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Application of magnetic technology for salinity stress mitigation and improving sunflower productivity under South Sinai conditions

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ABSTRACT

Forty percent of the Egyptian land (including the most of area in Sinai region) is considered poor or low quality, due mainly to salinity and sodicity problems. Application of magnetic technology treatments either on seeds and/or brackish irrigation water can be used as promising and economic tool for soil desalinization. A field trial using sunflower (*Helianthus annuus* L.; Var., Sakha-53) was conducted at Agricultural Experimental Station of Desert Research Centre, Ras Sidr province, South Sinai Governorate, Egypt during summer season of 2017 to evaluate the application of magnetic technology (either for irrigation water and/or seeds) on productivity of sunflower plants grown under soil and irrigation water salinity stresses conditions. The results showed that, sowing primo-magnetic sunflower seeds and irrigation with magnetically treated brackish-water decreasing clearly salinity stress due to leaching the most dominant soluble salts (i.e., Cl and Na) away from the spread of hairy roots and increasing the most of available nutrients (i.e., P, K and Mg) which reflected for improving accumulated dry matter in plant organs and Macro-elements in leaves at 60 DAS. Yield, yield components and seed oil (%) also were improved compared to sowing un-priming seeds and irrigation with brackish water (BW). Improving sunflower productivity due to application of magnetic water-technology may be open the door for modified field crops mapping under this region.

Key words: Sunflower productivity, magneto-priming, magnetic brackish-water, salinity stress

Introduction

In Sinai region, reducing quantity and quality of irrigation water is one of the major problems that limit agricultural development. This is due to the low rate of rainwater (an average, 200 mm/year). In addition, the irrational use of underground water which leads to a low level and quality through, increased its salinization. Soil desalination at such condition is also a crucial problem being faced by the agriculture sector under this condition. Therefore, it is necessary to use a good quality of irrigation water and/or correction brackish water to meet the requirements of agriculture under these conditions. In this regard, several studies have shown that, application of magnetic-water technology in agriculture is considered one of nontraditional technology and promising to improve soil and water properties for improving crop and water productivity (i.e. Hilal and Hilal, (2000), Aladjadjiyan (2007), Maheshwari and Grewal (2009) and Hozayn *et al*., 2014). Application of this technology is being applied either by the magnetization of water through passing in static magnetic devices or expose of seeds for magnetic field. Many studies also reported that the use of magnetic technology, whether water and/or seeds have a positive effect on the seed germination, plant growth, maturity and productivity of tested different crops (i.e., Oldcay and Erdem (2002), Matwijczuk, *et al*., (2012), Hozayn and Amira (2010 a&b), Hozayn *et al*., (2015), Zia ul Haq *et al*., (2016), Hachicha *et al*., (2017). This is through its impact on processes of plant physiological (i.e., photosynthetic-pigments, protein-biosynthesis, cell- reproduction, photochemical- activity, respiration rate, enzyme activities, contents of nucleic acid, etc ...), decrease of soil alkalinity, increase in mobile forms of fertilizers,

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increasing the viability of elements nutrition, further facilitate the nutrients, effectiveness in washing the salts away from rhizosphere (i.e Amira and Hozayn (2010a&b), Shabrangi and Majd (2009), Pakneijad *et al.,* (2011), Cakmak *et al.* (2009), Massimo (2014), Maheshwari and Grewal, (2009), Hilal *et al.,* (2013), Surendran *et al.,* (2016); Vladimir Zlotopolski, (2017); Razmkhah *et al*., (2018).

Under Egyptian conditions, the studies made by i.e., Hozayn *et al*., (2011, 2013, 2014, 2015b, 2016a&b) reported that crops irrigated with magnetic non saline-water in Nubaria region caused an improving growth, metabolism, quality and productivity of tested crops (wheat, barley and maize, faba bean, lentil, chickpea, ground nut, mung bean, sunflower and canola, flax, sugar beet and potatoes crops). These increases ranged from 8.25 to 42.00% in economic yield (ton fed^{-1}) according to tested crops. Similar trend was recorded for water productivity.

Now days, Egypt has been acute shortage in edible oil reached to 85 - 90% (FAO, 2011). Moreover, only 5.40 % of the land resources in Egypt is qualified as excellent, while about 40.0 % is of either poor or of low quality such as salinity and sodicity problems FAO (2005). In addition, Exposure of various crops to abiotic stresses due primarily to drought, heat, cold or salinity-is the major factor that prevents crops from realizing their full yield potential. In this regards, utilization of magnetic technologies, either for seeds and/or water is considered as a promising and nonconventional technology to improve water and crop productivity either under normal or abiotic stress. The aim of this research was to explore the role of applications magnetic technology (irrigation water and/or seeds) for alleviation salinity stresses conditions on productivity of sunflower under gated pipe irrigation system in South Sinai region.

