13 *Egypt. J. Agron.* **Vol. 43**, No.2, pp. 157-171 (2021)

Egyptian Journal of Agronomy
http://agro.journals.ekb.eg/

Effect of Salinity and Magnetically-Treated Saline Water on the Physiological and Agronomic Traits of Some Bread Wheat Genotypes

Alaa A. Said[(1)#], Abdel-Rahman A. Mustafa[(2)], A. Hamada[(3)]
[(1)]*Agronomy Department, Faculty of Agriculture, Sohag University, Sohag, Egypt;*
[(2)]*Soil and Water Department, Faculty of Agriculture, Sohag University, Sohag, Egypt;*
[(3)]*Agronomy Department, Faculty of Agriculture, Assiut University, Assiut, Egypt.*

THE PRESENT investigation was carried out to evaluate the effect of salinity and saline water magnetization on physiological and agronomic traits of 32 bread wheat genotypes and to determine the changes in soil properties. These genotypes were grown in pot experiments under greenhouse conditions during the winter growing seasons of 2017/2018 and 2018/2019 at Faculty of Agriculture, Sohag University, Sohag, Egypt and subjected to tap water (control), salinity levels (2,500 and 5,000ppm) and magnetically treated (2,500 and 5,000ppm) saline water. Results showed that values of soil soluble cations and anions were significantly lower under treated magnetic water (TMW). Moreover, magnetic saline water had a positive effect on relative water content by 7.84 and 7.10%, chlorophyll concentration by 6.03 and 9.92% and attributed to decrease the canopy temperature by 7.98 and 10.23% respectively in contrast with 2500 and 5000ppm saline water. Also, it increased plant height to 6.66 and 13.10%, 4.39 and 4.27% for number of spikes/plant, 5.18 and 8.18% for spike length, 5.13 and 10.57%, for biological yield/plant and 6.89 and 7.94% for grain yield/plant compared to irrigation saline water. Indeed, more studies are required to declare the impacts of magnetic water on the growth, yield and quality of other different crops. Stress Susceptibility Index (SSI) revealed that lines 9, 16, 3 recorded the lowest values of 0.57, 0.75 and 0.76, respectively, this showing relatively salt tolerant lines compared to other wheat genotypess and introducing new genetic sources for salt tolerance into breeding programs.

Keywords: Magnetic water, Salinity, Wheat.

Introduction

Wheat (*Triticum aestivum* L.) is one of Egypt's main food crops and is a moderately salt-tolerant crop (Maas & Hoffman, 1977). Wheat breeders presented a great effort to increase the productivity of wheat to meet the demands of a growing population in Egypt in the presence of the hot sub-tropical desert climate. New reclaimed areas are used to grow wheat, however, many of these new reclaimed lands in Egypt are suffering from salinity problems in which high salinity water is present (Al-Naggar et al., 2015), which restrict wheat production. Therefore, appropriate strategies are needed to conserve water and at the same time increasing the productivity of wheat by breeding salt-tolerant lines and employing salinity indices, like the salinity susceptibility index (SSI) which is a good indices for screening salt tolerant cultivars (Goudarzi & Pakniyat, 2008). Physiological mechanisms that underlie traits for salt tolerance could be used to identify new genetic sources of salt tolerance (Munns et. al., 2006).

Recently, promising technology had been used to relieve saltiness. One of the widely Said,

#Corresponding author email: alaa.said@agr.sohag.edu.eg
Received 20 /2/2021; Accepted 11/4/2021
DOI: 10.21608/agro.2021.64159.1250

modern technologies is magnetized water, which reduces the saltiness degree in irrigation water, lowers soil alkalinity, and it's the high leaching of excess soluble salts (Hilal & Hilal, 2000). The beneficial effects of applying the magnetic treatment in irrigation water enhanced crop growth and yield (Hozayn & Abdul Qados, 2010a, b; Grewal & Maheshwari, 2011) without any destructive or harmful impact. This study aims to test thirty wheat genotypes under two salinity levels and determine the changes in soil properties due to irrigation with magnetically treated saline water of 2,500 and 5,000ppm concentrations. In addition to examine the effect of magnetically-treated 2,500 and 5,000ppm saline water on different physiological and agronomic traits in wheat plants under greenhouse conditions.

Materials and Methods

During 2017/2018 and 2018/2019, two pot experiments were implemented in a greenhouse under natural illumination at the Faculty of Agriculture, Sohag University, Egypt. Thirty-two wheat genotypes of which 30 advanced wheat lines (F_8) and 2 commercial wheat cultivars (Table 1) were planted in plastic pots (10kg capacity), containing a mixture of clay and sandy soil (clay:sand, 2:1). One week after emergence, seedlings have been thinned to three per pot in a randomized complete block with three replications. At the beginning of each experiment, all pots were irrigated to field capacity with tap water (680ppm, Table 2) for three weeks after sowing. After that, 5 irrigation treatments (up to field capacity) were applied viz., the first one was irrigated with tap water (as a control) and the others were irrigated with saline water in two levels, 2,500 (S_1) and 5,000ppm (S_2) and the magnetically treated saline water also in the same two salinity levels, 2,500ppm (MTW 1) and 5,000ppm (MTW 2).

The saline water used in the study was prepared by adding weighted amounts of NaCl salt to irrigation water to achieve the required salinity levels. The saline water was magnetized using a one-inch magnetron (A100S magnetic device) with two magnets. The device is comprised of a 100mm pipe section with its internal diameter of 22mm. For magnetization treatments, it was passed twice through the magnetic treatment device at the flow rate of 10mL/s, providing the water magnetic field exposure of about three seconds. The recommended fertilizers doses for each pot were applied through the period of the experiment.

Physiological and agronomical traits

At the heading stage, flag leaves were used to determine some Physiological traits, i.e., relative water content, according to Schonfeld et al. (1988), total chlorophyll content (mg cm^{-2}) using chlorophyll meter (SPAD-502) and canopy temperature (°C) using an infrared thermometer. In addition to recording plant height (cm), No. of spikes/plant, spike length (cm), biological yield/plant (gm), and grain yield/plant (gm). Stress sensitivity index (SSI) was calculated for grain yield as described by Fischer & Maurer (1978).

Statistical analysis

After using the Bartlett's test of homogeneity of variances (Bartlett, 1937) the combined analysis was performed on the recorded data of physiological and agronomic traits according to Gomez & Gomez (1994) using Proc Mixed of SAS Package Version 9.2 (SAS/STAT, 2008). Means were compared by Revised Least Significant Difference (RLSD) at 5% level of significance (El-Rawi & Khalafalla, 1980).

Soil analysis

The abovementioned soil samples were collected and analyzed for their physical and chemical characteristics according to Page et al. (1982).

TABLE 1. Pedigree and source of 22 bread wheat genotypes used in the study

Genotypes	Pedigree
30 advanced wheat lines (F_8)	L1-L14: Derived from a cross between Sids 4 (local variety) × Tokwie (South Africa). L15-L30: Derived from a cross between Sids 4 × Kasyon/glennson-81 (ICARDA).
Sids 12	BUC//7C/ALD/5/MAYA74/ON//1160.147/3/BB/GLL/4/CHAT"S"/6/ MAYA/VUL//CMH74A.630/4*SXSD7096-4SD-1SD-1SD-0SD.
Giza 168	MIL/BUC//Seri CM93046-8M-0Y-0M-2Y-0B.

TABLE 2. Chemical characteristics of the irrigation water

Property	Unit	Value
pH	……	7.65
EC	mgL^{-1}	680
Na	mgL^{-1}	50.2
K	mgL^{-1}	81.7
Ca	mgL^{-1}	48.7
Mg	mgL^{-1}	24.6
HCO_3	mgL^{-1}	115.7
Cl	mgL^{-1}	48.6
SO_4	mgL^{-1}	214.8

Results and Discussion

Effects on soil properties

Magnetic water treatment does not change the chemical parameters of water. However, physical parameters were affected by magnetic fields viz., reduction of surface tension, viscosity, zeta potential, solubility, and diffusion (Cho & Lee, 2005; Chang & Weng, 2006; Gang et. al., 2012). Data tabulated in Table 3 showed the comparison of concentrations of different ions in the soil irrigated with treated magnetic water and the other irrigated with untreated magnetic water.

At first glance of Fig. 1, it is noted that the average values of soil soluble cations and anions were less in soil irrigated with treated magnetic water than the soil irrigated with either untreated magnetic water (2,500ppm) or tap water (control). Whereas an increase in the mean values of soil soluble cations and anions in the soil irrigated with saline water (5,000ppm) compared to the control treatment. In contrast, saline water's magnetic treatment (5,000ppm) decreased the mean values of soil soluble cations and anions. Similar results were observed by Mostafazadeh-Fard et al. (2011), Abd-Elrahman & Shalaby (2017), Hachicha et al. (2018) and Said et al. (2020).

