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The effect of magnetic water on concentration of micronutrient elements in basil leaves

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ABSTRACT

Although the magnetic field is an indispensible environmental factor for plants in soil, there is dearth of research regarding its effect on plant growth. In order to evaluate the effect of magnetic water on concentration of micronutrient elements in basil leaves, the present experiment was conducted under completely randomized factorial design with two treatments and three replications in greenhouse. The treatments consisted of the kind of water (magnetic and nonmagnetic water) and salinity treatment in three levels (distilled water, 30 mM and 50 mM salinity). The results indicated that the maximum effects on Mn, Zn and Cu concentration in basil leaves were produced by magnetic water. Concerning salinity treatments, the maximum effects on Mn, Zn, Cu and Total Fe in basil leaves were for water with 30 mM salinity. The interaction effects between the kind of water and salinity levels showed that maximum effects on these elements were related to magnetic distilled water.

Introduction

The growing need for agricultural products together with the increasing demand for vegetative raw materials for food production make it necessary to employ other branches of industry in new research and take safe decisions to increase agricultural products. Harmful changes made in soil, water, and atmosphere due to human interference and use of different chemical additives for increasing plant productivity have led to searching for new different methods to increase production rate (Aladjadjiyan 2007). A wide range of chemical materials and fertilizers have been used in agriculture in the last century. Although it has enhanced the quality of life, it has exerted negative effects on food products and environment. That is why agricultural researches have led to the study of determining factors such as ionization, laser ray, ultra violet ray, electrical and magnetic fields in plant products (Faqenabi et al. 2009). Whenever water is exposed to a magnetic field, some of its properties such as density, Electrical Conductivity (EC), salt solubility, and the rate of its solid deposition and evaporation undergo changes. Because of physical and chemical changes in irrigation water, magnetic water application has assumed great importance in agricultural consumptions. These changes depend on the rate of water flow through the magnetic field, chemical parameters such as carbonate rigidity and pH (Duarte Diaz et al. 1997). It has been reported that magnetic fields could affect both ion activity and polarity of bipolar molecules in the living cells (Majd and Shabrangi 2009). Most researches have suggested magnetic field has positive effects on seed germination rate. Majd and Shabrangi (2009) reported an 11% increase in lentil seed germination rate after 180 mT magnetic field treatment for 10 minutes, and a 34% increase after 240 mT treatment for 20 minutes. Amaya et al. (1996) showed that electromagnetic field produces an increase in seed germination percentage, bud appearance, and plant growth rate. It has been reported that water efficiency increased crops production and domestic quadrupeds by using magnetic water as the treatment (Lin and Yotvat 1990). In another study, it was shown that magnetic fields can have positive effects on root growth in different plants (Belyavskaya 2001, 2004). Exposing the corn seeds to a 5 mT magnetic field with a frequency of 40-160 Hz resulted in an increase in root growth, whereas in a magnetic field with a frequency of 240-320 Hz, reduction of primary growth in corn plants was indicated (Muraji et al. 1992). By exposing cress seedlings (Lepidium sativum) to 40, 42 and 45 ˚C temperature while passing them through a magnetic field, Ruzic and Jerman (2002) reported a reduction in heat stress for 40 minutes. They concluded that magnetic field is like a protective factor against heat stress. Podleoeny et al. (2004) put bean seeds in a variable magnetic field and evaluated its effect on seed germination before cultivation. By applying magnetic field, bud appearance became much more uniform. In addition, germination occurred 2-3 days earlier than the control group. They also attributed crops production enhancement in area unit to the magnetic field. Esitken and Turan (2004) studied the effect of variable magnetic field on crop production and ion accumulation in strawberry leaves. They exposed the strawberries cultivated in the greenhouse to a magnetic field with 96,192 and 384 mT. Fruit yield and fruit number per plant, and average fruit weight were higher in low-intensity magnetic fields in comparison to high-intensity ones. By enhancing the magnetic field intensity, the amounts of Na, Mn, Fe, Cu, Mg, Ca, K and Zn accumulated in leaves increased, but those of P and S reduced. In another study, Turker et al. (2007) found that magnetic field causes a decrease in the dry root weight of the maize plant and an increase in that of the sunflower plant.

