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Applications of magnetic technology in agriculture, a novel tool for improving water use efficiency and crop productivity: 2. wheat

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Abstract: Today, produce more food from less water is considered the main target for agriculture scientist, particularly in arid and semi-arid regions like Egypt which suffer from water scarcity. So, they tested common and un-common factors i.e., magnetic water treatment. Utilization of magnetic water technology is considered as a promising technique to improve water use efficiency and crop productivity. Two field trials using wheat (var. Sakha-93) were conducted at Research and Production Station, National Research Centre, Alemam Malek Village, Al Nubaria district, Al Behaira Governorate, Egypt (newly reclaimed sandy soil arid or semi- arid region) in 2011/12 and 2012/13 winter seasons to study and evaluate the effects of magnetizing irrigation water on growth, chemical constituent and wheat yield and its components. Control treatment was irrigated with normal water, while the other treatment (magnetized water) was irrigated with water after magnetization through a two inch Magnetron [A-200-DSM, 2 inch, Magnetic Technologies LLC PO Box 27559, Dubai, UAE].The results showed significant positive effects of magnetic treatment of water on some morphological criteria, some biochemical parameters and grain yield quantity and quality of wheat plant. In general, all growth parameters increased by magnetized water treatment (plant height, tiller fresh & dry weight and water contents) and concomitantly with an increase in the levels of photosynthetic pigments, yield components and nutritional values (N, P, Ca, Mg, Fe) and total amino acids and essential amino acids of the yielded grains. Moreover, Water-Use Efficiency (WUE) increased as a result of irrigation by 13 % compared to control treatment. Thus, the present results have shown that irrigation with MTW can be considered as one of the most valuable modern technologies that can assist in saving irrigation water.
Keywords: Magnetic water, Wheat, Growth, Yield, Quality, Water Use Efficiency, Sandy soil.

Introduction

Today, produce more food from less water is considered the main target for agriculture scientist, particularly in arid and semi-arid regions like Egypt which suffer from water scarcity. So, they tested common and un-common factors i.e., magnetic water treatment. Utilization of magnetic water technology is considered as a promising technique to improve water use efficiency and crop productivity. One of the ways by which we can reduce the total water used for irrigation is to employ practices that improve crop yield per unit volume of water used (i.e., water productivity). There have been some claims made that the magnetic treatment of irrigation water can improve water productivity[1]. If those claims are valid, there is scope for magnetic treatment of water to save water supplies and assist in coping with the future water scarcity.

The water treated by the magnetic field or pass through a magnetic device called magnetized water. Magnetic fields (MF) induce electric potential that exerts cellular stress causing biochemical, physical and physiological changes in cellular structures and functions in living systems. In higher plants, MF has been shown to induce stress effects[2,3]. The use of magnetically treated water for irrigation in agriculture takes an important place in the list of environmentally clean methods[4,5]. The influence of magnetic field on various growth processes of plants such as seed germination, seedling growth, plant growth, yield and the properties of crop quality have been the object of several researches[6,7]. Magnetic field changed the characteristics of cell membrane, effected the cell reproduction and caused some changes in cell metabolism. At the same time, it was put forward that magnetic field affected the growth characteristics and various functions like mRNA quality, gene expression, protein biosynthesis and enzyme activities and caused the changes concerning the various functions at the organ and tissue levels[8]. The reason of this effect can be searched in the presence of paramagnetic properties in chloroplast which can cause an acceleration of seeds metabolism by magnetic treatment[9]. In addition to, there were magnetic field increased yield and yield parameters of crops like, wheat and sugar beet[10,11]. It is important to carry on the determination of the biological effects formed in plants by magnetic field studies. Magnetic field plays an important role in cations uptake capacity and has a positive effect on immobile plant nutrient uptake which raises the products nutrition value of date palm[12]. MF increases nitrogen and ions uptake by plants[13] and plant chlorophyll content[8]. In addition, MF has been shown to increase the release of free radicals that are known to damage cellular macromolecules and their activities[3]. During adaptation to various types of environmental stress, plants accumulate cellular solutes[14]. The cellular solutes include quaternary amino acid derivatives such as proline, glycine betaine, alanine betaine, and proline betaine[15] .

Utilization of magnetic water technology is considered as a promising technique to improve water use efficiency and crop productivity. Increasing water use efficiency (WUE) associated with crop production is a way for arid and semi-arid areas to increase their agricultural production where there is little or no prospect for expansion of water resources[16]. Similarly, *Ayars et al.* (2006) suggested that WUE is a mechanism underlying plant resilience to water deficits prospects for water saving agriculture[17].