Materials and Methods

A field trial using sunflower (*Helianthus annuus* L.; Var., Sakha-53) was conducted at Agricultural Experimental Station of Desert Research Centre, Ras Sidr province, South Sinai Governorate, Egypt during summer season of 2017. The experimental area is located on the Gulf of Suez and the Red Sea coast (29º60'28" N latitude and 32º68'96" E longitude). The soil of site experiments and irrigation water were analyzed according to Chapman and Pratt (1978; table 1).

Table 1: Mechanical, Chemical and physical analysis of soil and irrigation water before sowing

Parameter	Soil depth (cm) 0-30	Soil depth (cm) 30-60	Irrigation water
Soil physical properties			
pH	7.66	7.00	8.60
EC (dSm^2)	8.65	7.90	9.68
Organic matter (%)	1.70	1.23	…
Particle size distribution			…
Sand (%)	81.28	86.08	..
Clay (%)	10.67	6.33	..
Silt (%)	8.05	7.59	..
Texture	Sandy loam		..
Soil chemical properties			
Soluble cations (mq/100g)			
Ca^{+2}	38.22	30.82	23.54
Mg^{+2}	27.44	22.00	24.48
Na^{+}	58.33	65.80	40.05
K^{+}	2.01	0.08	0.14
Soluble anions (mq/100g)			
$CO^{-2}{}_{3}$	0.00	0.00	0.00
$HCO^{-}{}_{3}$	3.44	2.00	4.50
$SO^{-2}{}_{4}$	58.93	65.20	29.23
Cl^{-}	64.14	51.50	48.94

The tested treatments were three irrigation water types [i) Brackish-water (BW), ii) Magnetic-BW[1]; brackish water after magnetization through passing a three inch static-magnetic unit produced by Delta Water Company, Industrial Zone-1, Alexandria, Egypt and iii) Magnetic-BW^2; brackish water after magnetization through passing a three inch permanent static magnetic device produced by Magnetic- Technologies Company LLC PO Box 27559, Dubai, UAE] and two priming seed treatments [Un-priming (Control) and magneto-priming]. The two tested factors were laid out in split-plot design with three replications under gated pipe irrigations system. The three irrigation water types and priming seeds treatments were allocated in main and sub-plots, respectively.

The seeds were soaked in water after passed into static magnetic unit (350 mT; 0.5 inch and made from Russia) for ten hours. After priming, seeds were air dried at room temperature. Seeds from the same lot were kept without priming (control).

The soil was ploughed twice, ridged at 0.60 meter apart and divided into main and sub-plots with area (15 m width x 4 m long) and (6 m width x 4m long), respectively. During seed bed preparation, 150 kg fed^{-1} calcium superphosphate (15.5% P_2O_5) was applied. Recommended rates of sunflower seeds (5 Kg fed^{-1}; Var., Sakha-53; obtained from Oil Research Department, Field Crop Research Institute, Agriculture Research Centre, Giza, Egypt) were sown in hills 20 cm apart at the third week of May, 2017. Gated pipe irrigation took place immediately after sowing and as plants needed during the period of experiment. Thinning was carried out after 21 days from sowing to secure one plants per hill on one side of the ridge. Nitrogen fertilizer as ammonium sulfate (20.60 N%) at the rate (45 kg N fed^{-1}) was added in four equal doses starting from 15 days after sowing till flowering. While, potassium fertilizer at the rate of 50 kg fed^{-1} as potassium sulfate (48 % K_2O) was added after one month from sowing. Others recommended agricultural practices for sowing sunflower was done according leaflet Agriculture Research Centre under this province conditions. Experimental layout was shown in (Figure 1).

