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Research Paper

Effects of Magnetized Low Quality Water on Some Soil Properties and Plant Growth

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Abstract: *The aim of this study is to evaluate the effect of magnetic treatments on Tomato grown under saline irrigation conditions (Nile water, 1000, 3000, 6000, 9000 and 12000 ppm). In doing so, three replicates of pot experiment involving magnetically and non-magnetically treated soil were conducted. The experiment conducted under normal environmental conditions during summer season of 2009 at Faculty of Agricultural Farm, Ismailia, Egypt. The results show that the using of magnetic with saline water had the valuable effect on soil and plant. The electrical conductivity of the soil was decreased with using magnetic saline water in irrigation sandy soil. The improvement in plant growth parameters which reflected in yield per plant was increased until the treatment of 6000 ppm magnetic water. The analysis of the data collected during the study proved that there were statistically significant increases in plant growth and some chemical contents of Tomato plant. The results of the current study demonstrated that magnetic treatments improved fresh and dry weights of Tomato plant compared to control. It appears that utilization of magnetized water technology may be considered a promising technique to improve Tomato yield productivity. The results obtained also concluded that the use of magnetic techniques with low quality water is very important for irrigation without any expected problems in the soils and plant.*

Keywords: Saline Water, Magnetic Water, Growth Criteria, Yield, Tomato.

Introduction

Water scarcity and the increasing global demand for water in many sectors, including agriculture, have become a global concern. Climate change has made the situation worse by reducing the amount of rainfall and increase irrigation-water requirements as higher temperatures will cause more evapotranspiration. Sustainable use of soil and water resources in a broad global perspective will be an important challenge for future soil science. Human demand for environmental resources is quickly growing around the world. Population facing water scarcity will double over the next 40 years.

Food production must increase to meet the needs of an additional 3.5 billion people over the next 40 years. Feeding world population of 6.5 billion in 2006, 7 billion in 2010, 8 billion by 2025 and 10 billion by 2050 is beyond mandates that soil quality be restored and enhanced. Under the population pressure in Egypt country, the need to provide additional land for farming to increases food production to support the acceleration of population growth compels the country to use all sources of low quality (e.g., saline, gray …) water. The use of saline water for agricultural production in water scarcity regions requires innovative and sustainable research, and an appropriate transfer of technologies. There is a pressing need for a system (technology roll e.g. magnetic field) that can help in using saline water. The use of sea water diluted with fresh water should be considered as complementary sources for the expansion of irrigated agriculture and agricultural development.

Over recent years there has been a rapid increase in the use of technologies employing electromagnetic fields (EMFs) and radiations covering all parts of the electromagnetic spectrum. Electricity produces two types of fields, an electric field and a magnetic field. Since the late 1970s, concern has primarily focused on the magnetic field, so today when people talk about EMF they generally are referring only to the magnetic field. A great number of papers on the effect of magnetic field on the physical and chemical properties of water [1,2,3,4,5,6,7,8], aqueous solutions [9,10] and salt crystallization in MFs [11-18] have been published.

The most commonly raised criticism about magnetic water treatment turns around the low reproducibility of the results and the mechanism through which magnetic fields exert the influences on the processes and the characteristics of scaling compounds is as yet not adequately explained.

Tombacz et al. (1991) have tested both flowing and static systems, and concluded that only in a flowing system (magnetic flux density ranges from 0.1 to 0.8 T) is the magnetic effect observed. Kobe et al. (2001) took 0.5 T as the magnetic flux density in their experiments to obtain successful treatment results[19]. These properties of liquid water are brought about by the hydrogen-bonded which is highly affected by electrical and magnetic fields. The number of hydrogen bonds is increased by approximately 0.34% when the MF strength increased from 1 to 10 T[19].

However, there are some potentially beneficial effects of EMFs or treatment on plant growth and other related parameters. There is no much research carried out on the effects of magnetic treatment of irrigation water on plant growth, yield and water productivity. Some studies have reported on potential benefit of magnetically treated water in water productivity in both crop and livestock production, increase in number of flowers, earliness and total fruit yield of strawberry and tomatoes, increase in nutrient uptake in different crops [20], increase of the seed germination, fresh weight and shoot length of maize, increase plant nutrient content, improve the growth, yield and yield components and chemical constituents of lentil and chickpea plant, increased the yield of cabbage**,** pea plants influenced the chemical composition of plants, soil nutrient availability and activate plant enzymes .

