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Effect of Magnetized Irrigation Water and Seeds on Some Water Properties, Growth Parameter and Yield Productivity of Cucumber Plants

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ABSTRACT

The aim of this study is to evaluate the effect of different magnetic field strengths (0.0, 20.0, 40.0 and 60.0 m T), at different time intervals ranging from 0 to 300 minutes on some properties of irrigation water the pH, electric-conductivity (EC), and total dissolved salts (TDS). The results showed that the pH significant increased under different magnetic field strength, while EC and TDS significant decreased by magnetic treatment under different magnetic field strength and time of treatment by15.60% after 300 minutes.

The results also show that water remembers and keeps the impact of passing through the magnetic field (water magnetic memory) for several hours, and pH decreased by 0.40 after 16 hours from treatment.

Seeds of four crops were magnetized through magnetized funnel has magnetic field strength (40 mT) for1hours and irrigated with magnetic water and their germination percentage after 7, 10, and 15 days were compared with the control treatment for non magnetized water or seeds. Generally the results reveal that there were a significant difference in the germination percentage for magnetized water and seeds at all days 7, 10 and 15 after germination compared with non-magnetized water and non-magnetized seed treatments.

Magnetized seeds of cucumber were growing for complete growth season (winter 2012) under controlled greenhouse condition. Cucumber magnetized seeds were growing and irrigated with magnetized water (40.0mT) the growth parameters, yield production, and some nutrients (N, P, K, Fe, Mn, Zn and Cu) content of cucumber crop were determined and discussed. The results demonstrated that the magnetic treatments improved plant height, yield (kg/m^2), fruit length, fruit diameter, and leaves dry matter percentage of cucumber plant compared to control treatment. This study appears that utilization of magnetized water technology may be considered a promising technique to improve cucumber yield productivity.

Key words **:** Magnetized water (MW), magnetized seeds (M.S), non-magnetized seeds (NMS), non magnetized water (NMW) cucumber plants

Introduction

Magnetically treated water (MTW) is water which has been passed through a magnetic field prior to use. There are a lot of benefits to using such treated water, although there is still considerable debate as to its efficiency. Deng and Pang, (2007) investigated the mechanism of magnetization of water and proposed a theory based on the molecular structure of water. In the model proposed by Pang and Deng, (2008), the interaction of the externally applied magnetic field with the electric current arising from the protons (or hydrogen ions) enhance conductivity along the closed hydrogen bonded chains of molecules occurring in water.

In such a case it is very necessary to investigate the properties of magnetized water, this investigation may not only clarify the role of magnetization of water but also explain the mechanism and features of biological effects of the magnetic field on human beings, animals and plants because there is plenty of water, about 70%－80%, in them. Pang and Deng, (2008).

Hasaani *et al.* (2015) study the interaction of magnetic fields with flowing water,they measure absorbance, pH, (TDS), EC, viscosity, surface tension and thermal conductivity for ordinary tap water before and after applying magnetic fields of strength 6560G which were generated by proper arrangement of permanent magnet pieces around the pipe accommodating the flowing water. They found that physical properties of magnetized water were inspected with proper and precise measuring techniques. These include the pH which was increased by 12%, while TDS and EC are both decreased by 33% and 36% respectively. As well as the mechanical parameters like viscosity and surface tension are decreased too by a factor of 23% and 18%, respectively. Even, the thermal conductivity was decreased by 16%.

Kochmarsky, (1996) outlines a model of possible mechanisms which describe how relatively weak fields can influence the statistical mean number of hydrogen bonds between water molecules.

Baker and Judd, (1996) showed that the increasing of magnetic field density leads to an increase in the salt removal percentage due to the following: water molecules are electrically charged, having a small dipole and

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thus a small dielectric constant. This dipole may be susceptible to the effects of exogenous electric and magnetic fields. The change in the electric dipole of water can result in change of the physical properties. Among those physical properties, are conductivity, TDS and pH.

Kotab, (2013) study the effect of using the magnetic water conditioner on some properties of water such as pH, TDS, and hardness. The results showed that the water flows through a closed loop, affected by magnetic field with flux density of 170 mT, the pH increased by 15.65% for 820 minutes of non-stop circulation. The increase in pH is divided to 93.5% for the first 360 minutes, and 6.5% for the last 460 minutes. The results also showed that TDS and Hardness of water are not affected by the magnetic water conditioner with flux density of 170 mT.

Biological benefits claimed include: increased commercial earliness of crops; increased yield; increased vitamin C, sugar and total acid content and increased flowering and fruit set (Pavlov *et al.,* 1983).

Physical methods of improving seed quality have been the subject of intense research. First successful attempts to improve quality of seeds by their exposure to magnetic or electromagnetic fields were carried out in the 1930s. Enhancement of seed vigor and germination of different species by treating seeds with magnetic or electromagnetic fields has been confirmed by many scientists (Martinez *et al*., 2000; Carbonell *et al*., (2008).

Hachicha *et al*. (2016) study the effect of electromagnetic treatment of saline water on seed germination of corn and the response of soil and potato crop irrigated with magnetic water. Results showed a significant increase in germination rate of corn seedlings watered with electromagnetic-treated saline water (EC =4 dS m^{-1}), particularly when water was exposed to electromagnetic fields for 15 min. Also the results showed a significant increase in tuber yield when irrigated with electromagnetic treated water. Significant decrease of soil salinity (ECe), Na+ and Cl^- contents of soils irrigated with electromagnetic treated saline water compared to the soils irrigated with non treated saline water. In contrast, the electromagnetic saline water treatment produced non-significant effect on tuber yield, Mg^{2+} and HCO_3^-. However, the electromagnetic treatment of saline water increased significantly K+, N and P absorption in all tissues of potato and decreased significantly the adverse effects of saline water. Based on our results, electromagnetic treatment of saline water can reduce the negative effect of salinity on corn germination and potato crop and increase yield in about 10% under test conditions.

Vashisth and Nagarajan, (2008) reported that a 46-71% increase in chickpea seed vigor, a 58-90% improvement in seedling root length and a 25-47% increase in seedling dry weight by magnetic treatments.

Under Egyptian condition, application of magnetic technology is a new concept. Hilal and Hilal (2000) reported that full wheat germination of 100% was obtained after 6 days for magnetic treatment compared to a rate of 83% after 9 days for normal practice. Guo Liang et al., (1994) reported that magnetizing seeds is very efficient to increase the number of germinating seeds and to hasten the germination process.