TABLE 3. Average values of chemical characteristics of soil before and after cropping during two growing seasons

Property	Unit	Values				
		Before cropping	After cropping			
			2,500ppm	5,000ppm	2,500ppm	5,000ppm
			Treated	Untreated	Treated	Untreated
pHe	…….	7.94	7.64	8.14	7.87	8.24
EC_e	dSm^{-1}	2.21	1.46	3.25	3.40	5.12
Ca^{2+},	mgl^{-1}	232.00	160.01	346.80	361.80	541.80
Mg^{2+},	mgl^{-1}	16.80	12.00	25.11	26.19	39.22
Na^+	mgl^{-1}	159.08	106.67	237.80	248.09	371.51
K^+	mgl^{-1}	33.14	26.67	49.54	51.69	77.40
HCO_3^-	mgl^{-1}	187.80	113.33	280.73	292.88	438.59
Cl	mgl^{-1}	375.62	257.33	561.49	585.77	877.20
SO_4^{-2}	mgl	387.78	259.99	579.66	604.73	905.59
Available N	ppm	463.49	787.93	533.33	808.71	557.26
Available P	ppm	19.84	33.73	30.16	37.67	39.50
Available K	ppm	166.67	283.33	226.19	312.78	279.79
$CaCO_3$, %	%	0.58	0.34	0.69	0.45	0.46
Organic matter	%	0.44	0.71	0.37	0.66	0.46
Field capacity	%	22	22	22	24	20
Wilting point	%	11	10	10	10	10
Water holding capacity	%	11	12	12	14	10
Sand	%	35.4	35.7	38.2	40.4	39.7
Silt	%	27.8	27.3	23.1	26.8	24.8
Clay	%	37.8	37	38.7	32.8	35.5
Texture class		Clay loam	Clay loam	Clay loam	Clay loam	Clay loam

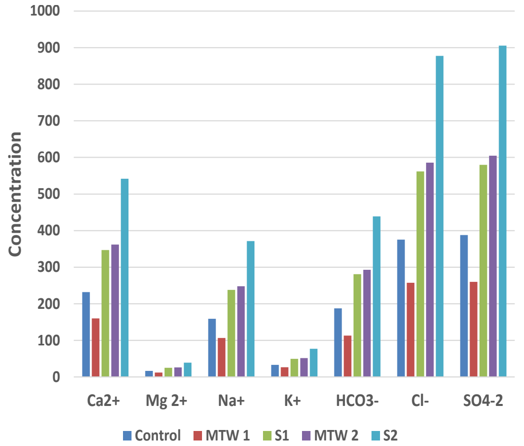

Fig. 1. The effect of magnetic water on soluble cations and anions in the soil

Irrigation with magnetic water clearly showed lower values of ECe than the irrigated with saline water (Table 3 and Fig. 2). It may be due to the high leaching efficiency of magnetic water as compared with normal water. The three main observed effects of magnetic treatment of water in the soil are removing excess soluble salts, reducing the pH, and increasing the solubility of some slightly soluble components (Hilal & Hilal, 2000; Mostafazadeh-Fard et al., 2011; Abd-Elrahman & Shalaby, 2017; Hachicha et al., 2018). Also, it was found a significant reduction of soil pH values in treated magnetic water. $CaCO_3$ concentrations were reduced by irrigating with magnetic water this reflects the effect of magnetized water on salt leaching and dissolution of $CaCO_3$ (Hachicha et al., 2018).

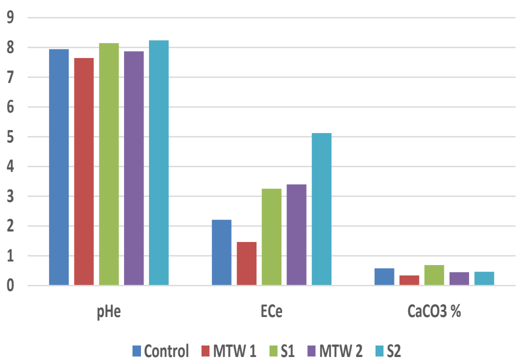

Fig. 2. The effect of magnetic treatment on pH, ECe and $CaCO_3$ in soil

There was an increase in available macronutrients in soil samples irrigated with treated magnetic water (Fig. 3). Hence, improving the growth of wheat plants was noticed due to the increase of nutrients activity in soil and plant (Maheshwari, 2009; Hilal et al., 2013; Mohamed 2013; Abd-Elrahman & Shalaby, 2017; Said et al., 2020).

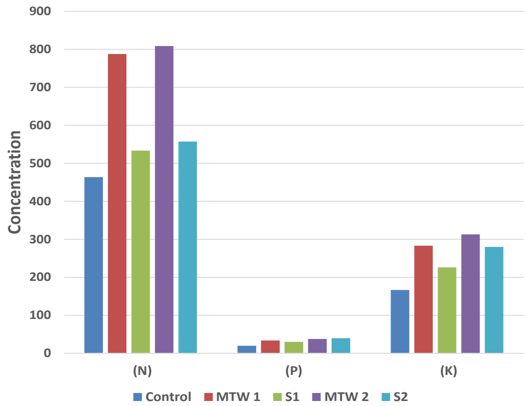

Fig. 3. The effect of magnetic water on available N, P and K in soil

As seen in Fig. 3, there was an increase in macronutrients availability in soil samples irrigated with treated magnetic water. The results of the current study showed an increase in the soil available N, P and K, particularly under magnetically treated saline water irrigation, which have played some role in improving the growth of wheat plants (Table 3). The effect of the magnetic field may be due to weak bonds between certain ions and thought to be a significant factor affecting their activity in soil and plant. This finding is in high agreement with the results found by Hilal et al. (2013), Mohamed (2013), Abd-Elrahman & Shalaby (2017) and Said et al. (2020).

Effects of salinity and magnetic water technology on wheat plants

Statistical analysis

The combined analysis of variance was carried out for all physiological and agronomic traits (Table 4), which indicated significant variation among genotypes, water treatments, and interaction between them.

Physiological traits

Data in Tables 5, 6, and Fig. 4 shows that wheat genotypes responded differently either within the same or between the salinity levels and magnetically treated saline water for all studied physiological traits.

The average relative water content of wheat genotypes for irrigated with tap water (as a control), 2,500 saline water (S_1), the magnetically treated 2,500 saline water (MTW 1), 5,000ppm saline water (S_2) and the magnetically treated 5,000 ppm saline water (MTW 2) (Table 5 and Fig. 4) in both seasons were 81.30, 66.91, 72.15, 56.62 and 60.65%, respectively. Whereas genotypes No. 1 (67.10%), 2 (68.77%), 27 (64.71%), and 30 (78.43%), having higher relative water content under 5,000 ppm saline water, which could be considered as relatively salt tolerant genotypes. Yadava et. al. (2020) revealed that relative water content significantly reduced by salinity stress in wheat. In particular, there was a significant increase in relative water content by applying 2,500 (7.84%) and 5,000ppm (7.10%) saline water when compared with the control over both seasons. Therefore, lines No. 3, 21, 22, and 25 are most responsive to magnetically treated 5,000ppm saline water with an increase of 19.10, 14.47, 18.80 and 14.52% compared with saline water, respectively. These results follow Al-Khazan et. al. (2011) and Sadeghipour (2016), who found that relative water content was higher in plants grown with Magnetic water treatment than those grown without magnetic treatment.

The mean performance of chlorophyll concentration for control, S_1, MTW_1 S_2 and MTW_2 were 56.70, 48.10, 51.01, 38.75 and 42.52mg cm^{-2}. Genotypes No. 1 by 42.68, 13 by 41.74, 19 by 41.63 and 20 by 41.81mg cm^{-2} have an increase in chlorophyll concentration under 5,000ppm saline water (Table 5 and Fig. 4). Borzouel et. al. (2020) showed that salt-tolerant cultivar Bam seems to be more efficient in terms of higher chlorophyll index as compared with cultivar Toos, under salt stress. There was a significant increase in chlorophyll concentration by using magnetically treated 2,500ppm saline water by 6.03% and magnetically treated 5,000ppm saline water by 9.92% compared to two saline water treatments across two seasons. Genotypes No. 4, 18, 27, and 30 showed a better response to magnetically treated 5,000ppm saline water with an increase of 15.11, 14.11, 15.96 and 14.25% compared with 5,000ppm saline water treatment, respectively. These findings are in harmony with El Sayed (2014), Abd-Elrahman & Shalaby (2017) and Said et al. (2020), who found that chlorophyll concentration in wheat plant leaves decreased under saline stress while increased significantly under irrigation with magnetized water. It may be due to magnetized water's effect.