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Maheshwari and Grewal (2009) studied the effect of magnetic field on irrigation water in pea, celery and snow pea. The effect of magnetic field on potable water (tap water), recycled water and saline water in yields of the three aforementioned plants were evaluated. The results showed that the effect of magnetic field is different in various plants and water qualities. They reported that magnetic irrigation increased Ca and P concentration in celery stems. Also, they showed a significant increase in the amount of Ca and Mg when the snow pea pods were irrigated by magnetic recycled water and 1000 ppm saline magnetic water. Reviewing the reports in many cases indicates that magnetic field has probably positive effects on plant growth and nutrient compositions. However, there are no reports available regarding the range of such effects. Hence, the aim of this research is to evaluate the effects of magnetic water on concentration of micronutrient elements in basil leaves.

Materials and methods

Plant material and growth condition

Modified seeds of basil plants (*Ocimum basilium*), cultivar Mobarakeh Isfahan, were bought from Pakan Bazr Co., Isfahan, Iran. Eight seeds were planted in each of the eighteen 60×40×30 centimeters (length×width×Height) boxes, with same distances, in the research greenhouse of the Agriculture Faculty at Bu Ali Sina University, Hamdean, Iran. The study was performed at controlled environmental conditions with the average night and day temperature of 13-35 ˚C in the greenhouse. The soil composition consisted of high-grade agricultural soil, sand, and completely rotten, animal fertilizer mixture with the proportion of 60 %, 24 % and 16 %, all of which were screened. Chemical and physical properties of the soil mixture were determined and the results are shown in Table 1.

Table 1. Chemical and physical properties of the soil mixture

Text	pH	EC (µs/cm)	Mn(mg/kg) Total	Cu(mg/kg) Total	Zn(mg/kg) Total	Fe(mg/kg) Total
Sandy Loam	7.98	2430	353.625	71.625	121.31	34519.14

Magnetic water preparation

The handmade magnetic water preparation device was made at Water Quality Laboratory in the Faculty of Agriculture, Hamdean, Iran. This device comprised some U-form magnets with north and south poles, all of which were proximally coaxial and totally created a specific length in the magnetic field (Figure1).

Figure 1. Arrangement of wired U-shape magnets.

For each magnet, 81 meters copper wire weighing 300 gr was used, and the copper wire was twisted around the core by hand. Since the magnets with equal and uniform properties were parallel with one another, magnetic field was vectorially uniform and perpendicular to water movement direction. As a result, the maximum magnetic field intensity was created. Magnetic field was developed by direct current (DC) feeding source.

Measurement of magnetic field intensity

In order to measure the magnetic field intensity, a magnetic scales (LH-6510, MATLABO, France) was used. Magnetic field intensity was determined by reading the recorded force by the scales. It was calculated equal to 0.1 Tesla by using the following formula:

$$B = \frac{F \times 10^{-4}}{i \times l}$$

where B is the intensity of the field (Tesla), F the recorded force by magnetic balance (N), i the current in the magnetic scales (A), and l the length of the scales where the magnet is put (cm).

Table 2. Analysis of variance of the effects of magnetic water on micronutrients concentration in dry leaves of basil plants

			Mean Square		
Source	DF	Mn	Zn	Total Fe	Cu
Kind of water	5	1006.5**	13.78**	459.55^{ns}	9.17**
Saline level	2	326.86**	4.47^{ns}	252858.6**	3.18**
Kind of water×saline level	2	1958.07**	17.27**	42165.37**	3.74**
Error	12	25.75	1.39	3010.39	0.1

** and ns respectively : significant at 1% possibility level and Non-significant

Table 3. comparison of the means regarding the effect of magnetic water on concentration of micronutrient elements (mg/kg) in dry basil leaves