Morejon *et al.* (2007) observed an increase in germination of Pinus tropicalis seeds from 43% in the control to 81% with magnetically treated water. Furthermore, they observed a marked improvement in seedling growth after germination due to the magnetically treated irrigation water. Hilal and Hilal (2000), working on tomatoes, pepper, cucumber and wheat seeds, and reported that there are an improvements in germination and seedling emergence when magnetically treated water and seeds were used. In particular, they observed that the germination of pepper seeds was higher with magnetically treated seeds compared to seeds with magnetically treated irrigation water. Cucumber seeds had the highest germination percentage when both irrigation water and seeds were magnetically treated. They also reported that tomato seeds responded more favorably to magnetically treated irrigation water than the magnetically treated seeds.

Materials and Methods

The present investigation was carried out to study and evaluate:

The effect of different magnetic field strengths, on some Chemical properties of magnetized irrigation water

The pH, electric conductivity (EC), and total dissolved salts (TDS) at different time intervals ranging from 0 to 300 minutes to achieve this; study was layout in laboratory experiment. Three unites of closing loopy each one of it represents magnetic field strength (20, 40, and 60 mT). Each unit contest of a PVC pipe of length 150cm, this pipe joins two plastic reservoirs of a nominal volume of 50 liter (Figure1). One reservoir was used as a groundwater container, i.e., for groundwater before magnetization and the other reservoirs was to collect groundwater after being magnetized by static constant magnetic field as follows;(20.0, 40.0 and 60.0 mT). Control valve was also fitted into the PVC pipe for monitoring the flow rate of water as experimentally required.

A100S magnetic device (A100S device is a magnetic water conditioners (MWC), fixed on pipeline 1.5", shown in Photo 1. A100S is placed on the middle of the PVC pipe1.5". While the magnetic treated irrigation water pumping and recycling to pass through the magnetic device at different magnetic field strength, then water flows out from the magnetization region of the setup to the collecting reservoir for each magnetic field strength.

The water parameters have been measured which is pH, EC and TDS taking reading every thirty minutes and the reading of each parameter replicated three times as shown in Table (1), and Figures 2, 3 and 4.

The EC and TDS have been measured by a EC/TDS meter, model HI9812. EC in (dS/m) and TDS in (ppm or mg/L), the pH values of the magnetized water samples were measured by a digital pH meter of model professional Benchtop pH BP3001.

Photo 1: The Magnetic water device (A100S).

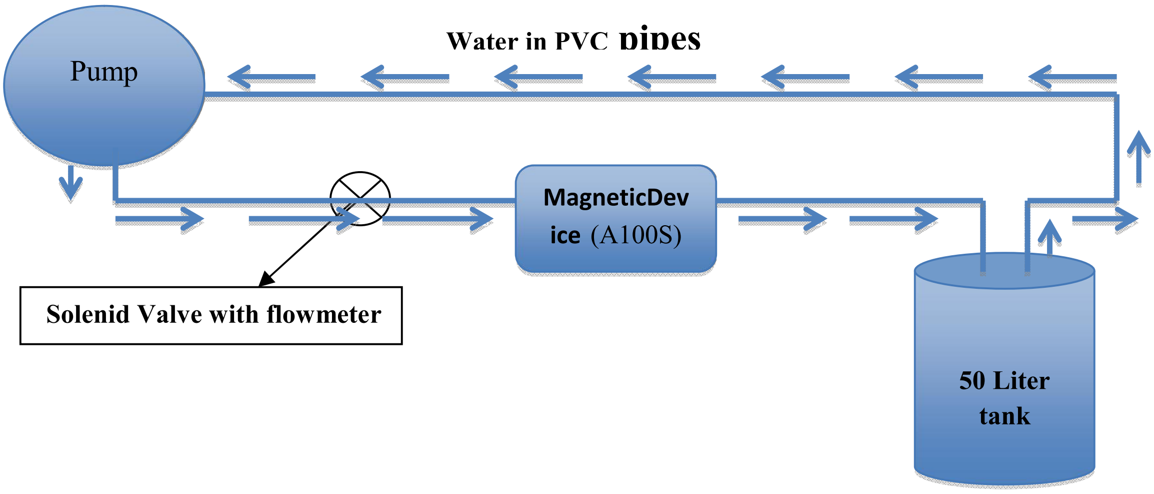

Fig. 1: Diagram of the experimental performs a closed loopof circulation for the magnetic treated water.

The effect of using magnetizing seeds and or magnetizing irrigation water on seed germination of some vegetative crops

Under controlled greenhouse conditions at the farm of college of agriculture King Faisal University, (KSA) Seeds of four vegetative crops (tomato, eggplant, cucumber and squash), without visible defect, insect damage and malformation were selected and divided into four groups in a complete randomized design. Each group consists of three replicates of seed for each crop; 600 seeds of each tested crop were passed through a magnetic funnel with magnetic field strength (40mT), for one hour before soaking with irrigation water according to Aladjadjiyan, (2007).

Magnetic seeds (600 seeds) for each crop were divided into two sections, the namely of the sections were as follows:

Section a: The first 300 magnetic seeds (MS) soaking with magnetized water with field strength (40mT), three replicate each one hundred seeds, magnetic seeds and magnetic water (MS+MW)

Section b: The other 300 magnetized seeds irrigated with the normal groundwater, magnetic seeds and non magnetic water (MS+NMW),

By the same way the non magnetized seeds were divided into two sections:

Section c: Normal 300 seeds without magnetized treatment (three replicate) irrigated with magnetized water, non magnetic seeds and magnetic water, (NMS+MW).

Section d: Seeds (300 seeds) without magnetized treatment irrigated with normal groundwater was used as control treatment, non magnetic seeds and no magnetized water (NMS+NMW) control treatment. Each seeds treatment was sown in flats cell (100 cell size 3-3-10 cm) containing mix (2 soils: 1peatmoss). Under the controlled greenhouse condition for a period of 15 days, irrigation was provided as and when required. Data obtained compared with the data obtained from the normal treatment (control), non treated grains and non treated water.

Photo 2: Seeds magnetizing device (40mT) with funnel attachment.