TABLE 4. Mean squares of the combined analysis of variance for all studied traits

S.o.v	D.F	Mean squares							
		Plant height	Spike length	No. of spikes/plant	Relative water content	Chlorophyll content	Canopy temp.	Biological yield/plant	Grain yield/plant
Year (Y)	1	245.86**	0.620*	0.876**	11004.45**	62.68**	190.72**	38.75**	73.68**
Error a	4	91.53	0.074	0.475	1525.28	39.16	37.10	8.11	18.27
Treat. (T)	4	16688.07**	201.51**	111.60**	15001.53**	9283.14**	2689.45**	4920.10**	691.79**
Y x T	4	12.74	0.034	1.61**	276.70**	14.48**	0.596	1.09	2.23**
Error b	16	4.89	0.076	0.594	110.81	22.93	27.64	3.83	2.71
Genotype (G)	31	943.01**	41.80**	21.61**	907.52**	111.35**	47.53**	414.80**	40.32**
Y x G	31	12.36**	0.194*	0.096	76.43**	1.98**	0.568**	2.90*	0.676**
T x G	124	126.73**	1.44**	0.976**	240.22**	27.21**	8.79**	23.17**	3.55**
Y x T x G	124	11.09**	0.179*	0.11	31.79**	1.68**	0.479**	2.06	0.396**
Pooled error	620	7.51	0.136	0.092	18.23	1.04	0.334	2.02	0.208
C.V. (%)		4.15	4.69	5.03	6.27	2.14	2.04	5.79	6.25

* & **: Significant at 5 % and 1 % levels of probability, respectively.

TABLE 5. Increased in mean performance of genotypes for relative water content and chlorophyll concentration traits over two seasons under magnetically- treated water (MTW) when compared with saline water treatments

Traits / Genotypes	Relative water content (%)							Chlorophyll concentration (mg cm^{-2})						
	Control	2500ppm	MTW 1	Increased (%)	5000ppm	MTW 2	Increased (%)	Control	2500ppm	MTW 1	Increased (%)	5000ppm	MTW 2	Increased (%)
Line 1	90.76	75.22	87.59	16.44	67.10	68.58	2.20	56.06	49.63	51.12	3.11	42.68	45.75	7.53
Line 2	75.75	71.75	77.97	8.66	68.77	71.26	3.62	59.34	50.75	54.56	7.49	39.89	44.56	11.71
Line 3	70.63	60.10	66.68	10.94	42.38	50.48	19.10	64.16	49.14	51.83	5.47	40.96	46.61	13.80
Line 4	80.91	66.24	69.86	5.47	49.92	50.51	1.18	55.04	48.42	51.24	5.82	38.15	43.91	15.11
Line 5	86.12	63.91	68.00	6.39	54.86	56.58	3.15	53.29	47.44	49.18	3.68	41.06	43.54	6.05
Line 6	89.20	68.65	80.67	17.50	52.91	56.13	6.08	58.06	49.37	56.14	13.71	36.93	41.79	13.18
Line 7	76.35	75.30	77.64	3.11	61.63	63.89	3.67	54.20	46.30	47.59	2.78	40.37	42.06	4.18
Line 8	89.63	58.78	70.48	19.90	52.47	55.23	5.26	57.58	48.11	52.38	8.87	40.66	42.84	5.35
Line 9	76.09	67.15	69.94	4.16	51.18	55.14	7.73	61.14	51.24	53.91	5.22	39.06	42.35	8.43
Line 10	83.06	67.37	69.05	2.51	63.44	66.64	5.04	57.82	46.85	48.88	4.35	36.04	40.35	11.98
Line 11	74.22	63.99	68.98	7.80	55.32	59.20	7.01	60.04	48.52	54.13	11.56	37.08	42.19	13.76
Line 12	78.82	66.26	69.16	4.37	59.64	63.85	7.05	55.92	45.69	47.74	4.48	34.34	38.45	11.99
Line 13	73.42	59.62	63.74	6.92	55.99	63.42	13.26	57.81	47.61	49.66	4.31	41.74	45.02	7.87
Line 14	84.17	68.92	69.73	1.18	52.92	53.08	0.30	59.70	48.99	53.09	8.36	41.39	46.27	11.79
Line 15	89.59	63.06	71.98	14.14	53.41	60.27	12.84	52.70	46.38	51.99	12.09	36.41	40.04	9.97
Line 16	79.57	57.38	61.98	8.02	45.81	50.70	10.67	51.91	45.44	47.09	3.63	31.58	35.59	12.70
Line 17	66.36	60.07	61.87	2.99	56.79	59.39	4.58	59.88	53.13	57.45	8.14	41.17	43.70	6.14
Line 18	81.67	54.10	61.12	12.98	50.37	54.70	8.59	62.53	49.21	50.82	3.28	39.84	45.46	14.11
Line 19	88.62	69.74	73.94	6.03	55.68	62.84	12.85	60.00	47.86	50.83	6.19	41.63	44.50	6.90
Line 20	82.61	74.93	76.87	2.59	57.42	59.18	3.07	51.67	49.72	51.20	2.98	41.81	46.30	10.74
Line 21	92.58	69.78	80.87	15.89	58.97	67.50	14.47	55.42	49.01	51.88	5.86	41.11	44.16	7.42
Line 22	81.09	49.96	57.17	14.44	39.63	47.08	18.80	58.21	46.39	48.33	4.19	32.49	36.81	13.29
Line 23	77.79	68.67	73.21	6.61	62.67	65.59	4.66	53.70	48.21	51.25	6.31	39.41	41.65	5.67
Line 24	72.04	65.00	66.29	1.98	60.28	61.66	2.29	63.29	47.59	49.77	4.59	34.76	39.02	12.25
Line 25	88.42	82.81	84.06	1.52	58.98	67.55	14.52	54.67	48.18	52.28	8.52	41.34	44.10	6.69
Line 26	73.08	68.83	69.92	1.59	64.26	66.05	2.79	58.25	48.19	49.84	3.41	40.26	42.97	6.72
Line 27	85.89	70.74	71.68	1.32	64.71	65.28	0.88	49.02	45.49	48.57	6.79	37.63	43.64	15.96
Line 28	72.93	71.74	80.57	12.30	56.11	62.81	11.93	55.99	49.24	51.55	4.69	37.71	42.87	13.70
Line 29	83.34	70.32	79.92	13.65	51.23	54.70	6.78	50.31	46.08	48.46	5.16	33.76	38.02	12.60
Line 30	89.84	81.13	83.25	2.61	78.43	80.12	2.16	54.79	46.55	50.16	7.75	35.81	40.91	14.25
Giza 168	82.19	65.53	74.01	12.94	56.26	61.22	8.81	56.68	46.90	50.01	6.63	41.34	42.29	2.30
Sids 12	84.77	63.99	70.75	10.56	52.40	60.03	14.58	57.22	49.55	51.34	3.63	43.52	44.99	3.37
Mean	**81.30**	**66.91**	**72.15**	**7.84**	**56.62**	**60.65**	**7.10**	**56.70**	**48.10**	**51.01**	**6.03**	**38.75**	**42.52**	**9.92**
RLSD $_{0.05}$	6.92	6.64	6.72		7.12	5.96		2.15	1.60	1.52		1.72	1.61	

TABLE 6. Increased in mean performance of genotypes for plant height and spike length traits over two seasons under magnetically-treated water (MTW) when compared with saline water treatments

