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The impact of magnetized saline irrigation water treatment on soil, water and plant

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Magnetizing saline water is considering one of the most important technology that have been proven to actually soften water. Field study was carried out to study the effect of magnetic treatment on saline ground water on the growth and crop production of tomato. Magnetic treatment of water had slightly decreased on electric conductivity. The rate of accumulated salt was 1.27 times greater in untreated saline water compared to the magnetic water treatment of at soil surface and 1.4 times greater at the 25-50 cm depth. A comparison of concentrations of different ions between the magnetic water treatment soil and non-MTW showed that sodium concentrations were 12.1% higher in untreated saline water at soil depths of 0–25cm and 22.5% higher at depths of 25-50 cm.The magnetic treatment of irrigation water increased the shoot and yield vs. control and gained higher total tomato yield 50.52 t ha^{-1} over untreated saline water (42.32 t ha^{-1}) with increase percentage 19.4%. The difference in the dry matter production due to different treatments can be referring to the vegetative growth of shoots. The changes induced in pH and EC in magnetic water treatment resulted in accelerating biological activity in plants and consequently influenced the growth of plants. There are increases in N, K, P, Fe and Mn in tomato plant that irrigated by magnetic water treatment compared to untreated saline water.

Keywords: Magnetic treatment, salinity, soil, groundwater, tomato.

INTRODUCTION

New technologies are needed to reduce the rate of salt accumulation and improve the leaching of salts away from the root zones of salt-sensitive agricultural crops. Over time, the use of saline water in agriculture leads to soil salinization. High concentrations of soluble salts accumulated in soil can significantly decrease soil productivity. MTW has shown promising agricultural potential, offering a wide range of benefits, including soil desalinization. According to (Yadollahpour et al. 2014), MTW has demonstrated the ability to reduce water consumption and improve crop yield and plant growth. As a general, the three main observed effects of MTW in soil are the removal of excess soluble salts, lowering of pH values, and the dissolving of slightly soluble components such as phosphates, carbonates and sulfates. Furthermore, MTW is reportedly an effective method for soil desalinization, Hilal and Hilal (2000). (Hachicha et al., 2018) also observed a significant decrease of soil salinity(EC, Na^{+} and Cl^{-} contents)in soils irrigated with MTW compared to the soils irrigated with non-MTW. In contrast ,compared to both treatments, MTW produced non-significant effects on tuber yield, Mg^{2+} and HCO_3^{-}Teixeira da Silva and Dobránszki (2014) and (Zaidi et al., 2014), quotes that the practical application of using magnetic field on agriculture starting from seed treatment, germination studies, seedling development and yields of different species, such as agricultural, horticultural, herbs and medicinal plants, fodder and industrial crops have been reported. The results tend to be both positive and negative. The effects of magnetic field on plant growth and development depend on many factors of magnetic fields (MFs),such as polarity, intensity, exposure time, and magnet type (Tanaka et al., 2010), who mentioned that since the observed effects were always genotype-dependent, all MFs should be tested individually before going in a larger scale. Most of these studies, however, employed a static magnetic field on seed. However, some studies have employed magnetized water and found that it can improve water productivity and crop yield Maheshwari and Grewal (2009). These findings suggest that, there is a possibility of using magnetic treatment of water to improve the crop production even with the use of low quality water. Using of magnetic field treatment to improve plant growth is not so expensive, if we consider on long term basis and at the same time not hazardous to the environment (Bates et al., 2008). Review of literature suggests that water can be magnetized when exposed to a magnetic field (Turker et al., 2007); Maheshwari and Grewal (2009). The beneficial effects of magnetically treated irrigation water have also been reported on germination percentages of seeds Hilal and Hilal (2000); (Matwijczuk et al., 2012); emergence rate (Podleoeny et al. 2004), root growth (Turker et al. 2007), essential element uptake Maheshwari and Grewal (2009), and seed yield Selim El-Nady (2011). Apart from these an increase in soil electrical conductivity Maheshwari and Grewal (2009), mobility of nutrients from fertilizers Hozayn and Abdul Qados, (2010), water holding capacity of soil (Al-Khazan et al., 2011). Where as a reduction in soil pH, water viscosity were attained by Chang and Weng (2006), surface tension Rashed-Mohassel et al., (2009), vaporization rate (Toledo et al., 2008), and pH of water (Fathi et al., 2006). Tomato seeds irrigated with magnetized water and/or magnetized seeds irrigated with magnetized water treatments were the best treatments for overcoming the bad effects of water deficit on tomato plant growth characteristics, water relations, proline concentration and photosynthetic pigments, as well as anatomical structure of some organs of tomato plants Selim El-Nady (2011). Lin and Yotvat (1990) reported that there is an increase in both crop and livestock production with magnetically treated water. Some studies have shown that enhancement number of flowers, earliness and total fruit yield of strawberry and tomatoes by the application of magnetic fields El-Gindy (2018) Esitken and Turan (2004); (Danilov et al., 1994). Also, there is an increase in nutrient uptake by magnetic treatment was observed in tomatoes (Diaz et al., 1997). (Amaya et al., 1996) and (Podleoeny et al., 2004) have shown that an optimal external electromagnetic field accelerates the plant growth, especially seed germination percentage and speed of emergence. (Podleoeny et al., 2004) studied the effects of MTW by exposing the broad bean seeds to variable magnetic strengths before sowing and observed marked beneficial effects on seed germination, emergence rate and seed yield. They found that plant emergence was more regular magnetic treatment and the emergence occurred 2–3 days earlier in comparison with the control treatment. Also, they attributed the improvement of the yield and yield components to the pre-sowing treatment of seeds with magnetic field.