The effect of using magnetizing water, on some growth parameters, macro and micronutrients content in shoots of cucumber plants

Field experiment was conducted through winter season (2012) to evaluate the effect of magnetizing irrigation water and or magnetizing cucumber seeds by magnetic field strength (40mT) under Al-Hassa Oasis kingdom of Saudi Arabia condition. Before commencement the experimental treatments, sample of soil was taken for chemical and mechanical analyses. Sample of irrigation water was also taken for chemical analysis by methods described by Cottenie *et al.*(1982) and Burt,(2004). The experimental design was complete randomized design. Treatments were assigned randomly in three replication according to the methods described by Gomez and Gomez, (1984), as shown in Fig. (2)

To avoid the effect of lateral movement of irrigation water, the strips were isolated by borders of 1.0 meters in width. Cucumber seeds were sown in the proper sowing date and all agriculture practices were followed according to the recommendation of extension service. Irrigation system was surface drip irrigation system, took place every day.

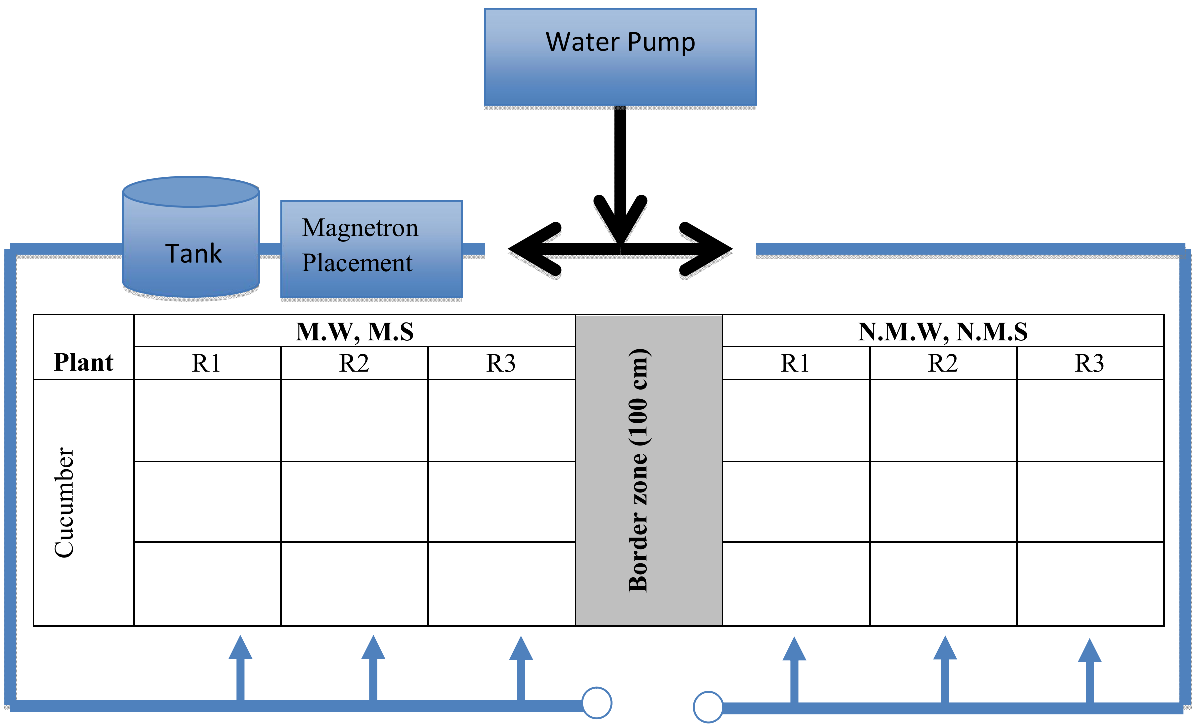

Fig. 2. Illustrated a schematic diagram for the distribution of the experimental field treatments of cucumber plants effected by magnetized both seeds and irrigation water. (M.W)= magnetic water and Magnetic seeds= (MS) non magnetized water = (NMW) and non magnetic seeds = (NMS).

After 45 days from sowing, shoot plant sample of cucumber was taken randomly from cucumber treated plants (magnetized seeds of cucumber irrigated by magnetized irrigation water) and from control treatment (non-magnetized seeds of cucumber irrigated by non magnetized irrigation water). The plant samples of each treatment were dried at 70 C^0 to constant weight, handily ground. Samples were wet ached with a mixture of perochloric and sulfuric acid (3:1). Micronutrients (Fe, Mn Zn, Cu) in the digest were measured in ppm by atomic absorption, spectrophotometer.

At harvest time after 45- days from sowing growth and developmental characteristics, including, plant height, number of leaves per plant, yield (kg/m^2), yield (number of fruits/m^2), fruit length (cm), fruit diameter (cm), days to 50% flowering and Leaves dry matter were calculated. The experimental soil, water and plant samples were analyzed according to the method described by Chapman and Pratt (1978).

The dry matter percentage was calculated according to (Henson *et al.,* 1981).

Statistical Procedures

All results were subjected to statistical analysis as a factorial experiment according to the method described by Gomez and Gomez (1984). The L.S.D. at 5% level of probability was used to calculate the significant differences between the mean values of treatments according to Snedecor and Cochran, (1981).

Results and Discussions

The effect of magnetic field strengths and time of treatments on some magnetized water chemical properties.

The pH of magnetized water

Data in Table (1) and Figure (3**),** illustrates the effect of different magnetic field strengths on the pH values, of recirculated water versus the time of circulation. Before circulation that identified to be the pH value was 7.24. The pH is significantly increased by increasing the circulation time over 300 minutes of non-stop circulation the pH values reaches to 7.77, 7.79, and 7.85 compared with the initial pH value 7.24 of untreated irrigation water. The relative increase was 7.32%, 6.60, and 7.43% for 20.0, 40.0, and 60.0 mT respectively; with 5.80% relative increase for the mean treatments.

Table 1: The effect of different magnetic field strengths on pH, EC and TDS of magnetized water under different time of treatments.