Traits / Genotypes	Canopy temperature (°C)							Plant height (cm)						
	Control	2500ppm	MTW 1	Increased (%)	5000ppm	MTW 2	Increased (%)	Control	2500ppm	MTW 1	Increased (%)	5000ppm	MTW 2	Increased (%)
Line 1	21.25	28.16	25.38	-9.86	31.22	30.89	-1.03	75.35	65.23	68.19	4.54	51.10	57.85	13.21
Line 2	24.85	28.79	27.08	-5.93	35.93	30.66	-14.67	60.08	57.48	66.81	16.24	45.98	51.33	11.64
Line 3	24.29	29.86	27.62	-7.49	32.43	29.79	-8.16	86.61	59.07	70.17	18.78	40.75	47.67	16.97
Line 4	23.11	29.35	27.58	-6.04	31.75	30.08	-5.28	80.76	70.77	72.52	2.47	63.63	65.44	2.85
Line 5	25.41	29.77	27.98	-6.01	32.53	29.86	-8.21	78.17	66.44	69.48	4.58	55.02	60.65	10.22
Line 6	20.66	27.64	26.77	-3.15	31.97	28.94	-9.47	78.42	66.18	72.58	9.67	59.19	62.45	5.51
Line 7	21.60	27.02	25.48	-5.66	31.86	28.82	-9.54	77.90	65.06	67.17	3.23	51.76	53.44	3.24
Line 8	21.86	27.98	25.86	-7.58	32.77	28.73	-12.33	82.21	72.62	73.44	1.13	67.44	69.48	3.03
Line 9	22.85	29.14	26.83	-7.95	32.90	29.05	-11.71	81.27	63.65	68.52	7.66	58.58	60.78	3.76
Line 10	20.83	25.72	24.10	-6.31	32.73	27.53	-15.90	83.19	73.06	74.88	2.48	59.52	61.75	3.75
Line 11	19.74	26.50	23.78	-10.27	32.36	28.22	-12.79	85.60	70.47	72.39	2.73	59.24	63.25	6.77
Line 12	25.97	27.82	26.91	-3.25	31.68	30.24	-4.53	81.46	67.59	72.00	6.52	60.77	65.35	7.54
Line 13	22.50	29.06	27.70	-4.70	32.68	29.66	-9.23	77.40	62.13	66.36	6.82	53.60	59.00	10.07
Line 14	21.52	30.05	27.14	-9.68	32.65	30.88	-5.40	85.67	72.88	76.28	4.67	62.78	66.59	6.07
Line 15	23.78	31.08	29.95	-3.62	34.79	31.97	-8.09	94.74	81.56	83.33	2.17	62.55	67.27	7.54
Line 16	26.74	30.55	29.48	-3.50	34.03	30.83	-9.40	78.23	72.31	74.29	2.74	64.56	68.90	6.71
Line 17	24.12	31.36	28.62	-8.72	35.92	31.42	-12.53	71.90	60.90	68.75	12.90	33.33	39.54	18.64
Line 18	21.19	30.66	26.70	-12.91	33.71	30.66	-9.05	88.52	68.46	72.54	5.96	60.83	63.08	3.68
Line 19	24.98	29.89	26.36	-11.80	36.70	31.17	-15.08	80.04	66.38	73.63	10.92	56.10	64.08	14.22
Line 20	24.93	30.73	28.31	-7.87	36.60	32.50	-11.20	82.40	66.10	73.93	11.84	48.13	59.06	22.73
Line 21	21.22	30.23	27.56	-8.82	32.66	30.71	-5.96	60.95	57.29	60.10	4.91	41.18	50.88	23.56
Line 22	22.21	28.21	25.32	-10.26	34.43	30.90	-10.25	82.23	60.35	70.71	17.16	55.79	65.31	17.06
Line 23	20.24	31.08	27.14	-12.65	33.80	28.47	-15.78	65.35	61.10	65.50	7.19	43.98	51.94	18.10
Line 24	20.56	28.21	25.19	-10.69	31.54	29.12	-7.67	76.93	60.40	62.42	3.35	55.90	56.33	0.78
Line 25	22.25	27.67	24.68	-10.81	30.95	26.34	-14.91	99.67	59.29	60.13	1.41	47.33	54.77	15.71
Line 26	22.15	30.39	26.93	-11.41	32.54	29.00	-10.86	79.48	63.46	65.02	2.46	59.52	63.08	5.99
Line 27	25.89	29.00	26.05	-10.16	30.37	29.71	-2.17	76.25	63.21	65.94	4.32	50.79	58.50	15.18
Line 28	25.18	28.98	27.58	-4.83	31.36	29.62	-5.54	83.81	69.94	76.67	9.62	59.05	70.10	18.72
Line 29	26.77	30.56	27.83	-8.91	32.59	29.71	-8.84	73.58	65.56	71.08	8.42	53.67	62.46	16.38
Line 30	20.19	26.36	23.74	-9.94	32.15	29.04	-9.68	91.08	65.46	73.85	12.83	63.08	68.69	8.88
Giza 168	26.50	30.44	27.93	-8.25	34.28	29.48	-14.02	75.98	57.44	58.79	2.35	46.19	53.06	14.88
Sids 12	25.44	29.10	27.46	-5.64	34.26	30.50	-10.97	70.66	56.17	66.85	19.03	50.00	60.49	20.98
Mean	**23.15**	**29.10**	**26.78**	**-7.98**	**33.07**	**29.83**	**-9.79**	**79.43**	**65.38**	**69.73**	**6.66**	**54.45**	**61.58**	**13.10**
RLSD $_{0.05}$	1.05	1.53	1.35		1.17	1.29		3.93	3.56	4.51		3.64	3.79	

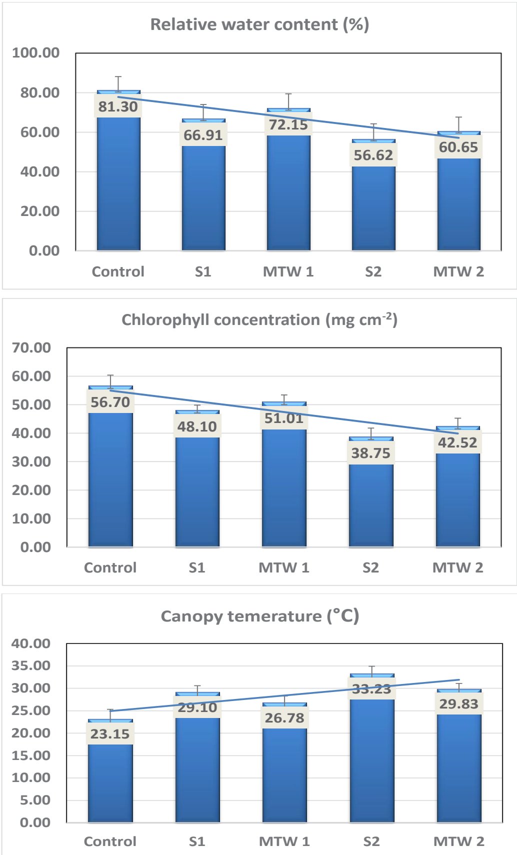

Fig. 4. Effects of control, saline, and magnetically-treated saline water on wheat genotypes using chlorophyll concentration, canopy temperature, and relative water content traits

The mean values of canopy temperature overall genotypes were 23.15, 29.10, 26.78, 33.07, and 29.83°C under control, S1, MTW 1, S2, and MTW 2 treatments (Table 6 and Fig. 4), respectively. It is clear that genotypes No. 1 (31.22°C), 25 (30.95°C), 27 (30.37°C) and 28 (31.36°C) have the lowest canopy temperature under higher salinity conditions, indicating that they are the most tolerant of salinity compared with other genotypes. The magnetically treated 2,500ppm and 5,000ppm saline water had positive effects on canopy temperature by -7.98% and -9.79% compared to the saline 1 and 2 treatments. Whereas genotypes No. 10, 19, 23, and 25 were the most significant response by magnetically treated 5000ppm saline water in canopy temperature with -15.90, -15.08, -15.78, and -14.91% compared with saline water treatment, respectively. Said et al. (2020) revealed that the magnetically treated 2,500 and 5,000ppm saline water had positive effects on canopy temperature by -6.14% and -3.93% compared with 2,500 and 5,000ppm saline water, respectively.

Agronomic traits

The average plant height was 79.43, 65.38, 69.73, 54.45 and 61.58cm, for tap water, 2500ppm, magnetically treated 2,500ppm, 5,000ppm and magnetically treated 5,000ppm saline water treatments, respectively (Fig. 5). Therefore, magnetically treated 2,500ppm and 5,000ppm saline water (Table 6) resulted in a 6.66% and 13.10% increase in plant height compared to irrigation with 2,500ppm and 5,000ppm saline water in both seasons. The genotypes No. 20, 21, 23, and 28 under magnetically treated 5000ppm saline water, indicating that they are the most responsive for plant height compared with 5000ppm saline water treatment with an increase of 22.73, 23.56, 18.10, and 18.72%, respectively. These results are in good agreement with De Souza et al. (2006), Nasher (2008) and Hozayn & Abdul Qados (2010a, b). Said et al. (2020) showed that the magnetically treated 2,500 and 5,000ppm saline water respectively resulted in 4.25% and 8.42% increase in plant height of wheat when compared to irrigation with saline water.