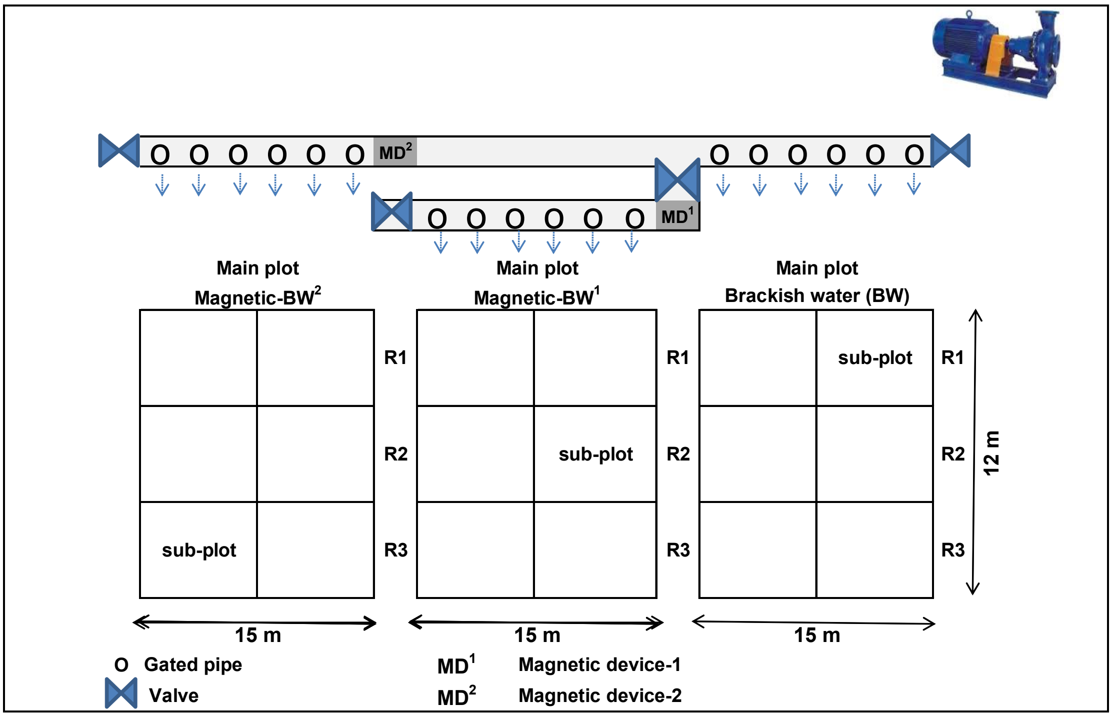

Fig. 1: Layout and design of experiment.

Data recorded:

After 60 days from sowing (DAS), ten plants were randomly taken from each plot to record plant height (cm), leaves (no. $plant^{-1}$), accumulated dry matter of leaves, stem and total plant (g $plant^{-1}$).

Total Chlorophyll in leaves was determined using SPAD Chlorophyll meter (Konica Minolta, 2012).

Macro-elements contents in dry leaves were determined according to Chapman & Pratt, (1978). Total N was determined by using Micro-Kjeldahl method. Potassium, calcium and sodium were determined using flame photometer (Genway). While, estimation of K^+ contents was determined using the Atomic-absorption spectrophotometer (Perkin Elemer 100 B).

At harvest, a random sample of ten guarded plants was taken from each experimental unit to determine plant height (cm), head diameter (cm), head weight (g), seed head weight (g) and 100-seeds weight (g). Plants in the three inner ridges were harvested and their heads were air dried and threshed to calculate seed yield fed^{-1}.

Seed oil percentage was determined using Soxthelt apparatus according to AOAC (2000) and oil yield fed^{-1} was calculated by multiplying seed yield by seed oil percentage.

At the end of experiments, soluble salts (I.e.Ca+2, Mg+, Na+, K+, Cl-, HCO3-and CEC) and available some macro and micro elements (i.e., N,P,K, Mg, Cu, Fe and Zn) were determined according to standard soil analysis methods described by Jackson (1967).

Data were statistically analyzed using MSTAT-C computer package (Freed *et al.* 1989). The least significant difference ($LSD_{5\%}$) test was used to compare among the means.

Results

Soluble salts (meq/l) in soil:

Data in Table (2) show that, clear differences were recorded among three irrigation water types in soil contents of tested soluble salts at two depths (0-30 cm and 30-60 cm). At depth (00-30cm), irrigation with Magnetic-BW^1 or Magnetic-BW^2 caused clear decreasing in soil contents of all tested soluble salts except Mg^{+2}. Revers trends were recorded at depth (30-60 cm).