Chara.	pH					EC					TDS				
Time of	Magnetic Field Strength					Magnetic Field Strength					Magnetic Field Strength				
Treatment minutes	0 mT	20 mT	40 mT	60 mT	Mean	0 mT	20 mT	40 mT	60 mT	Mean	0 mT	20 mT	40 mT	60 mT	Mean
00.0	7.24 t	7.24 t	7.24 t	7.24 t	7.24 K	2.82 a	2.82 a	2.81 a	2.81 a	2.82 A	1798.00 a	1798.00 a	1798.00 a	1798.00 a	1798.00A
30.0	7.24 t	7.28 s	7.31 r	7.34 q	7.29 J	2.81 a	2.78 b	2.68ef	2.69de	2.74 B	1798.00 a	1780.00 b	1715.00 de	1719.00 de	1753.00 B
60.0	7.24 t	7.34 q	7.37 p	7.39 o	7.34 I	2.81 a	2.75 c	2.63 h	2.64gh	2.71 C	1798.00 a	1762.00 c	1680.00 g	1690.00fg	1732.50 C
90.0	7.24 t	7.42 n	7.45m	7.48 l	7.40 H	2.81 a	2.57ij	2.55 k	2.56jk	2.62 D	1798.00 a	1680.00 g	1635.00 hi	1640.00 hi	1688.25 D
120.0	7.24 t	7.49 l	7.57 k	7.56 k	7.47 G	2.81 a	2.70d	2.50 l	2.51 l	2.63 D	1798.00 a	1728.00 d	1600.00jk	1609.00 j	1683.75 D
150.0	7.42 t	7.59 j	7.64 i	7.66 h	7.53 F	2.81 a	2.67 f	2.46 n	2.48m	2.61 E	1798.00 a	1709.00 e	1575.00 l	1588.00 kl	1667.50 E
180.0	7.24 t	7.63 i	7.68 g	7.85 a	7.60 E	2.81 a	2.65 f	2.38 n	2.40m	2.56 F	1798.00 a	1695.00 f	1525.00 m	1536.00 m	1638.50 F
210.0	7.24 t	7.68 g	7.74ef	7.85 a	7.63 D	2.81 a	2.58 g	2.31 p	2.33 o	2.51 G	1798.00 a	1648.00 h	1480.00n	1493.00 n	1604.75 G
240.0	7.24 t	7.73 f	7.76cd	7.85 a	7.65 C	2.81 a	2.55 i	2.26 r	2.28 q	2.48 H	1798.00 a	1630.00 i	1445.00 p	1460.00 o	1583.25 H
270.0	7.24 t	7.75de	7.78bc	7.85 a	7.65 B	2.81 a	2.51 k	2.20 u	2.21 u	2.43 T	1798.00 a	1605.00 j	1405.00 q	1412.00 q	1555.00 I
300.0	7.24t	7.77c	7.79b	7.85a	7.66A	2.81 a	2.47mn	2.11w	2.13v	2.38J	1798.00 a	1583.00 l	1351.00 r	1364.00 r	1524.00J
Mean	7.24 D	7.54 C	7.58 B	7.63 A	7.50	2.81A	2.64B	2.45D	2.46C	2.59	1798.00A	1692.55B	1564.46D	1573.55C	1657.14
LSD at 5 %	A	0.006				A	0.008				A	6.99			
	B	0.003				B	0.005				B	4.22			
	AxB	0.011				AxB	0.016				AxB	13.98			

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

One can explain the result as; when water flows through the magnetic field, the nuclei of its atoms are polarized, this polarization makes the atoms behave as tiny magnets with north and south poles. The net results are; increment in the pH value as a result of polarization and uniform arrangement of atoms as a result of the creating poles. Increasing the circulation time increases the residence time at which water is subjected to the magnetic field, which gives the atoms enough time for more polarization and more uniformity in the arrangement of atoms, Kotb, (2013).

The pH increases 0.41 during the first initial 240 minutes of circulation, this increment represents 97.41% from the total increase achieved. While the pH increases 0.01 during the last 60 minutes of circulation, this increment represents 2.59% from the total increase achieved. One can say that; the first 240 minutes of circulation divided the behavior of pH into two sections; the first section is from 0 to 240 minutes at which the pH increases with noticeable values, the second section is from 240 to 300 minutes at which the pH increases with very small values. This phenomenon needs to define the term saturation time according to Kotb, (2013) and it may be defined as; the circulation time through the magnetic water conditioner for maximum increase in the pH value. Consequently, for the circulation time less than the saturation time one can define that the water is in the state of sub-saturation, while for circulation times greater than the saturation time the water is the saturation as illustrated in Figure (3),which is defined as the magnetized water Saturation curve. These results were in a good agreement with that obtained by Rameen and Younes, (2011), Hasaani, *et al*. (2015) and Kotb, (2013). They concluded that when water is magnetized, chemical parameters such as TDS and EC experienced degradation of 33% and 36%, respectively. On the other hand, the pH parameter showed an upgrade of 12%.

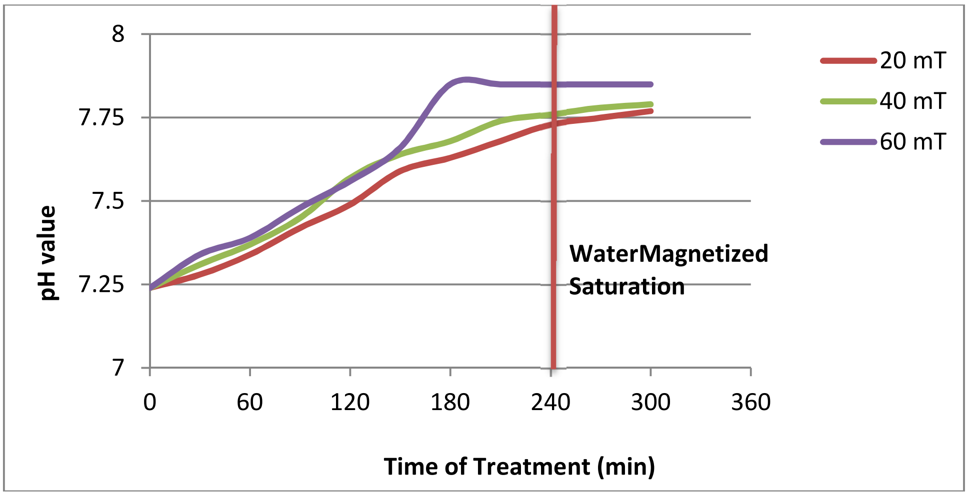

Fig. 3: Effect of different magnetic field strength and time treatment on pH value of magnetized water.

The EC and TDS of magnetized water

The results of magnetized water EC dSm^{-1}, and TDS (ppm) were decreased after the water had been exposed to a magnetization under different magnetic field strengths (20, 40, and 60.0 mT) compared with control treatment (0.0 mT). Since EC is related to the parameter TDS, therefore, after applying different magnetic field both EC and TDS were reduced as shown in Figure (4). The percentage decrease of EC values were amounted to 12.41%, 25.18%, and 24.47%, as a result of applying different magnetic field of strengths 20.0, 40.0, and 60.0mT, respectively.