The overall mean number of spikes per plant among control, S_1, MTW_1 S_2 and MTW_2 treatments showed significant differences by 7.24, 5.95, 6.21, 5.28, and 5.51 spikes per plant, respectively (Fig. 5). The highest number of spikes per plant was observed for lines no. 2 (6.08), 11 (6.08), 14 (6.26), and 24 (6.91 spikes) under 5,000ppm saline water. Asgari et. al. (2011) revealed that number of spikes per plant of all wheat genotypes decreased significantly with increasing salinity levels and Kouhdasht and Atrak cultivars showed significantly higher number of spikes per plant values than Rasoul and Tajan cultivars under mid and high salinity. It is of interest to note that magnetically treated 2,500ppm and 5000ppm saline water increased the number of spikes per plant by 4.39% and 4.27%, respectively, as compared with 2,500ppm and 5,000ppm saline water (Table 7). The lines most responsive in the number of spikes/plant under magnetically treated 5,000 ppm saline water were 16, 21, 28, and 29 with an increase of 10.86, 10.51, 9.68, and 11.38% when compared with 5,000ppm saline water, respectively. These results according to El Sayed (2014) and Hozayn et al. (2016). Said et. al. (2020) found the positive impacts of magnetic saline water on number of spikes per plant of wheat in compared to that of control.

TABLE 7. Increased in mean performance of genotypes for spike length and number of spikes/plant traits over two seasons under magnetically-treated water (MTW) when compared with saline water treatments

Traits / Genotypes	Spike length (cm)							Number of spikes/plant						
	Control	2500ppm	MTW 1	Increased (%)	5000ppm	MTW 2	Increased (%)	Control	2500ppm	MTW 1	Increased (%)	5000ppm	MTW 2	Increased (%)
Line 1	9.38	7.60	8.47	11.40	6.47	6.90	6.70	8.32	6.62	6.65	0.50	5.86	5.90	0.76
Line 2	9.65	6.40	7.52	17.45	5.10	6.08	19.28	8.19	6.99	7.41	5.96	6.08	6.11	0.46
Line 3	9.32	8.60	8.97	4.26	6.98	7.03	0.72	8.68	6.68	6.74	0.92	5.52	5.52	0.00
Line 4	11.97	11.10	11.43	3.00	9.10	10.43	14.65	7.46	6.04	6.10	0.92	5.65	6.07	7.37
Line 5	10.65	9.62	10.78	12.13	7.57	8.38	10.79	6.64	5.21	5.71	9.60	4.87	4.92	1.14
Line 6	9.85	8.47	9.30	9.84	7.57	8.47	11.89	7.73	6.15	6.20	0.76	5.68	5.85	2.93
Line 7	11.08	9.63	9.68	0.52	7.65	7.68	0.44	5.99	4.75	4.80	1.17	4.36	4.61	5.74
Line 8	10.52	9.25	9.48	2.52	8.27	8.32	0.60	6.66	5.58	5.86	4.95	4.34	4.40	1.28
Line 9	7.57	6.60	6.70	1.52	5.80	6.07	4.60	6.85	6.16	6.41	4.06	5.77	5.77	0.00
Line 10	6.87	5.78	6.52	12.68	5.23	6.00	14.65	6.60	5.09	5.45	7.09	4.37	4.37	0.00
Line 11	8.73	7.43	8.03	8.07	6.47	7.40	14.43	8.25	6.44	6.52	1.29	6.08	6.17	1.37
Line 12	10.38	9.67	9.75	0.86	8.32	8.52	2.40	7.02	6.23	6.28	0.89	5.48	5.82	6.08
Line 13	8.82	7.65	8.00	4.58	6.58	6.98	6.08	8.30	7.20	7.40	2.70	5.59	5.82	3.97
Line 14	8.93	8.17	8.90	8.98	7.55	8.38	11.04	9.57	6.99	6.99	0.00	6.26	6.57	4.88
Line 15	7.73	6.47	7.27	12.37	6.52	7.52	15.35	8.90	6.71	7.32	9.11	5.64	5.78	2.46
Line 16	9.22	7.20	7.67	6.48	6.23	6.60	5.88	6.41	5.83	6.08	4.29	5.37	5.95	10.86
Line 17	7.50	5.45	6.05	11.01	3.68	4.04	9.55	7.11	6.86	7.44	8.50	5.67	5.74	1.27
Line 18	9.85	9.10	9.13	0.33	5.48	6.10	11.25	6.84	6.52	6.91	5.97	5.86	6.05	3.24
Line 19	9.40	7.48	7.50	0.22	6.32	6.77	7.12	7.93	6.28	6.69	6.64	5.42	5.72	5.64
Line 20	8.57	7.62	7.73	1.53	6.17	6.28	1.89	6.43	5.44	6.33	16.33	4.77	5.21	9.32
Line 21	8.60	8.08	8.58	6.19	5.43	6.05	11.35	6.26	5.93	6.60	11.24	5.55	6.13	10.51
Line 22	7.82	6.93	7.12	2.64	5.67	5.77	1.76	7.32	5.35	6.21	16.11	4.86	5.20	6.86
Line 23	7.90	6.60	6.83	3.54	5.45	6.08	11.62	7.29	5.14	5.48	6.48	5.01	5.43	8.31
Line 24	9.15	7.52	7.68	2.22	6.03	6.17	2.35	10.05	7.62	7.62	0.00	6.91	7.16	3.62
Line 25	9.43	8.18	8.33	1.83	6.57	7.00	6.60	9.06	7.11	7.11	0.00	5.97	6.06	1.40
Line 26	8.52	7.37	7.48	1.58	6.22	6.77	8.85	5.72	4.56	5.00	9.76	4.72	5.05	7.07
Line 27	8.02	6.32	6.68	5.80	4.65	5.03	8.24	6.65	5.54	5.59	1.00	5.41	5.41	0.00
Line 28	7.90	6.70	7.48	11.69	5.75	6.18	7.54	5.66	5.55	5.66	2.00	4.88	5.35	9.68
Line 29	10.50	9.45	9.57	1.23	7.37	8.42	14.25	4.90	4.26	4.90	14.99	3.66	4.08	11.38
Line 30	11.03	9.35	9.73	4.10	8.45	8.58	1.58	7.00	5.81	5.93	2.01	5.22	5.47	4.79
Giza 168	10.17	9.18	9.27	0.91	8.23	9.25	12.35	7.05	6.02	6.04	0.17	4.71	5.32	12.99
Sids 12	10.03	8.73	9.18	5.15	7.27	8.07	11.01	4.77	3.65	3.84	5.33	3.32	3.68	10.87
Mean	**9.22**	**7.93**	**8.34**	**5.18**	**6.57**	**7.10**	**8.18**	**7.24**	**5.95**	**6.21**	**4.39**	**5.28**	**5.51**	**4.27**
RLSD $_{0.05}$	0.58	0.50	0.53		0.48	0.47		0.55	0.42	0.38		0.47	0.40	

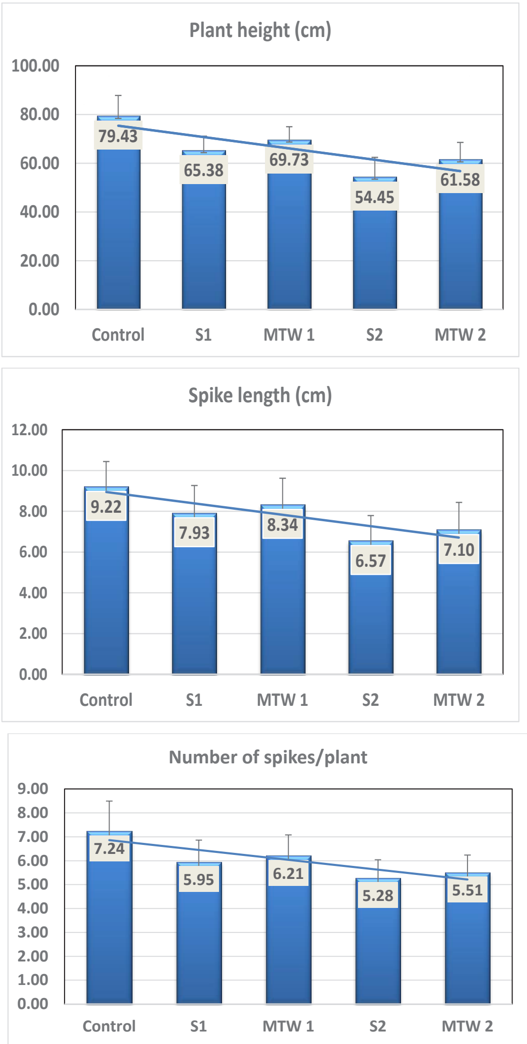

Fig. 5. Effects of control, saline, and magnetically-treated saline water on wheat genotypes by using plant height, spike length and the number of spikes/plant traits

The average spike length of wheat genotypes across control, S1, MTW 1, S2 and MTW 2 treatments (Fig. 5) in the two seasons were 9.22, 7.93, 8.34, 6.57 and 7.10cm, respectively. The most elongate spikes were found for lines no. 4, 8, 12 and 30 by 9.10, 8.27 8.32 and 80.45cm, respectively under 5,000ppm saline water. Asgari et. al. (2011) indicated that spike length of all wheat genotypes was decreased significantly by applying different levels of salinity as compared to control treatment and Kouhdasht genotype showed the significantly highest spike length under salt. Therefore, magnetically treated 2,500ppm and 5,000ppm saline water, respectively, resulted in a 5.18% and 8.18 % increase in spike length compared to irrigation with 2,500 ppm and 5,000ppm saline water (Table 7). Moreover, the highest increase in spike length under magnetically treated 5,000ppm saline water were found for lines no. 2, 4, 10 and 15 by 19.28, 14.65, 14.65 and 15.35%, respectively compared to 5,000ppm saline water treatment. The results are in harmony with those of Hozayn & Abdul Qados (2010a, b) and Alderfasi et al. (2016). Selim & Selim (2019) and Said et. al. (2020) showed that magnetic water application caused significant increases in spike length of wheat.