Despite many examinations, the effect of EMFs on saline water is not still recognized. There are many hypotheses which explain the action of EMFs, but they are unable to explain all phenomena. The reason for this is selective treatment. Therefore, the present study aims to evaluate the applicability of using of magnetized saline water in irrigation of Tomato plant. Also, some of the soil chemical changes were evaluated. The main objectives of the study are to:

- Quantify the performance of magnetically treated Nile water, and saline water on plant growth, and nutrient content of Tomato, and
- Determine the changes in soil properties due to irrigation with magnetically treated water.

Material and Methods

Location, Planting of Seedlings, and Growing Conditions: The study involved experiment and laboratory analysis of soil and plant properties. The experiment was conducted to examine the effects of magnetic treatment of different saline water on plant yield, soil properties, and nutrient composition of Tomato.

Tomato seeds were initially sown in seeding mixture on 20th January 2009, and normal water was used for establishing the seedlings. Once seedlings achieved required growth, healthy seedlings were selected for planting in the study which were transplanted on 1st Marsh 2009.

Magnetic Treatment and Water Analysis: Two water types were selected for the study: Nile water, and saline water. The saline water used in the study was prepared by adding measured amounts of NaCl salt to Nile water to achieve required salinity levels. To understand the impact of salinity levels on magnetically treated water, five salinity levels were used, 1000 ppm, 3000 ppm, 6000 ppm, 9000, and 12000 ppm. The irrigation water of different types was treated with a magnetic device before applying to the plants. The water passed throws 250 mT magnetron unit of 3.5cm diameter which produced by magnetic technologies (Germany).

The mean values of pH, EC, cations and anions values of different irrigation water types before and after magnetic treatment are presented in Table 1. Magnetic treatment of water tends to reduce slightly the water pH, while there is slightly increase in trend for EC values. The values of Mg, Na, Cl, SO_4 and K content of different water types were not affected by magnetic treatment of water (Table 1).

Soil Properties and Irrigation Scheduling: Two uniform size plants per pot were transplanted. Soil for the study was obtained from experimental farm of the Faculty of Agriculture, Suez Canal University and was sieved to remove any pebbles or non-soil material. Table 2 shows the soil chemical analysis of investigated soil before cropping. The soil was sandy in texture and had the value of pH1: 2.5 (soil: water) 8.2, ECe= 3.85 dSm^{-1}.

The main irrigation scheduling strategy used in the study was to apply enough water to bring the soil back to field capacity at the end of each irrigation. The plants were irrigated alternate days and the volume of irrigation water applied was determined by knowing the change in pot weight due to evapotranspiration since the last irrigation. The volume of water applied varied with treatments and the stage of crop growth and was recorded for each application.

Table 1
Water analyses before and after magnetized treatment

Treatment	Magnetic Field	EC dSm^{-1}	pH	Cations				Anions			
				Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3	HCO_3	Cl^-	SO_4
Nile water	without	0.375	7.90	0.85	0.77	1.30	0.25	0.0	1.06	1.75	0.90
	with	0.468	7.82	1.20	1.30	1.30	0.29	0.0	1.41	2.00	1.21
1000 ppm	without	1.481	7.83	1.14	1.88	11.22	0.40	0.0	2.80	9.80	2.21
	with	1.710	7.75	1.56	2.20	12.96	0.46	0.0	3.30	11.5	2.30
3000 ppm	without	4.725	7.85	2.80	4.90	36.48	1.87	0.0	4.00	37.0	4.60
	with	4.935	7.65	4.15	6.96	38.96	0.93	0.0	5.60	37.0	5.91
6000 ppm	without	9.030	7.80	6.11	7.12	75.60	1.35	0.0	6.80	75.0	7.20
	with	9.250	7.87	7.86	8.95	76.78	1.38	0.0	7.60	76.0	7.90
9000 ppm	without	14.230	7.99	9.82	14.75	119.0	1.74	0.0	9.80	122	10.2
	with	14.450	7.94	10.25	14.35	120.0	1.77	0.0	11.00	120	11.9
12000 ppm	without	18.395	7.93	18.51	22.32	135.1	2.02	0.0	17.90	146	17.1
	with	18.615	8.11	20.10	23.30	140.0	2.06	0.0	19.60	149	18.0

