutrient availability and uptake efficiency.

Table 10: Effect of irrigation water treatments and potassium fertilizer levels on root and sugar yield.

Potassium fertilizer (K)	Root yield (ton.fed^{-1})						Sugar yield (ton.fed^{-1})					
	1st season			2nd season			1st season			2nd season		
	Irrigation treatment (IR)											
	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
F1	12.86	13.63	13.25	10.58	11.92	11.25	2.02	2.32	2.17	1.53	1.84	1.69
F2*	12.72	13.88	13.30	10.80	12.10	11.45	2.02	2.41	2.21	1.62	1.93	1.78
F3	12.42	13.43	12.93	10.49	11.69	11.09	1.94	2.27	2.11	1.49	1.76	1.62
F4	12.14	13.07	12.61	10.04	11.54	10.79	1.89	2.20	2.05	1.42	1.71	1.56
F5	11.83	12.70	12.27	9.93	11.36	10.65	1.77	2.09	1.93	1.34	1.65	1.49
Mean	12.39	13.34	12.87	10.37	11.72	11.05	1.93	2.26	2.09	1.48	1.78	1.63
LSD	at 0.05											
IR			NS			0.43			NS			0.16
K			0.07			0.29			0.02			0.05
IRxK			0.13			0.56			0.03			0.09

3 –Water use efficiency (WUE).

The water consumption of the sugar beet crop was calculated for both seasons using the CROPWAT 8.0 program. Figures (3, and 4) show the highest average value of water use efficiency (8.73 and 6.52) kg. m^{-3} with magnetized irrigation water at 75% K_2O and 25% nano K for both seasons respectively. The lowest average value (4.51 and 3.42) kg.m^{-3} was with non-magnetized irrigation water with the addition of 100% nano K. This is because using magnetically treated water improves and increases water productivity (Maheshwari and Grewal, 2009).

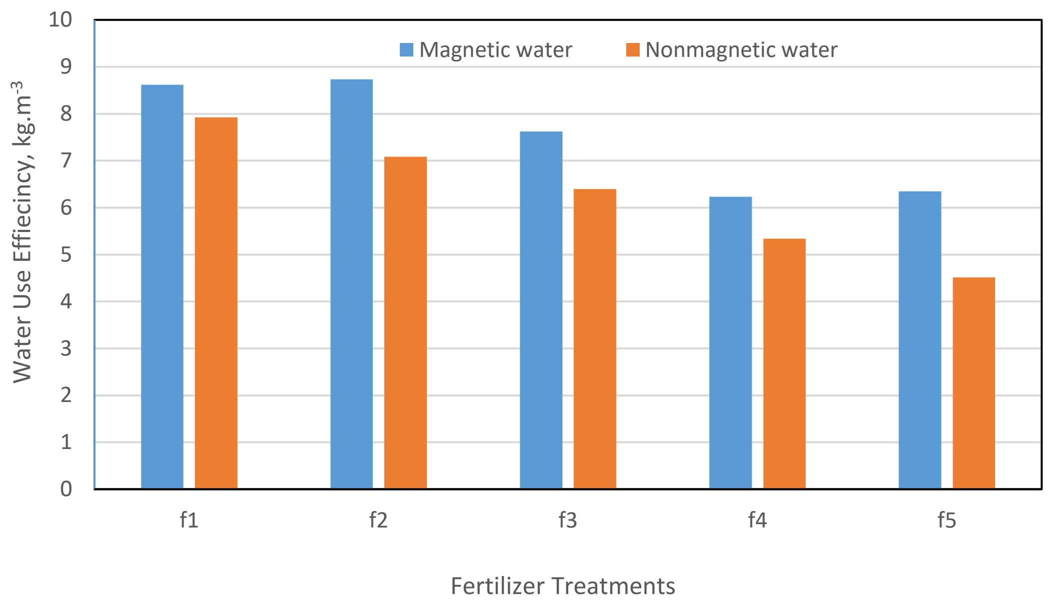

Fig. 3: Effect of water treatments and fertilizer levels on water use efficiency for 1st season.

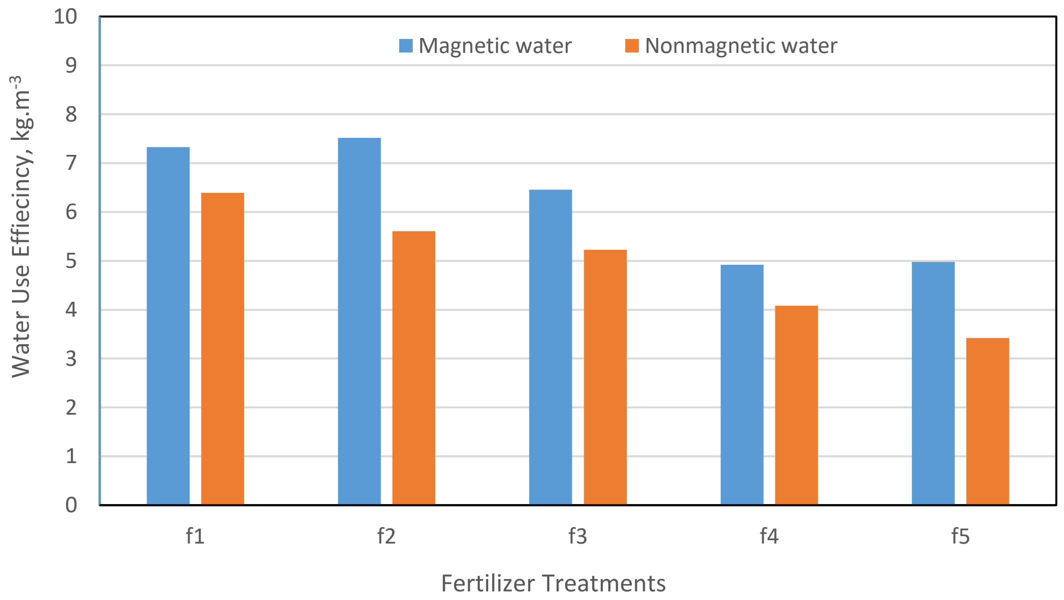

Fig. 4: Effect of water treatments and fertilizer levels on water use efficiency for the 2nd season.