In the present study, we investigated the effects of magnetic water on the growth, yield and some chemical composition and nutritional quality of wheat plants and increase water use efficiency (WUE), under arid regions condition.

Materials and Methods

Two field trials using wheat (var. Sakha-93) were conducted at Research and Production Station, National Research Centre, Alemam Malek Village, Al Nubaria district, Al Behaira Governorate, Egypt in 20011/12 and 2012/13winter seasons to study and evaluate the effects of magnetizing irrigation water on growth, chemical constituent and wheat yield and its components. The experimental soil and water were analyzed according to the method described by[18] (Tables 1).

Table 1. Soil and water analysis of site experiments.

	Soil depth			Water	
Parameters	**0-15**	**15-30**	**30-45**	**Before**	**after**
Particle size distribution					
Coarse sand	48.2	54.75		..	..
Fine sand	49.11	41.46		..	..
Clay + Silt	2.69	3.82		..	..
Texture	Sandy	Sandy	Sandy	..	..
PH (1:2.5)	8.22	7.94	8.06	7.55	7.13
EC(dSm^{-1})(1:5)	0.20	0.15	0.10	0.5	0.4
Organic matter (%)	0.67	0.43	0.40	…	
Soluble cations (mq/l)					
Ca^{++}	0.60	0.50	0.30	1.50	2.05
Mg^{++}	0.50	0.30	0.20	0.60	0.65
Na^{++}	0.90	0.80	0.50	2.50	3.00
K^{+}	0.20	0.10	0.01	0.20	0.31
Soluble anions (mq/l)					
CO^{-3}	-	-	-	0.01	0.01
HCO^{-3}	0.60	0.40	0.20	1.20	2.46
Cl^{-}	0.75	0.70	0.60	2.80	1.72
SO^{-4}	0.85	0.60	0.21	0.80	1.82

Cultivation method and layout of Experiment:

Grains of wheat were obtained from Wheat Research Department, Field Crop Research Institute, Agriculture Research Centre, Giza, Egypt. Recommended rate of wheat grain was planted in plots (10 length m x 12 m width) at the first week of November. Control treatment was irrigated with normal water, while the other treatment (magnetized water) was irrigated with water after magnetization through a two inch Magnetron [A-200-DSM, 2 inch, Magnetic Technologies LLC PO Box 27559, Dubai, UAE]. Four replications were used in each treatment. The recommended NPK fertilizers for wheat crop were applied through the period of experiment. Sprinkler irrigation was applied as plants needed. The layout of experiment was shown in (Fig. 1).

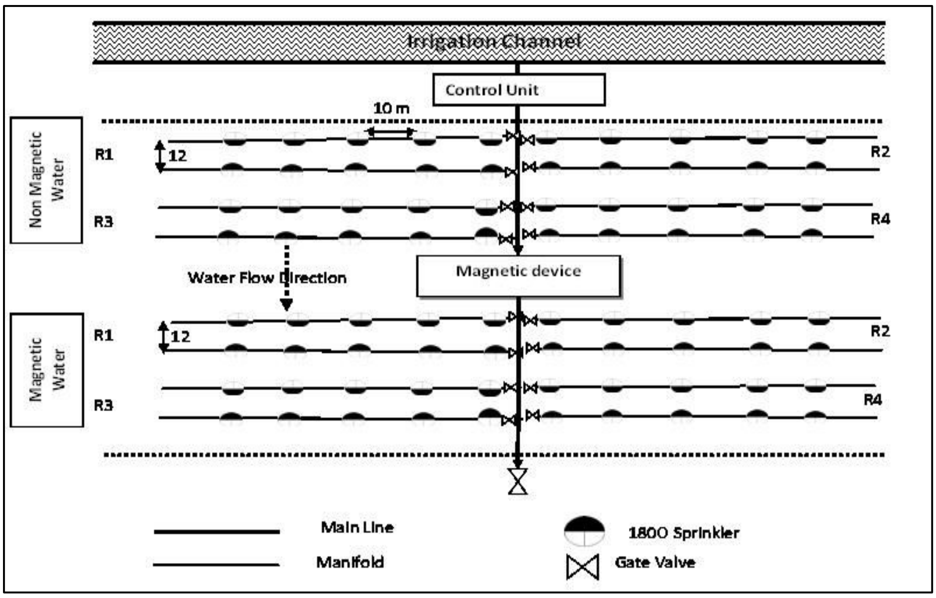


Figure 1: Layout of experiment design under solid set sprinkler system

Data Recorded:

Growth parameters:

After 85 days from sowing plant height, fresh and oven dry weight of 10 plants from each treatment were determined. Water content was determined according to[19] using the following formula: WC = 100× (fresh mass – dry mass)/fresh mass.