Table 2
Some chemical analysis of soil used before cropping

Soil	EC dSm^{-1}	pH	Cations				Anions			
			Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3	HCO_3	Cl^-	SO_4
	3.85	8.20	11.80	10.50	15.20	0.90	1.00	10.20	18.50	5.00

Table 3
Characterization of the soils samples after plant harvest

Water Treatment	Magnetic field	EC dSm^{-1}	pH	Cations				Anions				SAR
				Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3	HCO_3	Cl^-	SO_4	
Nile water	without	4.29	8.20	12.00	11.00	20.00	0.95	1.20	12.0	22.50	6.00	5.90
	with	3.55	8.00	14.00	10.00	14.20	1.30	1.60	10.0	21.00	7.00	4.10
1000 ppm	without	5.10	8.30	15.50	12.50	22.00	1.70	1.80	16.0	26.00	8.00	5.88
	with	4.81	8.40	16.20	10.20	20.00	1.70	1.70	14.0	24.50	8.80	5.50
3000 ppm	without	6.43	8.70	18.90	14.50	27.90	1.82	7.00	16.0	30.80	10.4	6.83
	with	5.73	8.50	17.30	12.70	25.50	1.88	6.00	14.0	28.00	9.70	6.58
6000 ppm	without	10.00	7.90	29.60	24.50	50.00	2.10	13.0	23.0	46.50	19.7	9.61
	with	9.50	8.10	25.70	22.10	46.20	2.00	11.0	21.0	45.70	17.0	9.45
9000 ppm	without	18.13	9.00	41.90	59.00	79.00	4.90	20.0	39.0	88.30	15.8	11.12
	with	16.45	8.80	38.00	56.00	77.00	4.70	16.0	36.9	86.30	21.0	11.23
12000 ppm	without	21.32	9.00	50.00	69.00	86.00	6.00	23.0	42.0	99.00	19.7	11.15
	with	19.62	8.60	48.00	67.00	84.00	5.00	22.0	39.0	97.99	19.9	11.08

Material and Methods

Magnetic exposure (250mT), 3.5cm diameter and 12cm long. Electrical conductivity and soluble K^+, Ca^{2+}, Mg^{2+}, Na^+ and Cl^- in soil paste extract and pH in suspension (1:2.5) were determined as described by APHA, (1985). Electrical conductivity in irrigation water was measured using conductivity meter (model 710) according to APHA, (1985). The pH of the soil samples is determined by bench type Beckman glass electrode pH meter in 1: 2.5 soil water suspensions. Anions of HCO_3^-, Cl^-, and SO_4^{2-}, cations of Ca^{2+}, Mg^{2+}, Na^+ and K^+ and phosphorus were determined according to APHA, (1985). The determinations of Available-K, and P according the method described in APHA (1985). Available K was determined in ammonium acetate extract by using flame photometer and Available P was determined calorimetrically in 0.5 M $NaHCO_3$ extract.

Results and Discussion

Soil Properties after Plant Harvest: The magnetic treatment of irrigation water had slightly significant effect in decreasing ECe values after the harvest of plants (Table 3). On the other hand, overall, the magnetic treatment resulted in significant effects on ECe. Except for 1000 and 6000 ppm saline water, the magnetic treatment of irrigation water types decreased and affected soil pH after the harvest (Table 3).