At depth (00-30cm), the decreasing % reached to 3.52, 12.88, 22.35, 70.36, 4.42, 25.62 and 27.28% in EC_e, Ca^{+2}, Na^+, K^+, Cl^-, HCO_3^- and CEC, respectively regarding irrigation with Magnetic-BW^1. Similar trends with double decreasing % approximately were recorded with Magnetic-BW^2 treatment, where the decreasing % reached to 33.44, 24.54, 51.90, 74.48, 30.23, 48.39 and 51.12% in the above mentioned parameters, respectively. Revers trends were recorded at depth (30-60 cm), where application of Magnetic-BW^1 or Magnetic-BW^2 treatment caused increasing by 34.39 and 11.82 in EC, 27.47 and 15.93 in Ca, 42.20 and 44.94 in Na, 40.47 and 00 in K, 54.56 and 17.10 in Cl, 41.29 and 55.22 in HCO_3, and 43.71 and 47.08% in CEC, respectively compared to irrigation with Brackish water. Mg^{+2} increases by 50.00 and 25.41% at depth (00-30cm) and decreased by 29.00 and 20.00% at depth (30-60cm) resulted in irrigation with Magnetic-BW^1 or Magnetic-BW^2 treatment, respectively compared to corresponding control. The same table, show increasing % in pH and CEC by 3.92 and 20.55 at depth (00-30cm) and 0.12 and 13.39 at depth (30-60cm) under Magnetic BW^1 treatment. Similar trends also were recorded under Magnetic BW^2 but by slightly increasing in CEC (1.95% as average of both depths), 0.25% and 4.05 at (30-60cm and 00-30cm depths), respectively as compared to brackish water.

Table 2: Soluble Salts (meq/l) in soil as affected by irrigation with brackish and magnetic brackish-water treatments.

Soluble Salts (meq/l)	Brackish water (BW)		Magnetic-BW^1		Magnetic-BW^2	
	00 - 30	30 - 60	00 - 30	30 - 60	00 - 30	30 - 60
pH	7.65	8.10	7.95	8.11	7.96	8.12
E.C. (dS/m)	6.25	5.67	6.03	7.62	4.16	6.34
Ca^{+2}	16.30	18.20	14.20	23.20	12.30	21.10
Mg^{+2}	12.20	20.00	18.30	14.20	15.30	16.00
Na^+	50.21	34.22	38.99	48.66	24.15	49.60
K^+	3.88	2.15	1.15	3.02	0.99	1.25
Cl^-	45.22	38.60	43.22	59.66	31.55	45.20
HCO_3^-	26.35	20.10	19.60	28.40	13.60	31.20
CEC (meq/100g soil)	36.50	40.20	44.00	45.80	37.20	41.00

Available nutrients (ppm) in soil:

Availability of some macro and micro-nutrients at the two soil depths (00-30 and 30-60 cm) varied regarding application of magnetic water treatments compared to control (Table 3). Irrigation with Magnetic-BW[1] caused substantial reduction in available soil of N by 34.38% and K by 12.31% at depth (00-30 cm), Cu by 34.55 and 42.55% and Zn by 1.06 and 35.90% at both depths (00-30 and 30-60cm), respectively compared to irrigation with Brackish water. While, revers trends were recorded for soil available N and K at depth (00-60 cm) and P, Mg and Fe at both depths (00-30 and 30-60cm) where the increases reached to 162.50, 33.33, 76.19, 1.89, 59.02, 70.23 and 38.77% for mentioned parameters respectively compared with control. Application of magnetic-BW[2] gave similar trends like magnetic-BW[1] for N, K and Cu. While, revers trends were recorded in the others available nutrients, where irrigation with magnetic-BW[2] decreasing P by 14.29% at depth (30-60 cm), K, Mg and Fe by 4.62, 42.64 and 24.65%, respectively at depth (00-30 cm) and increasing available soil of Zn at both depth by 31.91 and 2.65% respectively, compared to control treatment.

Table 3: Available nutrients (ppm) in soil as affected by irrigation with brackish and magnetic brackish-water treatments.

Available	Brackish water (BW)		Magnetic-BW[1]		Magnetic-BW[2]	
Nutrients (ppm)	00 - 30	30 - 60	00 - 30	30 - 60	00 - 30	30 - 60
N	3.20	0.80	2.10	2.10	2.60	2.20
P	8.40	2.10	11.20	3.70	13.20	1.80
K	65.00	47.00	57.00	65.00	62.00	48.00
Mg	2.65	1.22	2.70	1.94	1.52	1.33
Cu	0.55	0.94	0.36	0.54	0.54	0.62
Fe	2.15	3.25	3.66	4.51	1.62	3.90
Zn	0.94	1.17	0.93	0.75	1.24	1.20
$CaCo_3$ (%)	18.33	17.11	19.32	19.32	21.22	17.21