For biological yield, the mean performance over the two seasons recorded 32.59, 24.56, 25.82, 19.19 and 21.14g for control, S_1, MTW 1, S_2 and MTW 2 treatments, respectively. Lines no. 1, 21, 23 and 24 had the highest biological yield (25.25, 25.32, 21.99 and 23.44g, respectively) under 5,000 ppm saline water. The results are in harmony with those of Goudarzi & Pakniyat (2008) and Asgari et. al. (2011). There was a 5.13% and 10.57% increase in biological yield per plant by applying magnetically treated 2,500ppm and 5,000ppm saline water compared with the saline 1 and 2 treatments (Fig. 6 and Table 8). Furthermore, genotypes no. 1, 5, 17 and 27 are most responsive to magnetically treated 5,000ppm saline water with an increase of 17.04, 16.99, 17.89 and 24.14% compared with 5,000ppm saline water treatment, respectively. These results are in good agreement with Hozayn & Abdul Qados (2010a, b), El Sayed (2014), Hozayn et al. (2016) and Said et. al. (2020) who found the positive impacts of magnetic water on biological yield.

Data in Table 8 and Fig. 6 indicates that the mean grain yield per plant over all genotypes was for tap water, 2,500ppm saline water, magnetically treated 2,500ppm saline water, 5000ppm saline water and magnetically treated 5,000ppm saline water treatments were 10.15, 7.36, 7.84, 5.38 and 5.79g, respectively. However, there were significant differences between genotypes for grain yield by applying magnetically treated water 2,500ppm and 5,000ppm. As the magnetic treatment of 2,500 and 5,000ppm saline water increased grain yield by 6.89% and 7.94% when compared with 2,500ppm and 5,000ppm saline water treatments, respectively (Table 8). These results in accordance with Hozayn & Abdul Qados (2010a, b), Hozayn et al. (2016), Ibrahim et al. (2016) and Hachicha et al. (2018), who found that the grain yield increased significantly under magnetic irrigation. Hilal & Helal (2003)

TABLE 8. Increased in mean performance of genotypes for biological yield/plant and grain yield/plant traits over two seasons under magnetically-treated water (MTW) when compared with saline water treatments and stress sensitivity index (SSI)

Traits / Genotypes	Biological yield/plant (gm)							Grain yield/plant (gm)								
	Control	2500ppm	MTW 1	Increased (%)	5000ppm	MTW 2	Increased (%)	Control	2500ppm	SSI	MTW 1	Increased (%)	5000ppm	SSI	MTW 2	Increased (%)
Line 1	45.03	34.86	34.95	0.24	25.25	29.55	17.04	13.06	9.82	0.89	9.89	0.65	7.25	0.96	8.09	11.63
Line 2	32.13	27.78	30.79	10.82	20.41	21.74	6.51	9.68	8.68	0.37	9.46	8.95	6.00	0.79	6.14	2.26
Line 3	37.49	30.53	30.86	1.08	21.89	23.50	7.34	9.21	7.21	0.77	7.92	9.78	6.13	0.76	6.56	6.92
Line 4	29.64	24.39	25.42	4.20	19.36	20.82	7.55	10.63	8.38	0.76	8.67	3.47	6.74	0.79	7.27	7.90
Line 5	24.74	18.70	20.57	10.01	13.16	15.40	16.99	8.38	5.97	1.03	6.37	6.70	4.29	1.04	4.65	8.35
Line 6	31.64	25.55	25.71	0.65	19.54	21.11	8.07	14.14	9.11	1.27	9.45	3.79	6.72	1.09	7.12	5.99
Line 7	27.97	19.83	20.83	5.09	17.24	18.84	9.25	10.57	7.76	0.95	7.85	1.12	6.04	0.87	6.08	0.63
Line 8	32.51	26.09	27.10	3.88	18.21	18.34	0.72	9.52	7.63	0.71	7.95	4.17	3.84	1.24	3.95	2.84
Line 9	40.39	24.85	26.94	8.40	20.80	20.99	0.90	9.00	8.35	0.26	8.49	1.60	6.77	0.57	6.86	1.32
Line 10	36.30	26.30	26.81	1.97	20.79	21.29	2.38	8.43	6.05	1.01	6.67	10.17	3.58	1.18	3.79	5.72
Line 11	34.88	27.34	27.68	1.25	19.49	19.52	0.17	10.68	8.60	0.69	8.93	3.78	6.60	0.78	7.12	7.87
Line 12	24.53	19.90	21.50	8.05	16.73	18.82	12.45	8.49	7.19	0.55	7.21	0.28	4.38	1.00	4.49	2.37
Line 13	22.55	16.18	18.25	12.85	12.11	13.78	13.79	9.15	7.30	0.72	7.79	6.72	4.75	1.03	5.04	6.17
Line 14	28.84	18.33	19.47	6.20	15.98	18.39	15.12	12.67	7.47	1.47	7.81	4.58	5.45	1.19	5.78	6.13
Line 15	34.21	26.21	26.97	2.90	19.06	21.66	13.61	12.27	5.94	1.84	6.49	9.24	4.29	1.39	4.98	16.14
Line 16	26.52	22.04	24.46	10.99	19.85	22.52	13.43	9.05	6.98	0.82	7.64	9.34	6.18	0.75	6.41	3.69
Line 17	38.10	27.11	29.22	7.81	19.83	23.37	17.89	9.12	6.70	0.95	7.69	14.80	4.04	1.14	4.34	7.25
Line 18	33.64	29.49	30.46	3.28	21.91	24.06	9.85	10.26	8.99	0.38	9.18	2.11	6.42	0.79	6.46	0.63
Line 19	30.38	23.18	25.63	10.55	20.08	21.91	9.14	10.93	6.41	1.48	6.96	8.51	4.83	1.17	5.36	11.02
Line 20	30.45	20.66	23.10	11.83	15.12	17.53	15.97	7.87	5.91	0.89	7.01	18.63	4.47	0.90	5.10	14.04
Line 21	37.53	29.01	29.07	0.18	25.32	26.26	3.69	8.87	7.20	0.67	7.53	4.50	5.72	0.82	6.34	10.79
Line 22	38.67	25.78	26.22	1.69	20.14	22.98	14.11	11.37	5.97	1.70	6.35	6.35	4.13	1.32	4.36	5.38
Line 23	39.14	27.86	29.01	4.11	21.99	22.51	2.34	9.93	6.60	1.20	7.49	13.44	4.61	1.12	5.49	19.00
Line 24	40.84	27.15	28.95	6.64	23.44	23.56	0.53	14.89	8.34	1.57	8.87	6.37	6.49	1.16	6.81	4.94
Line 25	34.84	23.25	24.15	3.86	17.85	20.81	16.55	13.13	9.37	1.02	10.19	8.81	6.80	0.99	7.47	9.84
Line 26	31.11	22.71	25.32	11.49	16.70	19.49	16.67	10.64	8.39	0.76	9.28	10.61	6.34	0.87	6.74	6.35
Line 27	27.58	19.78	20.09	1.60	15.44	19.17	24.14	7.80	5.85	0.89	6.30	7.69	4.35	0.93	5.01	15.31
Line 28	28.66	20.73	21.58	4.09	14.84	17.29	16.57	8.07	5.72	1.04	6.31	10.22	4.20	1.00	4.88	16.04
Line 29	25.66	21.48	22.60	5.18	18.50	20.61	11.43	6.48	5.32	0.64	5.77	8.46	3.43	1.06	4.09	19.07
Line 30	28.14	21.78	23.40	7.43	19.16	19.89	3.79	10.42	7.32	1.06	7.75	5.82	5.11	1.06	5.35	4.67
Giza 168	35.90	28.01	29.39	4.92	22.65	25.96	14.62	9.88	7.59	0.99	8.26	8.88	6.09	0.97	6.58	8.18
Sids 12	32.76	29.16	29.83	2.30	21.32	24.65	15.58	10.26	7.24	1.17	7.32	1.07	6.19	1.03	6.53	5.62
Mean	**32.59**	**24.56**	**25.82**	**5.13**	**19.19**	**21.14**	**10.57**	**10.15**	**7.36**		**7.84**	**6.89**	**5.38**		**5.79**	**7.94**
$RLSD_{0.05}$	2.59	1.88	1.57		1.79	2.18		0.78	0.91		0.62		0.81		0.65	

reported that MTW has been utilized to improve yielding conditions of soil with high salinity and calcification, where significant enhancement in the yield were obtained for tomato, pepper, maize and wheat. Moreover, Selim et. al. (2019) indicated that the grain production increased in both wheat cultivars when using magnetic water. In addition, Said et. al. (2020) revealed that the magnetically treated 2,500 and 5,000ppm saline water had positive effects on grain yield per plant by 9.94 and 5.41% when compared with saline water treatments, respectively.