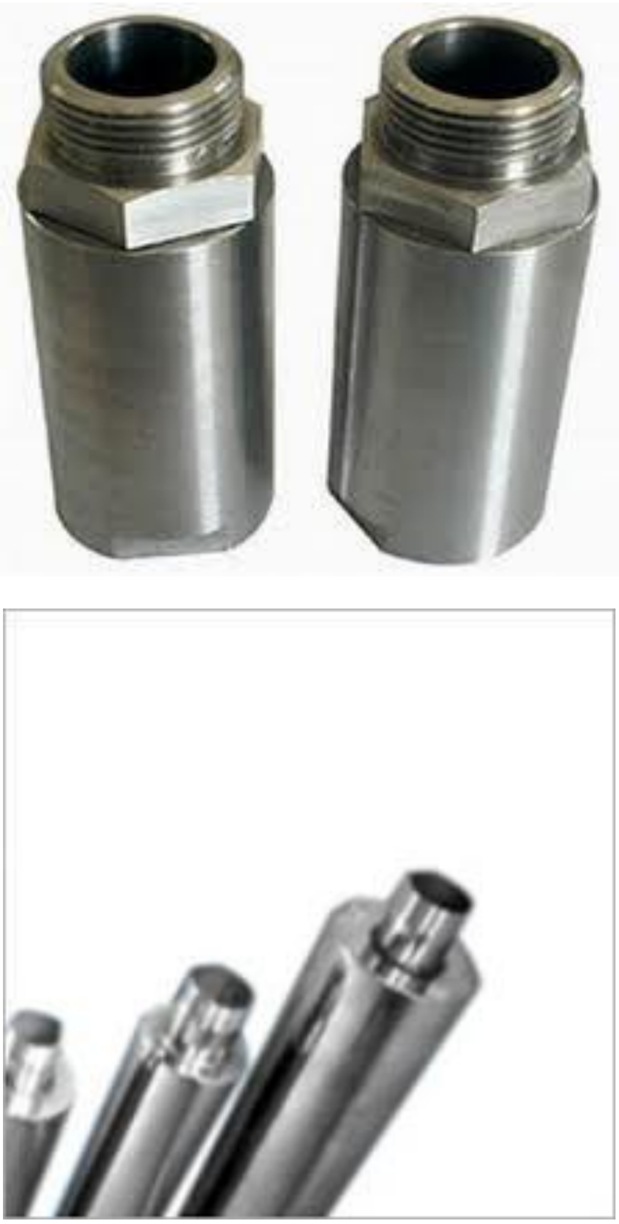

Figure 1: Magnetic exposure used in the study

Results of soluble cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}), and anions (HCO_3^{-}, Cl^{-} and SO_4^{2}) concentration in soil extract after harvesting indicated that using of magnetized irrigation water resulted in decreased in soluble cations concentration as compared with Nile water.

Morphological Plant Analyses

There were differential effects of magnetic treatments of different irrigation water types on yield based on both fresh weight and shoot dry weight (Table 4). The effects of magnetic treatment on saline irrigation water indicate significant increase in shoots and roots due to the magnetic treatment of water and saline water except for 9000 ppm.

Irrigation with magnetically treated 1000, 3000, 6000 ppm saline water and 12000 ppm water respectively resulted in 23%, % and 12% increase in plant shoots on fresh weight basis. Similarly, magnetically treated 1000, 3000, 6000 ppm saline water and 12000 ppm water treatment respectively resulted in 26%, % and 12% increase in roots dry weight. However, there was no statistically significant increase in the shoots or roots dry weight by irrigating with magnetically treated 12000 ppm saline water.

Figure 2 and Table 4 show the effect of different salinity levels and magnetite treatments on root for weight when compared with the control of Tomato during the growing season 2009. Except 9000 ppm saline water, the magnetic treatment have slightly significant effect on the root weight.

Nutrient Composition of Plant: Overall, except for 3000 and 9000 ppm, irrigating with magnetically treated water slightly significantly increased P concentrations of tomato shoots (Table 5). Irrigation with magnetically treated water slightly significantly increased P concentrations of tomato roots. On the other hand, except for 6000, 9000, and 12000 ppm, irrigation with magnetically treated water slightly significantly increased K concentrations of tomato shoots (Table 5).

The results of the current study (table 4 and 5) show that an increase in soil available P and extractable K, particularly under magnetically treated saline water irrigation, appears to have played some role in improving growth of Tomato plants.

Overall Discussions: Two objectives of the current study are identified in the introduction: First is to quantify the performance of magnetically treated Nile water, and saline water on plant growth, and nutrient (P and K) content of Tomato.

The beneficial effects of magnetic treatment of some water types in the current study may be due to some alterations within plant system at biochemical level and their possible effects at cell level. External electric and magnetic fields have been reported to influence both the activation of ions and polarization of dipoles in living cell. Electromagnetic fields (EMFs) can alter the plasma membrane structure and function. Goodman et al. (1983) reported an alteration of the level of some mRNA after exposure to EMFs.

Above statements further suggest that the magnetic treatment of water probably alters something in water, makes the water more functional within plant system and therefore probably influences the plant growth at cell level. Magnetic treatment of water may affect phyto-hormone production leading to improved cell activity and plant growth.

Second objective is to determine the changes in soil properties due to irrigation with magnetically treated water. The results of this study were shown that magnetized water play an important role in salts solubility resulting in increasing their cations and anions concentration. Removal of excess salts or decreasing their activity is necessary for preventing transformation of highly productive soil into non-productive salt affected soils [21,22].