The main objective of the current study is assess the effect of irrigation by magnetically treated saline water on plant growth, yield and nutrients status of tomato and some soil properties.

MATERIALS AND METHODS

The study area located at Al-Khatatba District, Monufia Governorate, and 43kilometers north of the Egyptian capital Cairo. It has a dry climate with average annual temperature is 20.9 °C and the annual average precipitation is about 31 mm. A magnet gauss strength of 1800–2000 was used for treating water. It contains two permanent magnets that are 120 mm in length and 130 mm width, separated by a distance of 30 mm. A static non-uniform magnetic field was generated between the two permanent magnets. The arrangement of their north and south poles and direction of the magnetic field generated are shown in Fig. (1).The permanent magnets were made of Strontium Ferrite Ceramic magnets ($SRO{\cdot}6Fe_2O_3$), a common material for permanent magnet applications. The magnetic treatment was under dynamic conditions because there was a continuous flow of water by the way of pumping it with ½ HP pump through PVC pipes at the rate of 2 l/sec through the magnet. pH (1:2.5), EC of extracted soil paste were estimated (Black et al., 1982) before and after magnetic treatment. While Na and K were determined by Flame photometer (GENWAY PFP 7), and Ca and Mg, grain size distribution were determined according to USDA (2014). Available potassium & phosphorus in soil were determined according to Jackson (1958).

Soil is classified according to Soil Survey Staff (2014).

Field experiment was conducted at completed randomized using magnetically treated water and saline water to study the effect of magnetic treatment saline water on growth and crop production of tomato (Lycopersicon *esculentum* Mill) cultivar 'Castel Rock', during the late summer season of 2015 (August - December). The characteristics of irrigation water are described in Table (1).The field was initially fallow and weed growth was controlled during the 10 days of the experiment. Nitrogen fertilizer (ammonium nitrate) was applied weekly at rate of (300 kg N/ha) through drip fertigation in split doses about (600 mg/l) during the growing season. This was done along with phosphorus (160 kg P/ha), as phosphoric acid (85%) and potassium (250 kg K/ha) as K_2SO_4. All NPK fertilizers were injected directly into the irrigation water using venture-type injector. Initial, post-harvest soils and plant produces at harvest of the experimental fields were analyzed for their chemical properties. Drip irrigation system had been designed according to the standard procedures. The laterals line (JR) is 16mm in diameter, 25 m in length and 1.5 m along with net discharge 4liter/hour. All pipes were made of polyethylene and there were 10 irrigations and 5 days irrigation interval. Irrigation requirement and schedule was prepared using FAO –CROPWAT software FAO (2009). A schematic drawing of part of the irrigation system that was used is shown in Fig.(2).

Shoot and fruit tissues were dried at 70 °C in a oven for subsequent dry weight analysis. Dried plant samples were then ground to pass through a 0.5 mm screen. Total N was determined by the micro-Kjeldahl method Bremner and Mulvaney (1982).

Figure.(1) Diagram of the Magnetic device used in the study (showing their N & S poles, and water flow between the two magnets in the PVC pipe).