Photosynthetic Pigments:

Total chlorophyll a and b and carotenoids contents in fresh leaves were estimated using the method by [20]. The fresh tissue was ground in a mortar and pestles using 80% acetone. The optical density (OD) of the solution was recorded at 662 and 645 nm (for chlorophyll a and b, respectively) and 470 nm (for carotenoids) using a spectrophotometer (Shimadzu UV-1700, Tokyo, Japan). The values of photosynthetic pigments were expressed in mg/100g FW. At harvest yield, yield components and quality of Canola crop were determined.

Yield and yield components:

At harvest stage, One square meter from each plot was counted to determine number of spikes/m^2 , plant height, number of spikelet and grains per spike, length and weight of spike, grains weight of spike and 100–grains weight were determined from randomly selected 20 tillers from each plot. Wheat was threshed manually to determine grains, straw and biological yield per plot (10 x 12m) that was converted into ton per fed. Harvest and crop indexes were calculated by dividing seed yield/biological yield and straw yield, respectively.

Water-Use Efficiency (WUE):

WUE values were calculated with the fowling Eqs.[21] **.**

$$\text{WUE} = \left(\frac{E_y}{E_t}\right) \times 100$$

Where WUE is the Water Use Efficiency (kg/m^3); E_y is the economical yield (kg/fed./season); E_t is the total Applied of irrigation water, m^3/fed./season

Estimation of amino acids:

Amino acids compositions of wheat protein were hydrolysis according to Catalog of amino acid analyzer (1999) LC 3000 as follow: 50 mg of dry powdered of wheat shoot was put into hydrolysis tube that containing 10 ml of HCL (6 N). The tube was closed (by melting the glass with a suitable gas- burner). The tube was put in an oven at 110ºC for 72 hours and then cooled down in an ice- bath. The solution was centrifuged (4000 rpm for 5 min) and the supernatant collected and evaporated in a rotary evaporator at 40º C. The residues was dissolved in 1- 2 ml distilled water and evaporated near dryness to remove traces of acid. The amino acid was determined with an Eppendorff - Germany LC 300 analyzer. The flow rate 0.2 ml/min, pressure of buffer, from 0.0 to 50 bar, pressure of reagent from 0.0 to 150 bar and reaction temperature 123º C.

Macronutrient and micronutrient contents:

Total N was determined by using micro-Kjeldahl method as described in[22]**.** Macro and microelement contents of the yielded grains were determined according to[23]. Phosphorus was determined using a Spekol spectrocolorimeter (VEB Carl Zeiss; Jena, Germany, while, estimation of K^+ contents were done using a flame photometer. Fe^{+2}, Mn^{+2}, Zn^{+2} contents were estimated using atomic absorption spectrophotometer

Statistical analysis:

Statistical analysis was carried out using SPSS program Version 16. A student test (Independent *t*-test) was also carried out to find the significant differences between magnetic and nonmagnetic water treatments.

Results

Changes in growth criteria:

The changes of growth characters (plant height, fresh and dry weight per tiller and water content) of wheat plants irrigated with magnetic water are shown in (Table 2). Wheat plants irrigated with magnetic water exhibited highly significant increases in plant height, fresh and dry weights/tiller over the plant irrigated with normal water. The improvement over control treatment reached to 11.29, 8.53, 7.45, and 1.48% for plant height, fresh and dry weight (g/tiller) and percentage of water contents (%), respectively as average of two seasons. Also, the water content showed a non significant increase as compared to control plant.