Vegetative growth (60 DAS):

Significant effects of irrigation water types, magneto-priming-seeds and its interaction treatments on growth tested parameters, (i.e., plant height (cm), leaves (no. plant^{-1}), accumulated dry matter of leaves, stem and total plant (g plant^{-1}) and total chlorophyll in leaves) were recorded in table (4). Regarding irrigation water types, the same table reveals that, irrigation with magnetically treated brackish-water[1] and magnetically treated brackish-water[2] treatments surpassed irrigation with brackish water in all tested growth parameters. As average of both magnetically brackish-water treatments, the percent of improvement compared to irrigation with brackish water reached to 13.40, 20.86, 39.89, 86.39, 74.70 and 11.40% in the previous growth parameters, respectively. The differences between magneto-priming seed treatments, significant increases were obtained due to sowing magneto-priming seeds compared to control treatment in all tested growth parameters. The percent of increment reached to 12.06 and 13.00, 35.56, 21.05, 23.98 and 5.85% in the previously mentioned growth parameters, respectively.

Regarding the interaction between irrigation water types and priming-seed, table (2) show significant differences in tested growth parameters except leaves number per plant. Sowing primo-magnetic seeds and irrigation with magnetically treated brackish-water[2] gave the highest value of tested growth parameters, followed by with significant differences sowing primo-magnetic seed and irrigation with magnetically treated brackish-water[1]. Generally, the increasing ranged between 12.14 - 56.55, 12.50 - 51.56, 32.62-122.93, 13.90 - 133.45, 19.93 - 131 and 1.70 - 19.90% in the previous growth parameters, respectively due to applications of magnetic treatments either for seed and/or water compared to sowing control seeds and irrigation with brackish water.

Macro-elements in leaves (60 DAS):

Table (5) show significant effects due to irrigation water types, priming-seeds, and its interactions treatments on leaves contents of macro-elements at 60 days from sowing. Irrigation with magnetically treated brackish-water (either Magnetic-BW[1] or Magnetic-BW[2]) improved leave contents of N, K, Mg and Ca by 26.13, 15.53, 25.57 and 30.40% (average of both magnetic water treatments), respectively compared to irrigation with brackish-water. Reveres trend was observed in leave contents of Na, where it was decreased by 18.60% due to applications of magnetically treated brackish water (average of Magnetic-BW[1] and Magnetic-BW[2]; Table 5). Similar positive trends were recorded due to sowing magneto-priming seeds compared to control. The interaction effect showed that sowing sunflower primo-magnetic seed and irrigation with magnetically treated brackish water (either Magnetic-BW[1] or Magnetic-BW[2]) gave more values compared to other treatments.

Table 4: Plant height, accumulated dry mater in plant organs and chlorophyll content in leaves (60 DAS) as affected by different magnetic treatments either for seeds and/or brackish irrigation water.

Treatment		Plant height (cm)	Leaves (no. plant^{-1})	Accumulated dry matter (g plant^{-1})			Total chlorophyll (SPAD)
Water type	Priming seed			Leaves	Stem	Plant	
Brackish water (BW)	Control	104.33	21.33	27.74	92.76	120.50	33.33
	Magneto-priming	117.00	25.00	38.86	105.65	144.51	33.90
Magnetic-BW[1]	Control	136.33	24.00	36.79	156.95	193.74	35.93
	Magneto-priming	144.00	26.67	44.86	191.48	236.34	37.73
Magnetic-BW[2]	Control	138.00	29.00	42.85	174.64	217.49	36.17
	Magneto-priming	163.33	32.33	61.84	216.55	278.39	39.97
F test		***	**ns**	***	**	**	*
LSD5%		**5.09**	**3.56**	**2.25**	**33.42**	**34.27**	**2.08**
Water type	Brackish water	110.67	23.17	33.30	99.21	132.51	33.62
	Magnetic-BW[1]	140.17	25.33	40.83	174.22	215.04	36.83
	Magnetic-BW[2]	150.67	30.67	52.35	195.59	247.94	38.07
F test		***	***	***	***	***	**
LSD5%		**1.73**	**1.43**	**0.92**	**21.06**	**21.35**	**1.46**
Seed priming	Control	126.22	24.78	35.79	141.45	177.24	35.14
	Magneto-priming	141.44	28.00	48.52	171.23	219.75	37.20
F test		***	***	***	***	***	**
CV%		**1.90**	**6.74**	**2.66**	**9.88**	**8.07**	**2.88**

Table 5: Macro elements in leaves (60 DAS) as affected by different magnetic treatments either for seeds and/or brackish irrigation water.