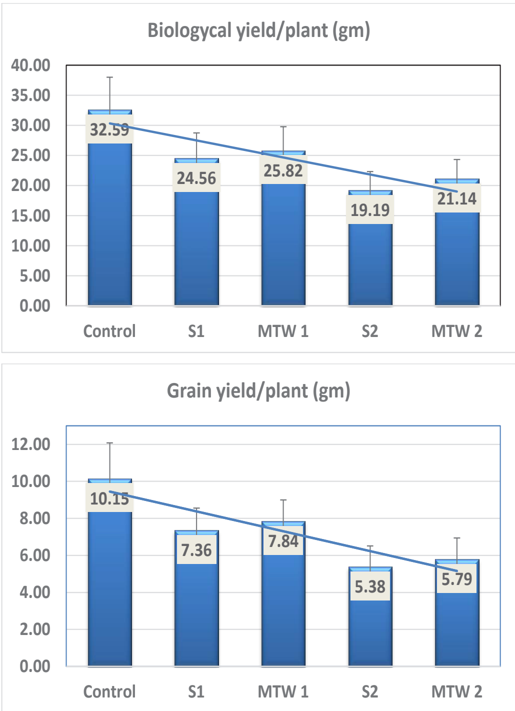

Fig. 6. Effects of control, saline and magnetically-treated saline water on wheat genotypes on biological yield/plant and grain yield/plant traits

Based on grain yield, a great of variation was seen between the 32 investigated wheat genotypes with regard to the stress susceptibility index (SSI) under saline conditions (Table 6). According to SSI, genotypes that have an index smaller than one (<1) are considered to be stress tolerant. Meanwhile, genotypes that have stress index greater than one (>1) are susceptible. Under the highest-level salinity (5,000ppm), SSI over the two years ranged from 0.57 for Line 9 to 1.39 for Line 15 and Lines 9, 16, 3 recorded the lowest value of SSI (0.57, 0.75 and 0.76, respectively) so we can conclude that they are relatively salt tolerant genotypes compared to other wheat genotypes, followed by lines 2, 4, 7, 11, 18 and 21 (ranged from 0.79 to 0.87). On the other hand, lines 10, 14, 17, 19, 22, 23 and 24 had the highest values for SSI (ranged from 1.12 to 1.32). Therefore, they are the lowest salt tolerant lines. Hamam & Negim (2014) and Gadallah et al. (2017) reported that the mean SSI over two seasons appeared to be a suitable selection index to distinguish resistant genotypes. SSI has been widely used by researchers to identify sensitive and resistant genotypes (Clarke et al., 1992).

Conclusions

Based on our results, the salinity susceptibility index (SSI) revealed that the genotypes 9, 16, 3 recorded the lowest value of SSI (0.57, 0.75, and 0.76, respectively), showing that they are relatively salt tolerant genotypes as compared to other wheat genotypes. Mean values of soil soluble cations and anions irrigated with treated magnetic water (MTW) were significantly less than irrigated with untreated magnetic water (having salinity of 2500 and 5000ppm). Moreover, the magnetic treatment of irrigation water resulted in improvement of the physiological traits viz., relative water content, chlorophyll concentration and canopy temperature, plant growth viz., plant height as well as yield and its components such as biological yield/plant, spike length and the number of spikes/plant. Hence, magnetic technology could be a promising technique for agricultural improvements and can be recommended for farmers, but extensive research is needed on different crops to overcome the practical challenges and gain knowledge in using MTW that affects crops besides, this technique is considered an environmentally friendly.

Reference

Abd-Elrahman, S.H., Shalaby, O.A. (2017) Response of wheat plants to irrigation with magnetized water under Egyptian soil conditions. *Egyptian Journal of Soil Science,* **57**(4), 477-488.

Alderfasi, A.A., Al-Suhaibani, N.A., Selim, M.M., Al-Hammad, B.A.A. (2016) Using magnetic technologies in management of water irrigation programs under arid and semi-arid ecosystem. *Advances in Plants & Agriculture Research,* **3**(4), 109–116.

Al-Khazan, M., Abdullatif, B.M., Al-Assaf, N. (2011) Effects of magnetically treated water on water status, chlorophyll pigments and some elements content of jojoba (*Simmondsia chinensis* L.) at different growth stages. *African Journal of Environmental Science and Technology,* **5**(9), 722-731.

Al-Naggar, A.M.M., Sabry, S.R.S., Atta, M.M.M., El-Aleem, O.M.A. (2015) Effects of salinity on performance, heritability, selection gain and correlations in wheat (*Triticum aestivum* L.) doubled haploids. *Scientia,* **10**(2), 70-83.

Asgari, H.R., Cornelis, W., Van Damme, P. (2011) Effect of salinity on wheat (*Triticum aestivum* L.) grain yield, yield components and ion uptake. *Desert*, **16**, 169-175.

Bartlett, M.S. (1937) Properties of Sufficiency and Statistical Tests, Proc. R. Soc. London, Ser. A 160: pp. 268–282.

Borzouel, A., Shalmani, M.A.A., Eskandari, A. (2020) Effects of salt and nitrogen on physiological indices and carbon isotope discrimination of wheat cultivars in the northeast of Iran. *Journal of Integrative Agriculture,* **19**(3), 656–667.

Chang, K., Weng, C. (2006) The effect of an external magnetic field on the structure of liquid water using molecular dynamics simulation. *Journal of Applied Physics,* **100**, 043917.

Cho, Y.I., Lee, S. (2005) Reduction of the surface tension of water due to physical water treatment for fouling control in heat exchangers. *International Communication in Heat and Mass Transfer,* **32**, 1-9.

Clarke, J.M., De Pauw, R.M., Townley-Smith, T.M. (1992) Evaluation of methods for quantification of drought tolerance in wheat. *Crop Science*, **32**, 728–732.

De Souza, A., Garci, D., Sueiro, L., Gilart, F., Porras, E., Licea, L. (2006) Presowing magnetic treatments of tomato seeds increase the growth and yield of shoots. *Bioelectromagnetics,* **27**, 247- 257.

El-Rawi, K., Khalafalla, A.M. (1980) Design and analysis of agricultural experiments. El Mousel Univ., Iraq, 19p.

El Sayed, H.E.A. (2014) Impact of magnetic water irrigation for improve the growth, chemical composition and yield production of broad bean (*Vicia faba* L.) Plant. *American Journal of Experimental Agriculture,* **4**(4), 476-496.

Fischer, R.A., Maurer, R. (1978) Drought resistance in spring wheat cultivars. I. Grain yield responses. *Crop and Pasture Science,* **29**(5), 897-912.

Gadallah, M.A., Milad, S.I., Mabrook, Y.M., Abo Yossef, A.Y., Gouda, M.A. (2017) Evaluation of some Egyptian bread wheat (*Triticum aestivum* L.) cultivars under salinity Stress. *Alexandria Science Exchange Journal,* **38**(2), 259-270.

Gang, N., St-Pierre, L.S., Persinger, M.A. (2012) Water dynamics following treatment by one hour of 0.16 tesla static magnetic fields depends on exposure volume. *Water*, **3**, 122-131.

Gomez, K.A., Gomez, A.A. (1984) "*Statistical Procedures for Agricultural Research*", 2nd ed., John Wiley and Sons, New York, USA.

Goudarzi, M., Pakniyat, H. (2008) Evaluation of wheat cultivars under salinity stress based on some agronomic and physiological traits. *Journal of Agriculture and Social Sciences,* **4**(3), 35-38.

Grewal, H.S., Maheshwari, B.L. (2011) Magnetic treatment of irrigation water and snow pea and chickpea seeds enhances early growth and nutrient contents of seedlings. *Bioelectromagnetics,* **32**, 58-65.