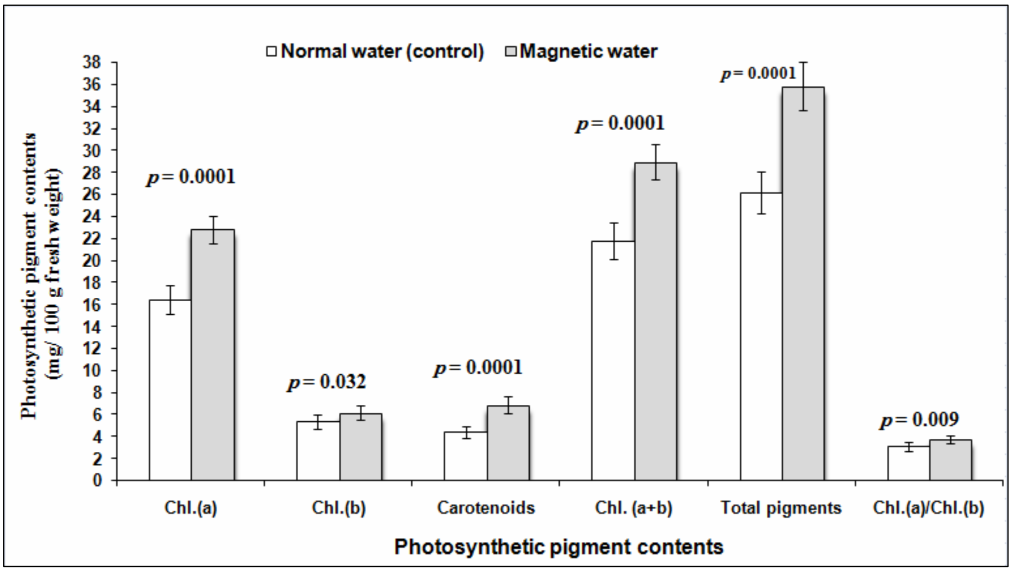
Table 2. Response of wheat growth at 85 days after sowing for irrigation with magnetic and normal water. (Average of two winter seasons)

Treatment	Mean ± S.E.		*p-value*	Increase (%) over control
Character	Normal water (control)	Magnetic water		
Plant height (cm)	42.53 ±0.54	47.33 ± 0.64	0.000	11.29
Fresh weight/tiller (g)	4.98 ± 0.02	5.76 ± 0.03	0.000	15.66
Dry weight/tiller (g)	0.97 ± 0.01	1.08 ± 0.01	0.000	11.34
Water contents (%)	80.42 ± 0.28	81.28 ± 0.17	0.015	1.07

N = 15, *, *** *t* is Significant at the $P < 0.05$ and $P < 0.001$ level, respectively.

Photosynthetic pigments contents:

Photosynthetic pigments content in fresh wheat at 85 days have shown a significant increase in response to irrigation with magnetic water. Pigment content is an indicator of plant health and productivity. The results in (Figure 2) Show that magnetic water significantly increased all photosynthetic pigment (Chl a, Chl b, Chl a+b, carotenoids and total pigment content) over the control. The percent of increments reached to 38.8%; 15.4%; 55.6%; 33.0%; and 36.3% in the above parameters, respectively**.**



N=8, *, **, * *t* is Significant at the *P* < 0.05, 0.01and 0.001 levels, respectively.**

Figure 2. Effect of irrigation with magnetized and normal water on photosynthetic pigment contents in wheat shoot at 85 days after sowing. (Average of two seasons).

Changes in yield and yield components:

Data revealed that irrigation wheat plants with magnetic water increased significantly all yield components as compared to control plants irrigation with normal water (Table 3). Irrigation plant with magnetic water significantly increased yield and yield components (plant height (cm), spike number m^{-2}, spikelet no. $spike^{-1}$, spike length (cm), spike weight (g), grain yield /spike (g),100grains weight (g), biological yield (ton fed^{-1}) and straw yield (ton fed^{-1}). The results in (Table 3) show that, irrigation wheat plants with magnetized water induced increases which reached to 10.32, 27.18 and 22.03% in grain yield, straw yield and biological yield per ton fed^{-1} over the control (average two seasons).

Table 3. Response of wheat yield and its components for irrigation with magnetic and normal water. (mean of two successive winter seasons).

Treatment / Character	Mean ± S.E. Normal water (control)	Magnetic water	*p-value*	Increase (%) over control
Plant height (cm)	70.80 ± 1.01	74.87 ± 1.25	0.017	5.75
Spike number m^{-2}	425.46 ± 11.53	480.60 ± 9.01	0.001	12.96
Spikeletes no. $spike^{-1}$	16.47 ± 0.36	17.73 ± 0.22	0.006	7.65
Spike length (cm)	9.03 ± 0.15	9.69 ± 0.22	0.019	7.31
Spike weight (g)	1.84 ± 0.10	2.13 ± 0.07	0.026	15.76
Spike grain wt. (g)	0.74 ± 0.25	0.89 ± 0.16	0.000	20.27
Grain/spike ratio	0.42 ± 0.27	0.43 ± 0.14	0.910	2.38
100-grain weight (g)	3.76 ± 0.03	3.96 ± 0.03	0.000	5.32
Biological yield (ton fed^{-1})	4.63 ± 0.19	5.65 ± 0.17	0.002	22.03
Grain yield (ton fed^{-1})	1.55 ± 0.06	1.71 ± 0.05	0.049	10.32
Straw yield (ton fed^{-1})	3.09 ± 0.19	3.93 ± 0.14	0.003	27.18

N= 15for yield components, N=8 for yields per feddan, *, **, *** *t* is Significant at the $P < 0.05$, 0.01and 0.001 levels, respectively, p-value > 0.05 is non significant

Water Use Efficiency (WUE):

Magnetized treated water that led to an increase in plants has the highest values of WUE as compared to normal water (Figure 3). Data in our study raveled that, application of magnetic water technology increased significantly crop water use efficiency by 13% compared to the irrigation with normal water.