Treatment		Macro-nutrients in flower (%)				
Water type	Seed priming	N	K	Mg	Na	Ca
Brackish water (BW)	Control	2.89	1.93	0.36	0.42	1.65
	Magneto-priming	3.38	2.08	0.38	0.41	1.79
Magnetic-BW[1]	Control	3.26	2.03	0.38	0.38	1.93
	Magneto-priming	3.39	2.27	0.39	0.37	2.05
Magnetic-BW[2]	Control	3.60	2.25	0.40	0.34	2.00
	Magneto-priming	3.71	2.33	0.42	0.32	2.12
F test		**ns**	**ns**	**ns**	**ns**	**ns**
LSD5%		**ns**	**ns**	**ns**	**ns**	**ns**
Water type	Brackish water	3.14	2.00	0.37	0.42	1.72
	Magnetic-BW[1]	3.32	2.15	0.39	0.37	1.99
	Magnetic-BW[2]	3.66	2.29	0.41	0.33	2.06
F test		***	*	**	***	**
LSD5%		**0.13**	**0.15**	**0.008**	**0.025**	**0.12**
Seed priming	Control	3.25	2.07	0.39	0.38	1.86
	Magneto-priming	3.49	2.23	0.40	0.37	1.99
F test		*	**	**	**ns**	**ns**
CV%		**5.1**	**3.81**	**2.50**	**3.39**	**5.81**

Sunflower yield and its components:

At harvest, tables (6 & 7) showed significant effects of irrigation water types, priming-seeds and its interaction treatments on sunflower yield and its components. Irrigation sunflower plants with magnetically treated brackish-water[1] and magnetically treated brackish-water[2] treatments surpassed irrigation with brackish-water in plant height (cm), head diameter (cm), head weight (g), seed head weight (g) and 100-seeds weight (g; Table 4), oil seed (%), seed and oil yield (Kg fed^{-1}; Table 5). As an average of both magnetically treated brackish-water treatments, the improvement reached to 39.50, 8.93, 26.86, 30.15 and 16.77, 7.54, 24.03 and 33.32%, respectively.

Table 6: Sun flower yield components at harvest as affected by different magnetic treatments either for seeds and/or brackish irrigation water.

Treatment		Plant height (cm)	Head parameter			100-seed weight (g)
Water type	Seed priming		Diameter (cm)	Weight (g)	Seed weight (g)	
Brackish water (BW)	Control	100.33	16.90	100.00	64.00	5.55
	Magneto-priming	118.67	17.27	110.33	72.00	5.92
Magnetic-BW[1]	Control	148.00	17.94	118.33	79.00	6.20
	Magneto-priming	150.67	19.19	139.00	93.00	6.55
Magnetic-BW[2]	Control	148.33	18.20	128.33	86.00	6.95
	Magneto-priming	164.00	19.11	148.00	96.00	7.08
	F_{test}	**	*	**ns**	*	*
	$LSD_{5\%}$	**3.56**	**0.61**	**ns**	**8.28**	ns
Water type	Brackish water	109.50	17.09	105.17	68.00	5.74
	Magnetic-BW[1]	149.33	18.57	128.67	86.00	6.38
	Magnetic-BW[2]	156.17	18.66	138.17	91.00	7.02
	F_{test}	***	**	***	***	**
	$LSD_{5\%}$	**10.47**	**0.64**	**14.71**	**4.53**	0.57
Seed priming	Control	132.22	17.68	115.56	76.33	6.24
	Magneto-priming	144.44	18.52	132.44	87.00	6.52
	F test	***	**	***	**	**ns**
	$CV_{\%}$	**1.29**	**1.68**	**5.46**	**5.07**	3.25

Table7: Sunflower yield (kg fed^{-1}) as affected by different magnetic treatments either for seeds and/or brackish irrigation water.