The corresponding percentage decrease of TDS (ppm) values of magnetized water were 11.96%, 24.86%, and 24.14%, as a result of applying different magnetic field strengths; 20.0, 40.0, and 60.0mT, respectively compared with control treatment (0.0 time and 0.0mT) as shown in Figure (5). These results are in good a agreement with the results obtained by Hasaani, et al, (2015), who concluded that the TDS's were decreased after the water had been exposed to a magnetic field . Since EC is related to the parameter TDS, therefore after applying a magnetic field both EC and TDS were reduced. The percentage decrease in EC and TDS amounted to 36% and 33%, respectively. As a result of applying a magnetic field of strength 6560G. On contrast, Kotb, A. (2013); found that over the 820 minutes of circulation through the magnetic water conditioner, the TDS of water does not affected by recirculation through the magnetic water conditioner.

Water magnetic memory

The data in Figure (6) illustrates the effect of storage and isolation of magnetized water (with pH of 7.850, after 300 minutes of recirculation through the magnetic water conditioner 60 mT) from atmospheric air on the pH value of magnetized water, which is measured six times taking one sample each four hours for measurement. The total storage objective time is 24 hours; figure (6) shows that the variation on the pH values of storage water with time. As shown the water remember and keep the impact of passing through the static magnetic field (60mT) for 300 minutes; it is noticed that the water's pH decreases slightly while maintaining high pH value,7.850, after 4.0 hours, then water memory continues to forget the magnetic impact to be with pH of 7.27 over the 24 hours. One can deduce that; for 0.61 pH increase in 300 minutes, the pH decreases 0.580 in 24 hours and the pH reached to 7.27.

This phenomenon needs to define the term (water memory) and it may be defined as; the time at which the magnetized water remember the impact of magnetic field. The pH value may be considered as the (water memory meter), according to Kotb, (2013).

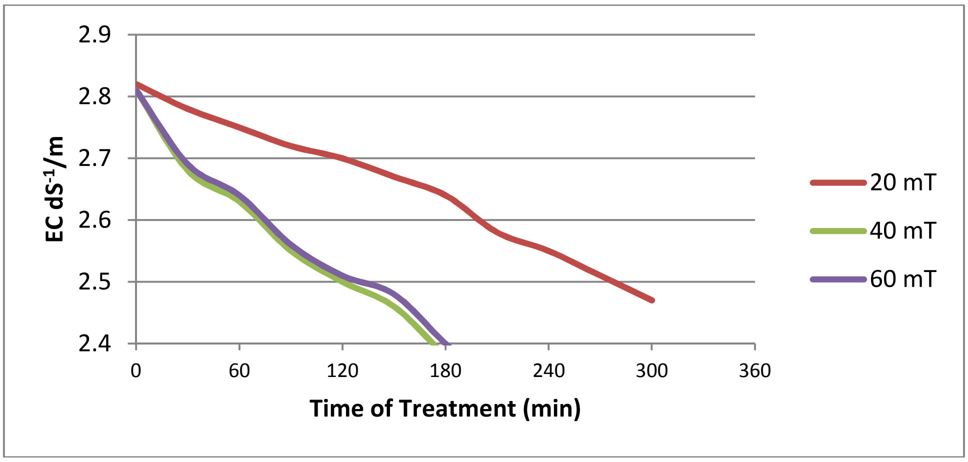

Fig. 4: Effect of different magnetic field strength and time treatment on EC (dsm-1) value of magnetized water.

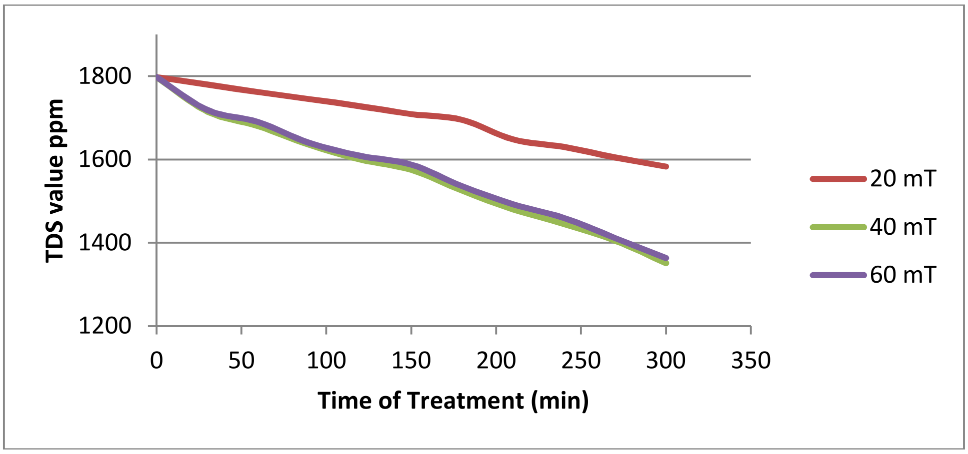

Fig. 5: Effect of different magnetic field strength and time treatment on TDS (ppm) value of magnetized water

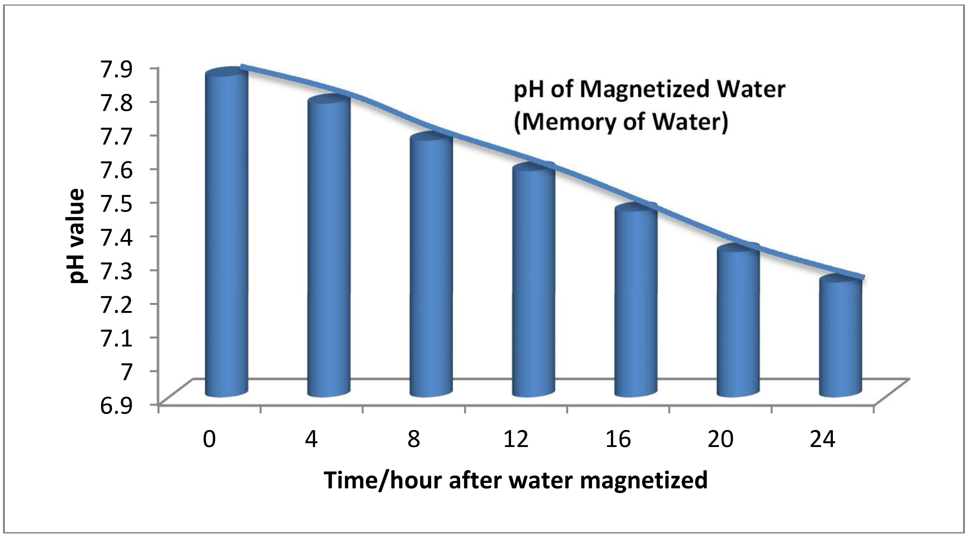

Fig. 6: The effect of time after magnetization on pH value of magnetized water

Effect of static magnetic field (40mT) on some chemical properties of magnetized irrigation water

The main soluble salts of irrigation water components of Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+} minerals. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions caused hardness of water, in addition to dissolved metals, carbonates CO_3^{--} bicarbonates HCO_3, Cl^{-}, and sulfates SO_4^{--} as dominated soluble salts.