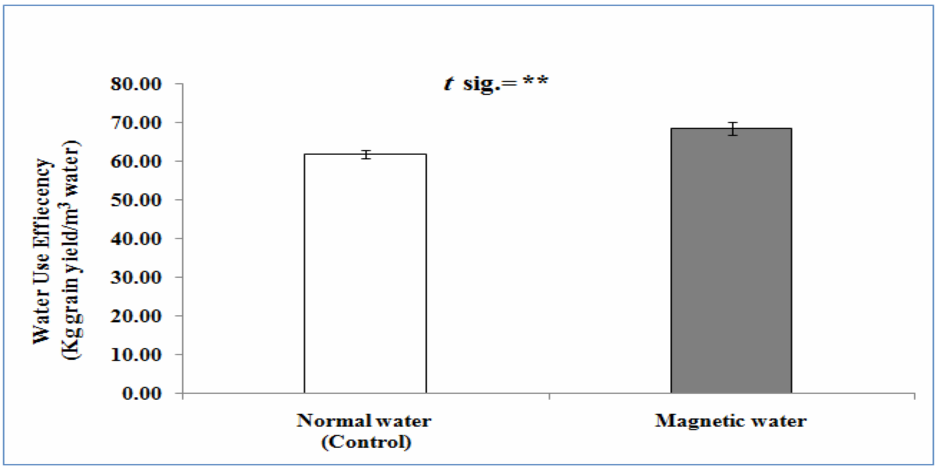


Figure. 3. Water use efficiency under normal and magnetic treatment. (Average of two seasons).
N=8, ** *t* is Significant at the $P < 0.01$.

Changes in amino acid composition of wheat grains:

The patterns of changes in the amino acid composition of the yielded grains of wheat plant treated with magnetic water are shown in (Table 4). Magnetic water increased the total amino acid contents, total essential amino acid contents (therionine, valine, methionine, isoleucine, leucine, histidine, lysine and phenylalanine) and the ratio of essential to non essential amino acids as compared with normal water (Table 4). Results revealed that, glutamic acid and proline were the highest values among the amino acids (most predominant). Glutamic acid values 0.978 -1.464 followed by proline 0.728 – 0.939 on wheat plant irrigated with normal water and magnetic water respectively. The results in (Table 3) show that, irrigation wheat plants with magnetized water induced increases which reached to 46.0, 37.9 and 40.6 % in essential, non essential and total amino acid over the control respectively.

Table 4. Amino acid composition in yielded grain of wheat plants irrigated with magnetic and normal water.

Treatment Amino acids (mg/ g grain dry weight)	Normal water (control)	Magnetic water	*p-value*
Aspartic	0.320 ± 0.012	0.459 ± 0.035	0.019
*Threonine	0.121 ± 0.012	0.154 ± 0.018	0.202
Serine	0.199 ± 0.012	0.258 ± 0.017	0.046
Glutamic Acid	0.979 ± 0.023	1.461 ± 0.035	0.000
Glycine	0.086 ± 0.001	0.129 ± 0.017	0.067
Alanine	0.279 ± 0.012	0.369 ± 0.017	0.012
*Valine	0.221 ± 0.012	0.298 ± 0.017	0.021
*Methionine	0.005 ± 0.001	0.018 ± 0.001	0.000
*Isoleucine	0.149 ± 0.006	0.229 ± 0.017	0.012
*Leucine	0.380 ± 0.035	0.581 ± 0.040	0.020
Tyrosine	0.169 ± 0.012	0.229 ± 0.017	0.044
*Phenylalanine	0.388 ± 0.029	0.551 ± 0.029	0.016
*Histidine	0.190 ± 0.012	0.280 ± 0.023	0.025
*Lysine	0.161 ± 0.012	0.240 ± 0.023	0.038
Arginine	0.320 ± 0.012	0.511 ± 0.029	0.004
Proline	0.729 ± 0.046	0.943 ± 0.061	0.049
*Essential	1.615 ± 0.116	2.350 ± 0.168	0.023
Non-Essential	2.761 ± 0.116	3.901 ± 0.193	0.007
Total amino Acid	4.696 ± 0.243	6.710 ± 0.396	0.012
Ess./non-Ess.	0.583 ± 0.018	0.601 ± 0.013	0.470