Hachicha M., Kahlaoui, B., Khamassi, N., Misle, E., Jouzdan, O. (2018) Effect of electromagnetic treatment of saline water on soil and crios. *Journal of the Saudi Society of Agricultural Sciences,* **17**, 154-162.

Hamam, K.A., Negim, O. (2014) Evaluation of wheat genotypes and some soil properties under saline water irrigation. *Annals of Agricultural Sciences,* **59**(2), 165- 176.

Hilal, M.H., Hilal, M.M. (2000) Application of magnetic technologies in desert agriculture. II-Effect of magnetic treatments of irrigation water on water on salt distribution in olive and citrus field and induced changes of ionic balance in soil and plant. *Egyptian Journal of Soil Science,* **40**(3), 423–435.

Hilal, M.H., Helal, M.M. (2003) Application of magnetic technologies in desert agriculture. Seed germination and seedling emergence of some crops in a saline calcareous soil. In: *Proc. II In. Conf.*

Impact of Electromagnetic Fields in the Agricultural Environment, Agrolaser, September 8–10, Lublin, Poland.

Hilal, M.H., El-Fakhrani, Y.M., Mabrouk, S.S., Mohamed, A.I., Ebead, B.M. (2013) Effect of magnetic treated irrigation water on salt removal from a sandy soil and on the availability of certain nutrients. *International Journal of Engineering and Applied Sciences*, **2**(2), 36-44.

Hozayn, M., Abdul Qados, A.M.S.A. (2010a) Irrigation with magnetized water enhances growth, chemical constituent and yield of chickpea (*Cicer arietinum* L.). *Agriculture and Biology Journal of North America,* **1**(4), 671-676.

Hozayn, M., Abdul Qados, A.M.S.A. (2010b) Magnetic water application for improving wheat (*Triticum aestivum* L.) crop production. *Agriculture and Biology Journal of North America*, **1**(4), 677-682.

Hozayn M., Abdallha, M.M., Abd El-Monem, A.A., El-Saady, A.A., Darwish, M.A. (2016) Applications of magnetic technology in agriculture: A novel tool for improving crop productivity (1): Canola. *African Journal of Agricultural Research,* **11**(5), 441-449.

Ibrahim, I., Al-Mashhadani, H., Rasheed, Kh.A., Ismail, E.N., Hassan, S.M. (2016) Effect of magnetic water treatment on salt tolerance of selected wheat cultivars. *Journal of International Environmental Application & Science,* **11**(1), 105-109.

Maas, E.V., Hoffman, G.J. (1977) Crop salt tolerance–current assessment. *Journal of the Irrigation and Drainage Division of the American Society of Civil Engineering,* **103**, 115–134.

Maheshwari, L.B. (2009) Magnetic treatment of irrigation water: Evaluation of its effects on vegetable crop yield and water productivity. *Ph. D Thesis*, University of Western Sydney, School of Environ., and Agriculture, Australia.

Mohamed, A.I. (2013) Effects of magnetized low quality water on some soil properties and plant growth. *International Journal of Research in Chemistry and Environment,* **3**(2), 140-147.

Mostafazadeh-Fard, B., Khoshravesh, M., Mousavi, S.F., Kiani, A.R. (2011) Effects of magnetized water and irrigation water salinity on soil moisture distribution in trickle irrigation. *Journal of Irrigation and Drainage Engineering,* **137**(6), 398–402.

Munns, R., James, R.A., Lauchli, A. (2006) Approaches to increasing the salt tolerance of wheat and other cereals. *Journal of Experimental Botany*, **57**(5), 1025–1043.

Nasher, S.H. (2008) The Effect of magnetic water on growth of chickpea seeds. *Engineering and Technology*, **26**(9), 4 pages.

Page, A.L., Miller, R.H., Keeney, D.R. (1982) "*Methods of Soil Analysis*. *Part 2: Chemical and Microbiological Analysis*". Am. Soc., Madison, Wisconsin, USA.

Sadeghipour, O. (2016) The effect of magnetized water on physiological and agronomic traits of cowpea (*Vigna unguiculata* L.). *International Journal of Research in Chemical, Metallurgical and Civil Engineering,* **3**(2), 195-198.

Said, A.A., Motawea, M.H., Mustafa, A.A., Fawzy, Y. (2020) The effect of saline water magnetization on physiological and agronomic traits of some bread wheat genotypes. *SVU-International Journal of Agricultural Sciences,* **2**(2), 356-377.

SAS (2008) Statistical Analysis System. Version 9.2, SAS Institute Inc., Cary, NC., USA.

Schonfeld, M.A., Johnson, R.C., Carver, B.F., Mornhinweg, D.W. (1988) Water relations in winter wheat as drought resistance indicators. *Crop Science,* **28**, 526-531.

Selim, A.H., Selim, D.A.H. (2019) Physio-biochemical behaviour, water use efficiency and productivity of wheat plants exposed to magnetic field. *Journal of Plant Production Mansoura University,* **10**(2), 185-191.

Selim, D.A.H., Nassar, R.M.A., Boghdady, M.S., Bonfill, M. (2019) Physiological and anatomical studies of two wheat cultivars irrigated with magnetic water under drought stress conditions. *Plant Physiology and Biochemistry,* **135**, 480–488.

Yadava, T., Kumara, A., Yadava, R.K., Yadava, G., Kumarb, R., Kushwaha, M. (2020) Salicylic acid and thiourea mitigate the salinity and drought stress on physiological traits governing yield in pearl millet-wheat. *Saudi Journal of Biological Sciences,* **27**, 2010–2017.

تأثير الملوحة والمياه المالحة المعالجة مغناطيسيا على الصفات الفسيولوجية والمحصولية لبعض التراكيب الوراثية لقمح الخبز

علاء على سعيد[1]، عبد الرحمن عبد الواحد مصطفى[2]، الحسين حمادة[3]
[1]قسم المحاصيل– كلية الزراعة – جامعة سوهاج – سوهاج – مصر ، و[2]قسم الأراضي والمياه – كلية الزراعة- جامعة سوهاج – سوهاج – مصر ، [3]قسم المحاصيل - كلية الزراعة - جامعة أسيوط –أسيوط - مصر .

أجريت هذه الدراسة لتقدير تأثير المياه المالحة والمياه المالحة المعالجة مغناطيسيا على الصفات الفسيولوجية والمحصولية لـ32 تركيب وراثي من قمح الخبز وأيضا لتحديد التغيرات في خواص التربة. حيث تمت زراعة هذه التراكيب الوراثية في تجربة أصص تحت ظروف الصوبة السلكية خلال مواسم الزراعة الشتوية 2017/2018 و2018/2019 في مزرعة كلية الزراعة، بالكوثر، جامعة سوهاج، سوهاج، مصر وتم تطبيق خمس معاملات ري وهما:

1. مياه الصنبور (كنترول)
2. مستوي ملوحة (2500 جزء في المليون)
3. مستوي ملوحة (5000 جزء في المليون)
4. المياه المالحة المعالجة مغناطيسيا (2500 جزء في المليون)
5. المياه المالحة المعالجة مغناطيسيا (5000 جزء في المليون)

أظهرت النتائج من خلال معامل الحساسية للإجهاد الملوحي أن التراكيب الوراثية رقم 9 و16 و3 سجلت أقل قيم 0.57 و0.75 و0.76 على التوالي، مما يدل على أنها أعلى سلالات مقاومة للملوحة ولم تختلف بشكل كبير عن الأصناف سدس 12 وجيزة 168.

كما أظهرت النتائج أن قيم الكاتيونات والأنيونات الذائبة في التربة كانت أقل بشكل معنوي تحت المياه المالحة المعالجة مغناطيسيا. علاوة على ذلك كان للمياه المالحة المعالجة مغناطيسيا تأثير إيجابي على المحتوى المائي النسبي للأوراق بنسبة 7.84 و7.10%، وتركيز الكلوروفيل بالأوراق بنسبة 6.03 و9.92% وكذلك انخفضت درجة حرارة الاوراق بنسبة 7.98 و10.23% على التوالي مقارنة مع 2500 و5000 جزء في المليون من المياه المالحة.

كذلك أظهرت النتائج زيادة في ارتفاع النبات إلى 6.66 و13.10% و4.39 و4.27% لعدد السنابل/ نبات و5.18 و8.18% لطول السنبلة و5.13 و10.57% للمحصول البيولوجي/ نبات و6.89 و7.94% لمحصول الحبوب/ نبات تحت المياه المالحة المعالجة مغناطيسيا على التوالي مقارنة مع 2500 و5000 جزء في المليون من المياه المالحة. لكن في الواقع، هناك حاجة إلى مزيد من الدراسات على تأثيرات المياه المغناطيسية على نمو وإنتاجية وجودة المحاصيل المختلفة الأخرى.