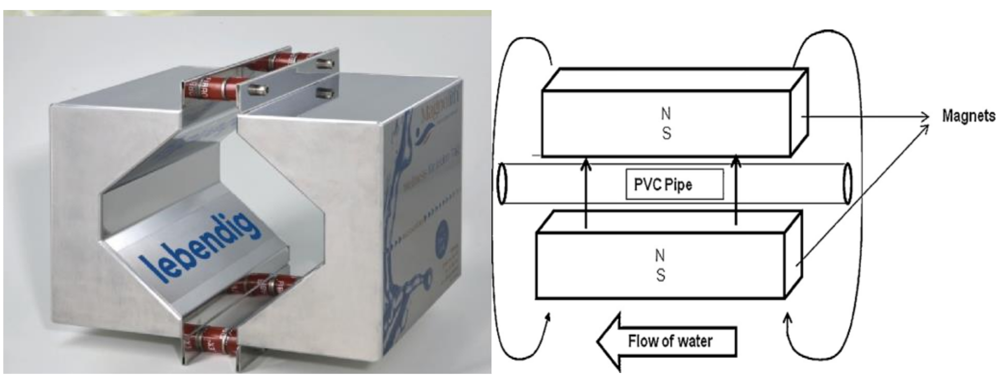
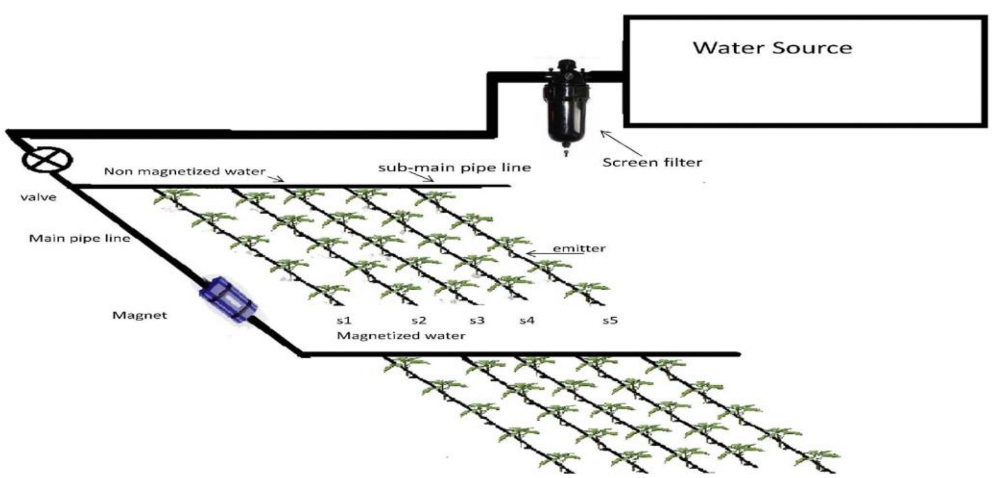


Figure. (2) Experimental set up showing the magnetic treatment and field layout.



RESULTS AND DISCUSSION

The experiment soil is deep, well-drained sandy (90.4% S, 5.5% Si and 4.3% C) ,slightly alkaline (pH 8.2), EC 1.3 dS/m, $CaCO_3$ 2.4% and organic matter content is 1.4%. The available N, P and K were 18, 9 and 52 mg/kg soil, respectively.
Data in Table (1) showed that magnetic treatment does not change chemical characteristics of irrigation water. However, it changes physical parameters and according to some authors, magnetic fields have effect on reduction of surface tension, viscosity, zeta potential, solubility, and diffusion (Bogatin et al., 1999); Cho and Lee (2005); Gang et al,(2012);Chang and Weng (2006) and Zlotopolski (2017).

The obtained data of Table (2) indicated that MTW had a significant effect on soluble salt content of soil. Soil salinity was decreased compared to the soil irrigated by untreated treatment. Surface and subsurface soil had less salt content. The rates of salt accumulation at different soil depths at periods 7 and 30 days of device installation are presented in Table (2 and 3). The rate of salt accumulation was represented as the difference between EC value at 30 days and the initial EC value, divided by time (initial EC was1.3 dS/cm). Results indicated that the rate of accumulated salt was1.27 times greater in the non-MTW compared to MTW at soil surface and 1.4 times greater at subsurface layer. A comparison of concentrations of different ions between MTW soil and non-MTW showed (Table 2 & 3) that sodium concentrations were12.1%higher in non-MTW at depths of 0–25cm and 22.5% higher at depths of 25-50cm. The same comparison for chloride and sulfates both of them were also higher for non-MTW (39.1% higher at 0–25 cm and 29.1% higher at 25-50cm depth for chloride and 18% higher at 0–25 cm and 26.5 % higher at 25-50 cm for sulfate, respectively. Similar results were obtained during field experiment by (Mostafazadeh- Fard et al., 2011) where MTW decreased concentrations of sulfate on average up to 36.0%. The obtained results in Table (4) indicate that MTW increased the shoot and yield vs non-MTW (Fig.3 & 4 respectively). MTW registered higher total tomato yield (50.52 t ha^{-1}) over non -MTW (42.32 t ha^{-1}), which accounted for 16.2% yield increase. Further, the difference in the dry matter production due to different treatments can be referring to the vegetative growth of shoots. Obtained data was in harmony with those obtained by El-Gindy (2018). The changes induced in pH and EC in MTW resulted in accelerating biological activity in plants and consequently influenced plants growth. Furthermore, the high gradient magnetic field might have resulted in faster activations of enzymes and hormones during the growth process and which might have resulted probably an improvement in the mobilization and transportation of nutrients. Besides, the magnetic treatment could act on the soil/water inter-face and may lead to destabilization of gas bubbles (air), thus disturbing the ionic balance between the shell of adsorbed negative ions and counter ions Hilal and Hilal (2000).