In study of Tackashinko (1997) indicate that the magnetized water removed 50 – 80 and Cl- 30% HCO3- compared to a removal of 30 and zero% respectively by normal irrigation water. Magnetized water has also doubled the leaching of $SO4^{-2}$ and increased O_2 content by 10% Tackashinko (1997). Zhu et al., (1982) has also reported that laboratory tests have showed that desalination of a saline soil was 29% greater in the first leaching and 33% greater in the second leaching with magnetized water compared to untreated water. Hilal et al., (2002) stated that magnetized water increase the leaching of excess soluble salts, lower soil alkalinity, and dissolve slightly soluble salts such carbonates, phosphates and sulfates[23].

There is almost no valid scientific data to support any water treatment benefit from magnetic devices. Many claims have been made that EMFs can improve water productivity or change the physic-chemical properties of water, or prepared laboratory solutions by influencing pH value, nucleation and growth, surface tension and chemical equilibria. Duffy (1977) concluded that permanent magnets have no effect on the hardness of water or the formation of scales on pipes. Gruber and Carda, (1981) concluded that there was no change in the physical and chemical properties or the calcium ion concentration of water treated with the devices [24]. A third study conducted by Alleman, (1985) [25] who concluded that no significant variation in the chemical water quality for temperature, specific conductivity, surface tension, boiling point of depression, pH, alkalinity, total hardness and calcium existed between the control and the “treated” systems. Supported by this evidence, the Canadian Water Quality Association issued a statement in 1987 that magnetic water treatment devices are ineffective in treating hard water or preventing scales.

Despite this claims, companies, sales representatives, and product brochures for the devices may make any one of the following claims: “Gives hard water properties of soft water”, “Prevents water from forming normal chemical reactions that cause hard water scale, rust, and corrosion.”, “Stops buildup of scale and rust and eliminates or reduces existing rust.”, “Reduces hydrogen sulfide smells and iron buildups.”

Table 4
Effect of different salinity levels and magnetized treatments on morphological shoots and roots of Tomato

Water Treatments	Magnetic Field	Plant Weight			
		Fresh Shoot	Fresh Root	Dry Shoot	Dry Root
Nile water	without	44.00	20.50	6.30	3.63
	with	77.00	75.0	10.50	10.46
1000 ppm	without	73.00	25.0	11.50	4.02
	with	75.00	52.0	11.00	6.58
3000 ppm	without	29.00	21.0	4.56	3.49
	with	40.00	30.0	6.52	5.50
6000 ppm	without	22.00	14.0	4.44	1.75
	with	37.00	35.0	6.50	4.89
9000 ppm	without	20.00	15.0	3.70	2.25
	with	10.00	16.0	2.30	1.96
12000 ppm	without	8.00	9.00	1.78	1.10
	with	12.00	11.00	2.04	2.14

Table 5
Effect of different salinity levels and magnetite treatments on plant phosphorus and potissum of Tomato

Water Treatments	Magnetic Field	Plant Composition %			
		P Shoot	P Root	K Shoot	K Root
Nile water	without	0.25	0.13	4.40	0.70
	with	0.28	0.16	4.50	0.88
1000 ppm	without	0.18	0.11	1.92	0.80
	with	0.19	0.12	1.97	0.85
3000 ppm	without	0.16	0.099	1.85	0.77
	with	0.15	0.10	1.85	0.79
6000 ppm	without	0.13	0.089	1.76	0.67
	with	0.14	0.086	1.74	0.67
9000 ppm	without	0.12	0.070	1.67	0.58
	with	0.11	0.069	1.61	0.50
12000 ppm	without	0.10	0.056	1.66	0.47
	with	0.10	0.054	1.59	0.35

Conclusion

The aim of the current study is to evaluate the applicability of using the magnetized saline water for irrigation Tomato plant and study its effect on soil and plant properties. This study found that the effects of magnetic treatment varied with the type of irrigation water used, and there were statistically significant increases in plant growth. On the other hand, as to soil properties after plant harvest, the use of magnetically treated irrigation water reduced soil pH but increased soil EC and available P. Overall, the results indicate some beneficial effect of magnetically treated irrigation water, particularly for saline water.

 Nile water	 1000 ppm	 3000 ppm
Without - With	Without - With	Without - With
 6000 ppm	 9000 ppm	 12000 ppm
Without - With	Without - With	Without - With

Figure 2: Effect of different salinity levels and magnetized treatments on root dry weight when compared with the control of Tomato

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