N= 3, *, **, *** *t* is Significant at the $P < 0.05$, 0.01and 0.001 levels, respectively, *p-value* > 0.05 is non significant**.**

Changes in macronutrient and micronutrient contents in wheat grains:

Regarding the effect of magnetized treated water on nitrogen, phosphorus and potassium contents of wheat grains. Data presented in (Table 5) revealed that, irrigation wheat plant with magnetic water to newly reclaimed sandy soil increased significantly grain contents of nitrogen , phosphorus,calcium and magnesium and non significant increase in potassium content as compared with control plants. Regarding to micronutrient contents, (Table 5) presented the effect of magnetized treated water on micronutrient contents (Fe^{++}, Mn^{++}, Zn^{++}, Cu^{++})of the yielded wheat grains. Data clearly show that, magnetic water increased significantly Fe^{++} content and non significant increase in Zn^{++} content.). It was noticed that, irrigation with magnetically treated water lead to decrease in Mn^{++}content at yielded grain.

Table 5. Nutritional value in yielded grain of wheat plants irrigated with magnetic and normal water.

Character		Treatment: Mean ± SD: Normal water (control)	Magnetic water	*p-value*	Increase (+) or decrease (-) % over control
Macronutrients (%)	N	2.11 ± 0.02	2.67 ± 0.04	0.000	26.54
	P	1.40 ± 0.05	1.63 ± 0.03	0.013	16.43
	K	0.50 ± 0.01	0.52 ± 0.01	0.196	4.00
	Ca	0.60 ± 0.01	0.68 ± 0.01	0.008	13.33
	Mg	0.14 ± 0.01	0.17 ± 0.01	0.016	21.43
Micronutrients (ppm)	Fe	0.59 ± 0.02	0.81 ± 0.06	0.005	37.29
	Mn	36.00 ± 1.15	30.00 ± 0.60	0.012	-16.67
	Zn	51.80 ± 1.15	53.10 ± 1.73	0.566	2.51
	Cu	9.00 ± 0.12	9.00 ± 0.29	1.000	0.00

N= 3, *, **, *** *t* is Significant at the $P < 0.05$, 0.01and 0.001 levels, respectively, *p-value* > 0.05 is non significant

Discussion

Growth criteria:

Wheat plants irrigated with magnetic water exhibited highly significant increases in plant height, fresh and dry weights/plant over the control. Also, the water content showed a non significant increase as compared to control plant. Magnetic water is considered one of several physical factors affects plant growth and its development. Results obtained in (Table 2) showed that wheat plants which irrigated with magnetic water grew taller and heavier than those irrigated with tap water. The stimulatory effect of the application of magnetic water on the growth parameters reported in this study may be attributed to the increase in photosynthetic pigments (Fig. 2). In this connection, [24]reported that magnetic water significantly induces cell metabolism and mitosis meristematic cells of flax. Our results are in agreement with those obtained by other researchers**;** *Hilal and Hilal* (2000) they reported that magnetized water has more tripled seedling emergence of wheat than tap water[25]. *Reina et al.* (2001) found significance increase in the rate of water absorption accompanied with an increase in total mass of lettuce with the increase of magnetic force[26]. Also, *Hozayn and Abdul Qados* (2010) and *Omran et al*., (2014) showed that irrigated with magnetic water exhibited marked increases in the most of vegetative growth of wheat and barley plant[10,27]. *Atak et al.* (2003) and *Aycih and Alikamanoglu* (2005) concluded that magnetic field increased the shoot and root regeneration rate and their fresh weight in soybean and paulownia organ cultures[8,28]. Moreover, *Nasher* (2008) concluded that, magnetized water increased growth and consider an important factor for inducing plant growth[29]. In earlier study [30]reported that the mechanisms of magnetic field may be including biochemical changes or altered enzyme activities.

Irrigation with magnetically treated water increased relative water content (RWC) of wheat plants. RWC is the appropriate measure of plant water status in terms of the physiological consequence of cellular water deficit[31]**.** Perhaps the reason for this increase is the ability of these plants to absorb water, as a result of increase in roots length of these plants[32].