The data in Table (2), were illustrated the effect of magnetic treatment of irrigation water by static magnetic field (40mT) on some chemical water properties. It's clearly that the EC of magnetized water significantly decreased by magnetic treatment at 40.0mT compared with the control treatment (0.0 mT). Also the TDS values give the same trend of EC values. The obtained result of pH was done affected significantly increased by magnetic treatment at 40.0mT when compared with the control treatment (0.0 mT). Regarding to the effect of magnetic treatment on soluble cations (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+} $meq.l^{-1}$), the data revealed that all soluble cations accept for K^{+} in magnetized water were significantly decreased by magnetic treatment at (40.0mT) compared with the control treatment (0.0 mT). For soluble anions (HCO_3^{-}, Cl^{-}, SO_4^{2-} $meq.L^{-1}$) there were significant decreases by magnetized water at 40.0mT compared with the control treatment (0.0 mT).

Several studies demonstrated that magnetic water treatment (MWT) influences molecular and physicochemical properties of water that alter the quality of water. The origin of physical and chemical modulations of water molecules under magnetic treatment is the alteration of water nucleus; Cai, *et al*.(2009); Coey, and Cass, (2000).

Table 2: Some chemical properties of the irrigation water before and after magnetizing treatment by magnetic field strength (40mT).

Characteristics	Non-magnetized water0.0 mT	Magnetized water 4 0.0 mT	LSD at 5%
EC (dS/m)	2.809 A	2.557 B	0.13
TDS (mg/L)	1798.333 A	1632.00 B	1.44
pH	7.380A	7.420 A	0.03
Soluble Cations, meq/L			
Ca^{2+}	7.940 A	7.060 B	0.025
Mg^{2+}	4.360 A	4.190 B	0.05
Na^{+}	14.903 A	13.410 B	0.038
K^{+}	0.900 A	0.890 A	N.S
Soluble Anions, meq/L			
CO_3^{2-}	----	-----	----
HCO_3^{-}	4.460 A	4.150 B	0.03
Cl^{-}	10.003 A	9.600 B	0.04
SO_4^{2-}	13.640 A	11.850 B	0.012
Micronutrients, mg/L			
Fe	0.072 A	0.567 A	N.S
Mn	0.017 A	0.126 A	N.S
Zn	0.045 A	0.315 A	N.S
Cu	0.012 A	0.084 A	N.S

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

The effects of magnetic treatment on irrigation water include increasing the number of crystallization centers and the altering the free gas content, Bogatin *et al*. (1999). Both effects improve the quality of irrigation water. Irrigation with magnetically treated water is the most effective for soils with high sodaic content (Bogatin *et al*., 1999).

Effect of static magnetic field (40mT) on some chemical and physical properties of soil used before and after irrigation with magnetized water

The data in Table (3), shown some soil chemical and physical properties before and after irrigation with magnetized water (40.0 mT). In the current study, the data revealed that soil salinity expressed EC $dSm^{-1}$was significantly decreased after irrigation by magnetized water of strength (40.0mT) compared with the soil EC value before irrigated with magnetized water. The soil EC values were 2.81and 1.991 before and after Irrigation with magnetized water respectively. These results are in a agreement with that obtained by Hachicha *et al*., (2016), who found that the electromagnetic treatment of saline irrigation water caused significant decrease of soil salinity (EC), Na+ and Cl^{-} contents of soils irrigated with electromagnetic treated saline water compared to the soils irrigated with non treated saline water. On the other hand the pH value of soil irrigated with magnetized water was slightly increased compared with its value before irrigation, this attributed to the buffer action of soil which resist the pH change.

Soluble soil cations and anions in (soil extract 1:1) under using the magnetized irrigation water are presented in (Table 3). There are significant differences in soluble soil cations and anions as result of the irrigated soil with magnetized water. Soluble soil cations of Ca^{2+}, Mg^{2+}, and Na^{+}, except of K^{+}, were significantly decreased by adding the magnetized irrigation water to soil. The soluble K^{+}, ion didn't affect significantly by irrigation with magnetized water. It was found that soil soluble Na^+ was significantly decreased from 15.53 meq.l^{-1} before irrigation with magnetized to 8.57 meq.l^{-1}, using non magnetized water. These results are harmonious with those obtained by Mohamed and Ebead, (2013), who found that soil soluble Na^+ was decreased by using magnetized water for irrigation.

Regarding to the physical properties, the data in Table (3) shown that particle size distribution% of soil has no any significantly differences by using magnetized water for irrigation.

Table 3: Some chemical and physical analysis of soil used before and after irrigated with magnetic water treatment (40mT)

Characters / Treatments	EC dsm^{-1}	pH	Soluble Cations (mmol kg-1)				Soluble anions (mmol kg-1)				Particle Size distribution (%)			Soil Texture
			Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3	HCO_3	Cl	SO_4	Sand	Silt	Clay	
Soil before irrigation with magnetic water	2.633 A	7.353 B	9.37 A	1.19 A	15.53 A	0.383 A	0.0	7.007 A	13.727 A	5.65 A	82.123 A	8.52 A	9.36 A	Sandy Loam
Soil after irrigation with magnetic water	1.907 B	7.40 A	9.06 A	0.99 B	8.57 B	0.48 A	0.0	5.810 B	10.947 B	1.28 B	82.121 A	8.53 A	9.34 A	Sandy Loam
LSD at %%	0.026	0.038	N.S	0.025	0.066	N.S		0.057	0.131	0.043	N.S	N.S	N.S	

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

Effect of static magnetic field (40mT) of Seeds and irrigation water on seed germination percentage of some vegetative crops, (tomato, eggplant, cucumber, and squash)

Many of the germinating seeds might fail to emerge especially under stress conditions. Saline soil or saline water and both are the most important factors that affect on seeds germination. For this reason it's important to apply magnetic seeds treatment for improved seeds germination of different corps.