Table (5) showed that the concentration of some elements in the dry matter of tomato plants as affected by magnetic treated saline water. Data on hand revealed that there are an increase in nitrogen, potassium, phosphorous, iron and manganese in tomato plant, in MTW compared to non-MTW. While concentration of sodium and zinc decreased with MTW compared to non-MTW.

Data manifested in (Table 4), illustrated that magnitizing saline irrigation water enhanced fruit yield, shoot and total dry matter of tomato plant. It could estimate the increase percentage after magnetic water by 19.4, 17.4 and 20.7 % for fruit yield, shoot and total dry matter relative to the control treatment, respectively. This finding was in harmony with those obtained by (Danilov et al. 1994) and (Diaz et al., 1997) and El-Gindy (2018) who attributed the results to good root distribution, enhancing nutrient availability and encourage most of the metabolism process in plant.

Table (1). Chemical characteristics of irrigation water.

	pH	EC (dS/m)	TSS (ppm)	Soluble cations and anions ($meql^{-1}$)						
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{--}	Cl^{-}	SO_4^{-}
Non treated water	7.45	3.03	1940	10.0	6.2	13.3	0.8	0.6	14.0	15.7
Treated water	7. 41	3.00	1942	9.9	6.3	13.0	0.7	0.7	13.8	15.6

Table(2). Effect of MTW on chemical components of studied soil after 7 days

Depth (cm)	Sample	pH	EC	Soluble cations and anions (meq/l)						
		(1:1)	(dS/m)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^-
0-25	**Treated**	8.0	4.0	11.0	9.3	18.0	1.6	1.4	28.0	12.5
	Control	8.2	5.1	9.5	18.0	20.2	1.7	1.5	32.5	15.5
25-50	**Treated**	8.2	3.3	8.0	7.2	16	1.5	1.0	18.7	13.0
	Control	8.3	4.2	13.0	9.3	17.0	1.4	1.4	28.0	12.5
50-75	**Treated**	8.4	3.9	12.0	7.2	15.0	1.6	1.5	23.2	14.0
	Control	8.5	3.2	10.0	6.1	15.0	1.5	1.5	21.2	9.8

Table (3). Effect of MTW on chemical components of studied soil after 30 days

Depth (cm)	Sample	pH	EC	Soluble cations and anions (meq/l)						
		(1:1)	(dS/m)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^-
0-25	**Treated**	7.8	4.6	14.5	10.0	19.5	2.2	1.6	28.4	16.0
	Control	8.1	5.5	15.8	10.7	28.8	2.0	2.0	34.5	19.0
25-50	**Treated**	8.0	3.7	13.0	8.5	15.0	1.8	1.5	23.0	13.0
	Control	8.2	4.4	13.5	9.1	19.4	1.7	1.5	29.7	16.5
50-75	**Treated**	8.3	3.5	10.5	7.0	16.1	1.7	1.0	21.5	13.7
	Control	8.4	3.8	12.0	7.2	15.0	1.6	1.5	15.5	12.1

Table (4). Tomato yield, biomass production as affected by MTW

Treatments	Fruit	Shoot DW	Total DW
	(kg ha^{-1})		
MTW	50.52	1.42	3.50
non-MTW	42.32	1.21	2.90

DW: dry weight

Table (5). Effect of MTW on concentration of some elements in tomato plants

Treatments	N	K	Na	P	Fe	Mn	Zn
	%				ppm		
MTW	1.68	1.8	0.128	0.42	150	230	20
non-MTW	1.20	1.2	0.176	0.21	110	150	40

Figure (3) Influence of MTW on tomato growth

Figure.(4)non-MTW of tomato cultivation

CONCLUSION

The purpose of the research is to try to find a way to use the artesian irrigation water which contains a high percentage of soluble salts for the purpose of sustaining agriculture in areas far away from the Nile River or whose water needs are not met due to Egypt's limited share of the Nile water. Magnetic treatment does not change chemical characteristics of irrigation water while change some chemical characteristics of soil as salinity. Magnetic treatment resulted in significant increases of tomato yield and also content of N, P, K and Fe in tomato plants increased at the crop harvest. Further research should be conducted in the future on different types of magnetism on irrigation water with high salt content.

CONFLICT OF INTEREST

There was no conflict of interest.

AUTHOR CONTRIBUTIONS

Both of Ageeb and Talaab designed and performleed the experiments and also wrote the manuscript. Abd El-Hady and Ebtisam I. Eldardiry and performed laboratory analysis, samples collection, data analysis and also wrote the manuscript. Wahab is sharing in idea and reviewed the manuscript. All authors read and approved the final version.

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