Treatment		Seed oil (%)	Yield (Kg fed^{-1})	
Water type	Seed priming		Seed	Oil
Brackish water (BW)	Control	40.15	669.33	268.72
	Magneto-priming	41.05	737.00	302.54
Magnetic-BW[1]	Control	41.63	850.67	354.10
	Magneto-priming	43.18	874.00	377.39
Magnetic-BW[2]	Control	44.50	859.67	382.58
	Magneto-priming	45.32	904.33	409.84
	F test	**ns**	*	**ns**
	$LSD_{5\%}$	**ns**	**51.86**	**ns**
Water type	Brackish water	40.60	703.17	285.63
	Magnetic-BW[1]	42.40	862.33	365.75
	Magnetic-BW[2]	44.91	882.00	396.21
	F test	***	***	***
	$LSD_{5\%}$	**0.81**	**29.94**	**13.32**
Seed priming	Control	42.09	793.22	335.13
	Magneto-priming	43.18	838.44	363.26
	F test	**	**	**
	$CV_{\%}$	**0.82**	**3.18**	**3.96**

Regarding priming-seed treatments, significant increases were obtained due to sowing magneto-priming seeds compared to control treatment in sunflower yield and its components (Table 4 & 5). The increment reached to 9.24, 4.77, 15.45, 13.97 and 4.51% in plant height (cm), head diameter (cm), head weight (g), seed head weight (g) and 100-seeds weight (g; Table 4) and by 2.59, 5.70 and 8.39 at seed oil (%), seed and oil yield (kg fed^{-1}; Table 5), respectively. Significant differences were recorded in recorded sunflower yield and its components at harvest due to the interaction between irrigation types and priming-seed treatments. Sowing primo-magnetic seed with irrigation by magnetically treated brackish-water^2 treatment gave the highest value of all recorded yield parameters, followed by sowing primo-magnetic seeds with irrigation by magnetically treated brackish-water^1 while, sowing control seeds and irrigation with brackish water gave the lowest values in all tested parameters compared to others treatments (Table 6&7 and Figure 2).