Photosynthetic pigment contents:

Photosynthetic pigments content in fresh wheat at 85 days have shown a significant increase in response to irrigation with magnetic water. Pigment content is an indicator of plant health and productivity. This increment may be attributed to increasing ions mobility and ions uptake improved under MF which leads to a better photo stimulation in wheat plants[33]**.** Moreover, magnetic field has the ability to change water properties, thus magnetized water increased rice chlorophyll content[34]**.** *Nasher* (2008) found that irrigated with magnetized water were significant increases in in the photosynthetic pigments (chlorophyll a, chlorophyll b, and carotenoids), photosynthetic activity, and translocation efficiency of the photo assimilates of over the control on chick pea and common bean plants respectively[29]. These results may be due to the effect of magnetic field on alteration the key of cellular processes such as gene transcription which play an important role in altering cellular processes. The increase in the photosynthetic pigments of wheat leaves resulted from magnetic water are closely related to the increases in the contents of certain elements (eg. N, Fe, Mg Table 5). Several authors are of the opinion that Fe and Mg functions in the synthesis of chloroplastic protein and so it may play a vital role in chlorophyll synthesis[35]**.** Moreover, the increase of photosynthetic pigments may be due to the decrease of the amount of manganese in magnetic water compared to normal water (Table 5). *Khazan and Abdullatif*, (2009) has attributed the increase of photosynthetic pigments to the decrease of the amount of manganese in treated water compared to normal water[32]. Similarly, *Macfie and Taylor* (1992) have reported that shortage in the amount of chlorophyll under the environmental stress is due to manganese toxicity which leads to a lack of chlorophyll between the veins of leaves leading to a decrease of photosynthesis as a whole[36]. Recently *Hozayn and Abdul Qados* (2010), *Hozayn et al.,* (2011) reported that, magnetic treatment increased photosynthetic pigment contents via increasing growth (IAA)[10,37].

Moreover, results of carotenoides showed high rate in plants irrigated with magnetically treated water compared to normal water. This is considered as a good adaptive factor under stress conditions. *Maheshwari et al.* (2009) have reported that, the increase in carotenoides is one of the adaptive responses that protect chlorophyll and enables plant to complete its life cycle[38].

Wheat yield and its components:

The results in (Table 3) show that, irrigation wheat plants with magnetized water induced significant increase in all yield and yield components compared to control treatment. These results are the logical to improvement growth parameters (Table 2), and photosynthetic pigments (Fig. 2). The stimulatory effect of magnetic water on yield and yield components reported in this study is in agreement with that obtained by other researchers. *Hozayen, et al.* (2014) indicated that, magnetic water increased yield of wheat, faba bean, chick-pea, lentil, canola and flax[38]. This increase was accompanied the stimulation effect of MW on leaf chlorophyll content. *Kordas* (2002) found that, the exposure of green tops and root systems of wheat plant to magnetic field brought about increased quantity of coarse grain by 10.6% and 6.3%, respectively[39]. *De Souza et al.* (2006) showed that magnetic treatments on tomato increased significantly the mean fruit weight; the fruit yield per plant; the fruit yield per area and the equatorial diameter of fruits in comparison with the controls. Exposure of plants to MW is highly effective in enhancing growth characteristics[40]. This observation suggests that there may be resonance-like phenomena which increase the internal energy of the seed that occurs. Therefore, it may be possible to get higher yield on lentil[41]. However, [29]found that, chick-pea plants that are irrigated using water that is treated by magnetic field, easily take in mineral salts from the soil and no sediment is formed on the soil surface. This results in an increased crop production and in an increased quality of agricultural products.

Water Use Efficiency (WUE):

Magnetized treated water that led to an increase in plants has the highest values of WUE as compared to normal water (Figure 2). The differences in WUE between the two water type treatments when subjected to water deficits, clearly indicates that the crops employ different mechanisms in response to drought conditions and require different approaches for irrigation. A mechanism that enables it to reduce its water consumption while maintaining high biomass.

Similar to economic yield per feddan, there was differential impact of magnetic treatment on water productivity (kg of yield produced per L of water used) (Figure 2). *Mulook Al-Khazan et al.* (2011) recorded that irrigation of jojoba plants with magnetized water led to increase water use efficiency under normal and drought water stress as compared to the recommended irrigation[42]. Magnetic treatment of irrigation water is an acknowledged technique for achieving high water use efficiencies due to its effect on some physical and chemical properties of water and soil and the most useful mechanism in arid regions[31,43]**.** These changes result in an increased ability of soil to get rid of salts and consequently better assimilation of nutrients and fertilizers in plants during the vegetative period.