CONCLUSION

The field experiment was conducted in Wadi El Natrun for two consecutive seasons, to study the effect of using magnetic water under a drip irrigation system with different levels of fertilization on the quality and productivity of sugar beet crop. Five percentages of potassium with nano-potassium were used in the experiment, the most at results with magnetic water by adding (75% mineral potassium and 25% nano potassium) were as follows:

1- The highest averages of sucrose, lost sugar in molasses, extracted sugar, and quality index were (20.24, 2.27, 17.42, and 88.29) % respectively.

2- The highest root productivity and the amount of sugar produced by the crop were (13.88 and 2.41) tons/fed.

3- The highest water use efficiency was (8.73, and 6.52) kg/m^3 for the first and second seasons, respectively.

Finally, using potassium nano fertilizers results in increased sugar content compared to conventional fertilization methods. When combined with magnetic water, these benefits can be amplified due to improved nutrient availability and absorption efficiency.

The study recommends using magnetic water for irrigation with nano potassium fertilizer.

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تأثير تقنية النانو للسماد البوتاسي بحقنه لمياه ممغنطة من خلال الري بالتنقيط على محصول بنجر السكر

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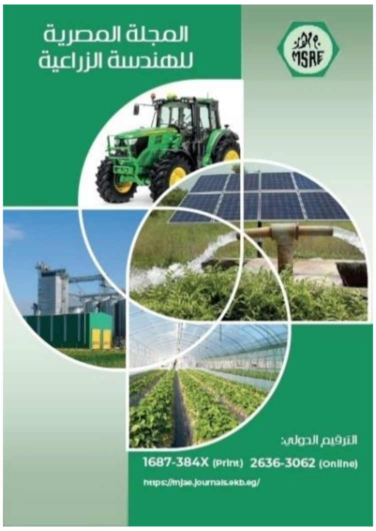

الكلمات المفتاحية:
البنجر السكري؛
إنتاجية الغلة؛
المياه المغناطيسية؛
الأسمدة النانوية.

الملخص العربي

أجريت التجربة لاستجابة بنجر السكر لإضافة نوع ومعدلات البوتاسيوم وماء الري الممغنط. أجريت في وادي النطرون، محافظة البحيرة، مصر، خلال موسمي النمو ٢٠١٩-٢٠٢٠ و٢٠٢٠-٢٠٢١ لدراسة إنتاجية محصول بنجر السكر تحت نظام الري بالتنقيط. تم زراعة صنف بنجر السكر "فيروز" خلال الأسبوع الأول من شهر أكتوبر، وتم الحصاد عند عمر ١٧٥ يوم، استخدم برنامج CROPWAT 8.0 لتحديد الاحتياجات المائية والفترة ما بين الريات. تمت دراسة معاملات التجربة لتأثير الماء الممغنط والغير ممغنط. وقد استخدمت خمس نسب من البوتاسيوم مع التسميد النانو بوتاسيوم وهي(١٠٠٪ بوتاسيوم ، ٧٥٪ بوتاسيوم + ٢٥٪ النانو بوتاسيوم ، ٥٠٪ بوتاسيوم + ٥٠٪ النانو بوتاسيوم ، ٢٥٪ بوتاسيوم + ٧٥٪ النانو بوتاسيوم و١٠٠٪ النانو بوتاسيوم) على التوالي. سجلت أعلى المتوسطات للسكروز، السكر المفقود (المتبقي) في المولاس، السكر المستخلص ودليل الجودة (٢٠,٢٤، ٢,٢٧، ١٧,٤٢ و٨٨,٢٩ %) على التوالى، مع الماء الممغنط بإضافة (٧٥٪ بوتاسيوم معدني و٢٥٪ نانو بوتاسيوم). وكانت أعلى انتاجية للجذور وكمية السكر المنتجة للمحصول هي (١٣,٨٨ و٢,٤١) طن/فدان، مع الماء الممغنط وبإضافة (٧٥٪ بوتاسيوم و٢٥٪ نانو بوتاسيوم). وكانت أعلى كفاءة لاستخدام المياه هي (٨,٧٣ و٦,٥٢) كجم/م٣ للموسمين الأول والثاني على التوالي، مع الماء الممغنط بإضافة (٧٥٪ بوتاسيوم و٢٥٪ نانو بوتاسيوم). وكنتيجة لهذا البحث تحت ظروف التجارب الخاصة به وجد أن: استخدام الأسمدة البوتاسومية بتقنية النانو أدي إلى زيادة نسبة تركيز السكر مقارنةً بالتسميد البوتاسيومي التقليدي. وعند حقنها من خلال نظام الري الكيماوي الممغنط، يمكن تعظيم الاستفادة برفع كفاءة إستخدام المياه والأسمدة من خلال تيسير العناصر الغذائية وكفاءة امتصاصها تبعاً لفسيولوجي النبات المنزرع.