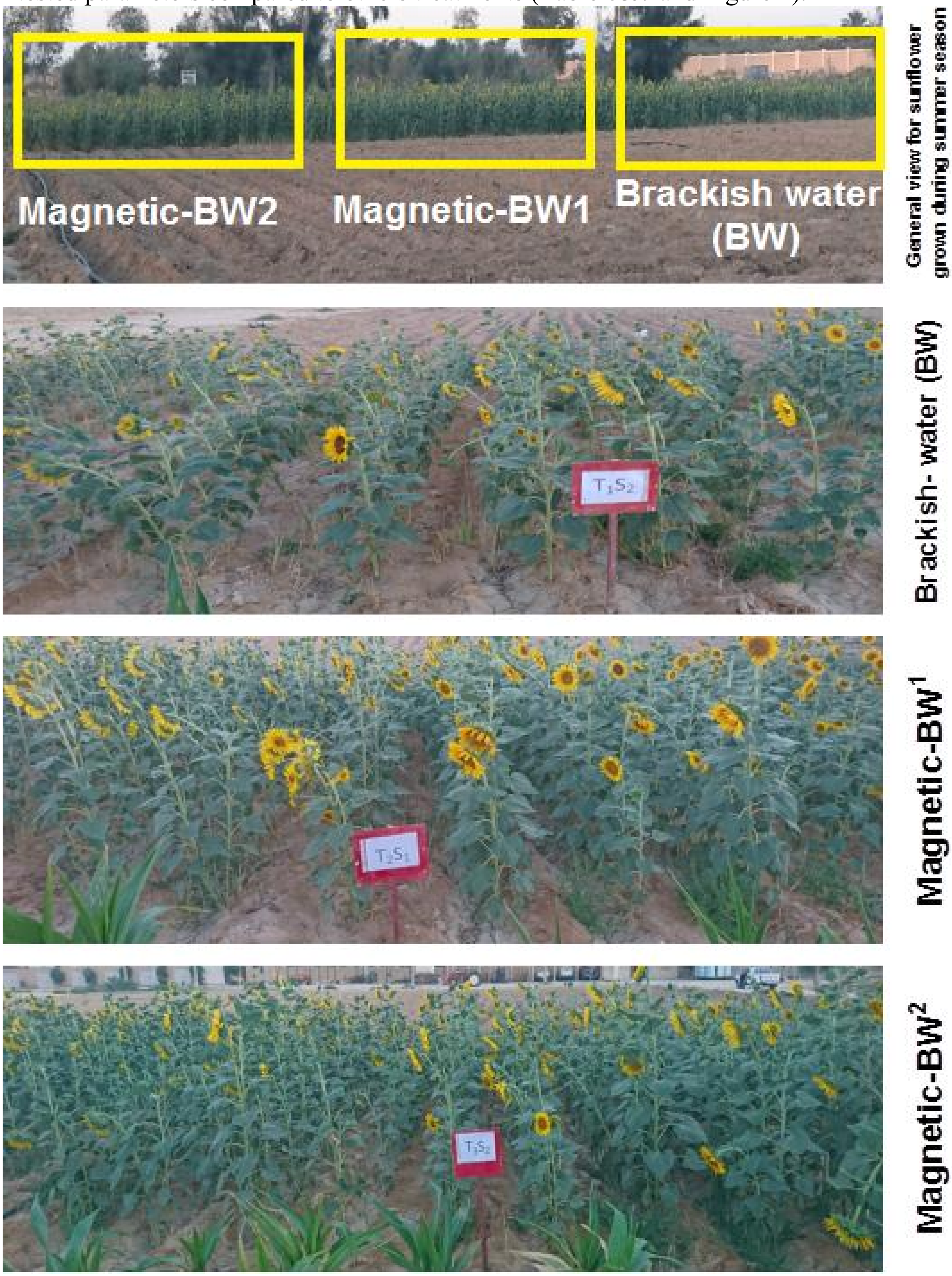

Fig. 2: General differences among irrigation brackish water types.

Discussion

Sowing primo-magnetic sunflower seeds and irrigation with magnetically treated brackish-water improves clearly and significantly growth and productivity of sunflower crop grown under salinity stress condition in Ras Sider region. Decreasing salinity stress may be due to leaching salinity soluble salts (i.e., Cl, Na) away from the spread of hairy roots (Table 2). Moreover, increasing available nutrients i.e., P, K, Mg resulted in increasing plant growth, yield and yield components (Table 3). In this regards, Hillal & Hillal (2000a) concluded that application of a magnetic field on water decreases the hydration of salt ions and colloids, having a positive effect on salt solubility, accelerated coagulation and salt crystallization. Moreover, Tai *et al*. (2008) notes that water undergoing magnetic field leads to a change in its properties as it becomes more vigorous and able to easy flow. They added that magnetized water increases the percentage of nutrients such as phosphorus, potassium and zinc in plants. They also added that magnetized water prevents the absorption of harmful metals such as lead and nickel by the roots, and thus prevents them from reaching the fruits.

There were minor changes in pH due to magnetic effects (increase) compared with the un-magnetized water .Moreover , lowering pH of water or soil accelerate the ability of sunflower plants to uptake macro and micro nutrients more efficiently Electrical conductivity was greater on the untreated plots compared to the treated plots . These parameters were improved under magnetic treatment consequently it enables sunflower plants to uptake greater amounts of micro and macronutrients and reflected directly on sunflower yield and quality

These results also confirmed the previous studies but under non-saline condition in Nubaria region (i.e., Hozayn *et al*., 2013, 2014, 2015a&b, 2016 a&b, 2017). Where they revealed that, some cereal (i.e., wheat, barley and maize), legumes (i.e., faba bean, lentil, chickpea and mung bean), oil (i.e., sunflower, canola and ground nut), fiber (i.e., flax), sugar (i.e., sugar beet) and vegetable crops (i.e., potato and onion) irrigated with non-saline water gave more values of growth, yield and quality compared untreated treatment. The improvement in economic yield varied according to tested crops where ranged from 8.25 - 42.00%. In abroad also, clear increasing (10.6-144.8%) in economic yield of many crops (i.e. cereal, rice, wheat, soybean, broad bean, sunflower, sugar beet, pepper and pea) were recorded regarding application of magnetic-water treatments and/or magnetic field under macro experiments (i.e., Vasilevski 2003; Aladjadjiyan, 2007; Vashisth and Nagalajan, 2010; Surendran *et al*., 2016; Vladimir 2017; Razmkhaha *et al*., 2018). They also recorded that, the increasing in yield were accompanied by improvement in quality parameters i.e., sugar, protein, oil and carbohydrates percentage. Change in some physical and chemical properties of water and soil may be reflected in the positive effects on growth, yield and water productivity regarding magnetic water treatments (Mehawar and Grewal 2009; Surendran *et al*., 2016; Vladimir 2017; Razmkhaha *et al*., 2018 and Ben omer, 2018).

Conclusion

Under this condition, it be concluded that, Application of magnetic technology treatments either on seeds and/or brackish irrigation water can be used as an effective method for alleviation salinity stress and improving sunflower productivity. The study indicated that there is a partial desalinization of soil and well water used for irrigation due to the magnetic technology application but the effect was more pronounced for soil than the irrigated water, Also, this study may be open the door for modification of the recommendation of some agronomic practices for field crop production.

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