Changes in amino acid composition of wheat grains:

Magnetic water increased the total amino acid contents, total essential amino acid contents, non essential amino acid and the ratio of essential to non essential amino acids as compared with normal water (Table 4). In this connection [44]noticed that MF increased amino acids content in mushroom (*Agaricus bispours*). However, proline is one of the most important amino acids; which accumulated under magnetic water in the present work (Table 4). Similarly, [45]concluded that proline accumulation in date palm seedlings is affected by exposure to low dose of MF. Among these, proline is the most commonly studied as a biochemical indicator of stress[46]. Proline has been shown to protect plants against damages caused by free radicals by scavenging the radicals and stabilizing of macromolecules[47]. In addition, the results in (Table 4) show that magnetic water increased glutamic acid over the control. The percent of increments reached to 49.7%; above the control. This increment may be attributed to the proline pathway could be shifted by MF exposure, through oxidation of proline to glutamate or forming glutamic acid g-semialdehyde[47]. During adaptation to various types of environmental stress, plants accumulate cellular solutes[14]. The cellular solutes include quaternary amino acid derivatives such as proline, glycine betaine, alanine betaine, and proline betaine[15].

Nutritional value in yielded grain of wheat plants:

The magnetized treated water plants achieved attained significantly high nutrient contents in terms of which represented by nitrogen, phosphorus, calcium, magnesium and ferric, but non significant increase in potassium and zinc at yielded grain (Table 5). The increase of essential elements aided treated water plants to increase their chlorophyll content. Magnesium ions are found in the centre of chlorophyll molecules, and as chlorophyll is an essential component in the reaction of photosynthesis, which produces energy for growth, magnesium ions are therefore essential[48]. On the other hand, potassium and phosphorous are needed for the plant cell's chemical reactions, in the formation and movement of carbohydrates, the development of roots which are necessary for the absorption of minerals and water, ATP, basically a molecule of energy and nucleic acids[49]. Magnetic field may play an important role in cation uptake capacity and has a positive effect on immobile plant nutrient uptake which raise the products nutrition value[50]. It could be proposed that magnetized water increased the water absorption and hence increased Ca^{+2} and K^{+} uptake[26], resulting in improved germination and growth (Table 2). The authors interpreted this effect to be due to increased nutrient uptake resulted from magnetic field induced changes in cell membrane characteristics, gene expression, protein biosynthesis and enzyme activities[27]. Ca is involved in regulation at all stages of plant growth and development, including growth and differentiation, photo morphogenesis and embryogenesis, the self incompatibility responses in pollen-pistil interactions and movement of stomatal cells[51].

Moreover, N, P, K, Mg, Fe, and Zn were also affected under SMF and increased significantly while Mn decreased with magnetized water irrigation. Analogues with [50]indicated that increasing MF strength from control to 0.384 T increased contents of N, K, Ca, Mg, Fe, Mn, Na and Zn but reduced P and S content the leaves of strawberry. In addition, results may vary according to plant organs, [52]study indicated that MF increased contents of (Mg, Fe and Cu) in buckwheat (*Hruszowska sp.*) grain and (P, Ca, K and Zn) in straw .A study on tomato plants showed that the application of MF to irrigation water increased nutrient element contents of plants[1]. Ions uptake increased flowing MF treatment, [38]suggested that owing to plant cells having negative electrical charge, they take up ions with a positive electrical charge.

Therefore, MF could be a substitution of chemical additives, which can reduce toxins in raw materials and thus raise the food safety. There were few studies linking magnetic field with elements accumulation in plants of wheat[52].

Nutrition value could be enhanced by MF treatment. Sharaf El-Deen (2003) noticed that MF increased amino acids, Ca and K content in mushroom (*Agaricus bispours*)[44]. It has been reported that external magnetic fields influence both the activation of ions and polarization of dipoles in living cells[53]. Additional cationic micronutrients (Fe^{++}, Mn^{++}, Zn^{++}) play essential roles as cofactors and activators of enzymes. Increasing the Zn^{++} and Fe^{++} concentration in food crop plants, resulting in better crop and improved human health is an important global challenge[54].

Conclusion

Magnetic water treatment could be a promising technique for agricultural improvements. Magnetized water is harmless, healthy and eco-friendly technology. The present findings have shown that irrigation with magnetic water traetment can be considered as one of the most valuable modern technologies that can improve yield and quantities and qualitative production of wheat plant under newly reclaimed sandy soil. It could be concluded from this study that, wheat plant irrigation with magnetized water could effectively increase growth parameters, the photosynthesize property of plants, yield and some chemical constituents. Magnetic field may play an important role in cations uptake capacity and has a positive effect on immobile plant nutrient uptake which raise the products nutrition value of wheat grains (N, P, K, Ca, Fe, & Zn), total amino acids and total essential amino acids in yielded grains.

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