As shown in Table (4), data obtained clarify the effect of magnetic technologies for seeds or irrigation water by static magnetic field (40mT) at different time of germination 7, 10, 15 days from sowing seeds of tomato, eggplant, cucumber, and squash crops were magnetized it's seeds or non and irrigated with or without magnetic water. Results indicate that magnetization of both seeds and water caused significant increased seeds germination as compared with control or to every treatment sole.

Full germination percentage100% for all seeds of the four crops were obtained after 15 days from sowing for magnetic water and magnetic seeds together compared with 80, 77, 88 and 87 % for tomato, eggplant, cucumber and squash respectively after 15 days from sowing as compared with control treatment.

Data also manifested that the magnetized seeds irrigated by non magnetized water for any test crop caused significant increase in germination percentage at any period of germination compared with the control treatment. The germination percentage was about 56, 52, 59 and 57 respectively for tomato, eggplant, cucumber, and squash crops compared with 33.33, 30.0, 36.0 and 34 for control treatment after 7 days for germination. These trend is true for all germination period of 7, 10, and 15 days and for all crops.

Regarding the effect of magnetic treatments of seeds or irrigation water the data in Table (4) reveal that the cucumber plant gave better results compared with other vegetative crops.

These results are in agreement with that obtained by Hilal and Hilal, (2000), who found that magnetic treatment of seeds and water caused a full germination rate of 100 % after 6 days from sowing compared to only 83% germination after 9 days from sowing for untreated wheat grains. In this regard, Martinez *et al.*(2009), one of the possible explanation of observed positive effect of magnetic treatment could be found in paramagnetic properties of some atoms in plant cells and pigments, i.e. chloroplasts. Magnetic properties of molecules determine their ability to absorb the energy of magnetic field, then transform it into other kind of energy and transfer this energy later to other structures in plant cells, thus activating them.

Effect of magnetic field (40mT) of irrigation water and seed of cucumber on cucumber growth parameters

Data in Table (5) reveal the effect of irrigation with magnetized water and magnetized seed of cucumber plants on plant growth parameters. Data illustrate that except for number of leaves, all growth parameter; the plant height (cm), days to 50% flowering, yield (kg/m^2), yield (number of fruits/m^2), leaves dry matter % yield (number of fruits/m^2), fruit length (cm), and germination percentage (%) of cucumber plants were improved significantly by using irrigation water and magnetized seeds as compared to the control treatment (untreated seeds and untreated water through the growing season), where's the vegetative characteristics increased linearly in response to magnetic treatment of irrigation water or seeds of cucumber plants. Similar enhancing effect of magnetized irrigation water were reported on gladiolus plants Khattab *et al.*(2000), celery and snow peas plants

Maheshwari and Grewal, (2009) and flax Abdul Qados and Hozayn, (2010). On the other hand, the same trend was found in response to pre-sowing seeds by Rochalska, (2008) on sugar beet, Carbonell *et al.* (2011) on pea. In addition, Ghaffoor *et al.* (2003) on onion, Ayeni, (2010) on tomato and eggplant reached to gradually increase in vegetative characteristics.

Table 4: Germination percentage of some vegetative crop seeds under controlled greenhouse experiments as affected by magnetic field strength (40mT) treatment for irrigation water and seeds

Treatment	Tomato				Age plant			
	Seedling counts after				Seedling counts after			
	7 Days	10 Days	15 Days	Mean	7 Days	10 Days	15 Days	Mean
Normal seeds and normal water	33.33 j	55.00 hi	80.00 e	56.11D	30.00k	51.00 i	77.00 f	52.67D
Normal seeds and Magnetized water	54.00 i	73.00 f	86.00 d	71.00 C	47.33 j	71.00 g	85.33e	67.89C
Magnetized seeds and Magnetized water	61.00 g	98.00 b	100.00 a	86.33 A	59.00 h	91.00 c	100.0a	83.33A
Magnetized seeds and normal water	56.00h	90.00 c	97.00b	81.00 B	52.00 i	87.00 d	94.00 b	77.67B
Mean	51.08C	79.00 B	90.75 A	73.61	47.08C	75.00B	89.08A	70.39
LSD at 5%	A	0.74			A	0.81		
	B	0.64			B	0.69		
	AB	1.28			AB	1.39		
Treatment	Cucumber				Squash			
	Seedling counts after				Seedling counts after			
	7 Days	10 Days	15 Days	Mean	7 Days	10 Days	15 Days	Mean
Normal seeds and normal water	36.00 j	57.00 i	88.00 e	60.33D	34.00 i	56.00 g	87.00 d	59.00 D
Normal seeds and Magnetized water	56.00 i	80.00 f	93.00 d	76.33 C	53.00 h	80.00 e	91.00 c	74.67 C
Magnetized seeds and Magnetized water	68.00 g	99.00 ab	100.0 a	89.00 A	64.00 f	97.00 b	100.0a	87.00 A
Magnetized seeds and normal water	59.00 h	95.00 c	98.00 b	84.00 B	57.00 g	92.00 c	96.00 b	81.67 B
Mean	54.75 C	82.75 B	94.75 A	77.42	52.00 C	81.25 B	93.50 A	75.58
LSD at 5%	A	0.81			A	1.01		
	B	0.71			B	0.87		
	AB	1.41			AB	1.75		

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

Table 5: Effect of static magnetic field (40mT) of irrigation water and Cucumber seeds on Cucumber plant growth parameters.

Characteristics	NMW+NMS	MW+MS	LSD at 5%
Plant height (cm)	275.00 A	352.00 B	8.96
Number of leaves	61.00 A	67.00 A	N.S
days to 50% flowering	35.00 A	40.00 B	2.87
Yield (Kg/m^2)	4.71 A	5.88 B	0.06
Yield (number of Fruits/m^2)	35.00 A	42.00 B	2.48
Fruit length (cm)	13.39 A	13.88 B	0.007
Fruit diameter (cm)	2.80 A	2.96 B	0.05
Leaves dry matter %	11.44 A	13.50 B	0.025
Germination rate (%)	88.33 A	100.00 B	1.43

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

It is clear from results presented in Table (5) that the application of magnetized irrigation water significantly increased the yield (kg/m^2) as compared with untreated irrigation water. Similar conclusions were also obtained by Tian *et al.* (1991) who concluded that the irrigation with magnetized water increased rice yield. Harari and Lin (1992) on muskmelon, Bogoescu, (2000) on cabbage, Khattab *et al.* (2000) on gladiolus, Podlesny *et al.*(2008) on pea, Maheshwari and Grewal (2009) on snow pea, celery and pea plants, Abdul Qados and Hozayn (2010), on flax and Hozayn and Abdul Qados (2010) on chickpea reported similar results.

Despite of all these advantages of the magnetic treatments in the plant characteristics, chemical composition and availability of nutrients in the soil, as well as the increments of total yield, the mechanism of action of magnetic field treatment in the plants is still unknown until now, but several theories had been proposed to explain this action. Phirke *et al.* (1996), Turker *et al.* (2007), Maheshwari and Grewal (2009), Hozayn and Abdul Qados (2010) associated the mechanism of magnetic field with the activation of phytohormone such as gibberellic acid-equivalents, indole-3-acetic acid and trans-zeatin as well as activation of the bio-enzyme systems which leads to the growth improvement and increased the crop yield.

Stange *et al.*(2002) cited that the electromagnetic fields modify the rate of ion transport across the plasma membrane or otherwise affect the structure of cell membrane lipid protein dynamics, this may cause the alteration in the permeability of the plasma membrane of plant roots. In the same manner, Taia *et al.* (2007) found significant increase in the rate of water absorption, and explained the results by the variations induced by magnetic fields in the ionic currents across the cellular membrane with leads to change in the osmotic pressure. In the same trend, Balouchi and Sanavy (2009) reported that the magnetic field influences the structures of cell membranes and in this way increases their permeability and ion transport through the ion channels, which then affects various metabolic pathway activities. In addition, Vashisth and Nagarajan (2009) demonstrated that the leachate conductivity of magnetic-exposed seeds was lower than unexposed seeds, suggesting better membrane integrity in magnetically-exposed seeds. In the magnetic-treated seeds, weak binding sites were more and strong and multi-molecular binding sites were less compared to the unexposed seeds. Total binding sites were more in unexposed control seeds. The modification of binding properties of seed water and increased seed membrane integrity in magnetically-exposed seeds might have enhanced the germination traits and early seedling growth of maize.

Lin and Yotvat (1990) indicated that the irrigation with magnetic treated water may reduce the fertilizer portion, also pointed out that the irrigation with nutrient solutions containing considerably lower concentrations of fertilizer, since the concentrations measured in soil solutions were appreciably higher when irrigation by magnetized water. Moreover, Ratushnyak *et al.* (2008) showed that the magnetic seed treatment increased the amount of microbial content of the soils such as nitrogen-fixation bacteria, this increasing in microorganisms may improve the availability of elements in the soil to plant uptake.

This in turn led to avoid the use of a big amount of mineral fertilizers. Consequently, the activity and proliferation of microorganisms in the soil may explain the increase of soil acidity in the study by Maheshwari and Grewal, (2009) who attributed the relatively greater of soil acidification to the release of greater organic acids in the rhizosphere by celery and snow pea plants irrigated with magnetic treated water compared to untreated plants. Organic acids released in rhizosphere may be responsible, thus making the nutrients more available to plant uptake.

Effect of magnetized irrigation water and magnetized seeds on some macro and micronutrients content of cucumber shoot plants

Results presented in Table (6) shown the effect of irrigation with magnetic water and seeds of cucumber on the macro and micronutrients content of cucumber shoots. Generally the data indicate that the irrigation with magnetized water and seeds of cucumber at (40mT) improved significantly nitrogen, phosphorus and potassium content in cucumber shoots. The values of N,P and K% were (1.55, 0.145, and 0.081) as compared with non magnetic water and non magnetized seeds (control)where record values of N, P and K % (1.388, 0.123, and 0.072) for N, P, and K respectively, through the growing seasons. Also, the same trend was obtained for iron, manganese, zinc and copper content (ppm) in shoots of cucumber plants. Magnetic water may influence desorption of P and N from soil adsorbed P and N on colloidal complex, and thus increasing its availability to plants resulting in an improved plant growth and productivity.

Table 6: Effect of static magnetic field (40mT) irrigation water and Cucumber seeds on some macro and micronutrients content of shoot of Cucumber plants.

Treatment	Macro nutrients content in shoot of Cucumber plants (%)			Micro nutrients content in shoot of cucumber plants (ppm)			
	N	P	K	Fe	Mn	Zn	Cu
Magnetic water	1.550 A	0.145A	0.081A	327.40A	54.013A	82.00A	14.890A
Non magnetic water	1.388 B	0.123B	0.072B	285.22B	46.090B	68.977B	13.870B
LSD at 5 %	0.031	0.001	0.004	N.S	0.057	0.029	0.066

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

Noran *et al.,* (1996) observed (under drip irrigation system) differences in the concentrations of K, N, P, Na, Ca, and Mg in soils irrigated with magnetic water when compared with normal water. They argued that magnetic water more available for plants to absorb nutrients from soil solution, probably due to the effect of acceleration of the crystallizations and precipitation processes of the solute minerals. Results also indicate that, nitrogen, phosphorus, and potassium % as well as Fe, Mn, Zn and Cu (ppm) increased significantly when magnetic water used for irrigation.

Conclusion

Results of this study demonstrated beneficial effects of applying magnetic water treatment, on soil and plants. The magnetic treatment of irrigation water plays an important role for growth parameters of cucumber plant. Magnetic irrigation water and or magnetized seeds increased, significantly the germination percentage of tomato, eggplant, squash and cucumber seeds. The magnetic water treatment (MWT) improved absorption of the nutrients (N, P, K, Fe, Mn, Zn, and Cu) by the cucumber plants and decreased the ion toxicity for the crop by decreasing the Na^+ contents in the soil solution and consequently in the plants. In addition to these beneficial effects, the magnetic treatment of seeds and irrigation water had a positive effect on yield. This means that this technology can be recommended for farmers to improve their crop yield 1` production when they are facing poor soil and water quality. However, it will be critical to understand the mechanisms and processes that affect plant yield when they are irrigated with magnetic treated water, to identify the limits of the operating requirements and to evaluate its effectiveness under open field situations.

In this regard, few studies have been conducted on the effects of magnetic treatment of irrigation water on plant growth and crop and water productivity. In addition, further field and laboratory experiments are needed to overcome the field challenges and to gain knowledge about the mechanism of action of the MWT.

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