Treat		Mn (mg/kg)	Zn (mg/kg)	Total Fe (mg/kg)	Cu (mg/kg)
Kind of water	A	48.88a	16.52a	622.31a	7a
	B	33.93b	14.77b	632.41a	4.57b
Saline level	1	43.6a	15.19a	692.22b	5.5a
	2	47.45a	16.64a	792.38a	5.88a
	3	33.18b	15.09a	397.48c	4.47b
Kind of water×saline level	1	39.6c	16.1ab	679.55b	5.8a
	2	73.5a	17.65a	877.2a	6.1a
	3	33.56cd	15.8ab	479.8c	6.1a
	4	27.65de	14.29bc	704.88b	5.2b
	5	21.4b	17.48a	707.57b	5.6ab
	6	53.63b	12.54c	315.15d	2.85c

A and B respectively: magnetic and Non-magnetic water

1 to 3 respectively: distilled water, water with 30 mM saline, water with 50 mM saline

Mean data in each column with at least one similar character shows non significancy at 5% possibility level by Duncan’s test.

Statistical designs and data analysis

The experiments were performed in the form of completely randomized design, with two treatments and three replications. The treatments consisted of kind of water (magnetic and nonmagnetic water) and salinity treatment in three levels (distilled water, 30 mM and 50 mM salinity). Totally, 18 boxes were prepared. At first, the plants were irrigated with distilled water for about one month; then, the relevant treatments were applied. In order to keep the soil surface with depth of 2 and 3 cm wet, the irrigation water was sprayed every two days to prevent movement of seeds. Later, the digital tensiometer (P714, Taiwan) was used. Later, the saline water was prepared by NaCl. Eight plants were brought out of the boxes and their leaves were separated. Then, they were put in the oven at the temperature of 75 ˚C. In order to measure the concentration of the elements in the leaves, 0.5 gr of the milled leaf samples were put in the stove, at 520-550 ˚C for 3-4 hours, to be ashened. After that, 10 ml of 1 N hydrochloridric acid was added to the samples and then they were put in the water bath with 85 ˚C temperature until they got a lemon-like color (Mortvedt and Cox 1991). The concentrations of the studied elements were read by using atomic absorption device (Varian Model 220). Statistical data analysis was performed by using SAS version 9 software and the comparison of the means was performed by Duncan's Multi domain Test.

Results and discussion

Table 2 shows the analysis of the variance and table 3 the comparison of the means regarding the effect of magnetic water on concentration of micronutrient elements in dry basil leaves. At 1% possibility level, the analysis of variance showed that the kind of water had a significant effect on Mn, Zn and Cu concentration; in addition, the salinity level had a significant effect on Mn, Total Fe and Cu concentration (Table 2). Furthermore, the interaction effects between them had a significant effect on concentration of all elements at 1% possibility level (Table 2).

Mean comparison of the kind of water treatments indicated that maximum effects on Mn, Zn and Cu concentrations were related to magnetic water, which might be due to their solubility in the soil solution and; therefore, their more uptake by plants (Table 3). Also, mean comparison of salinity levels showed that salinity had a direct effect on uptake of these elements, i.e. salinity increase resulted in increase of the elements uptake. In contrast, the uptake decreased for the 50 mM concentration due to the fact that the effects of salinity stress decreased the uptake of water and, consequently, of these elements. The interaction effects between the kind of water and salinity levels showed that maximum effects on these elements concentration were related to magnetic distilled water (Table 3). The findings of the present study are similar to those of Esitken and Turan (2004) which reported increase of these elements in leaves by raising the magnetic field intensity. The beneficial effects of magnetic water treatments in this research may be due to some alterations within the plant system at biochemical level and their possible effects at cell level. Thus, these biochemical processes can have a negative effect and decrease the uptake of these elements. External electric and magnetic fields influenced ions activation as well as dipoles polarization in living cells (Moon and Chung 2000). Electromagnetic fields can alter the plasma membrane structure and function (Paradisi et al. 1993; Blank 1995). All in all, it can be concluded that the magnetic treatment of water, perhaps, alters the structure of water, which makes water more functional in plant system and thus might influence the plant growth at cell level. Finally, magnetic treatment of water may also affect phyto-hormone production, which leads to improved cell activity and plant growth.

Conclusion

The magnetic water treatment resulted in statistically significant increases in Mn, Zn, Cu and Total Fe in basil plant. Magnetic field may serve an important role in cation uptake capacity and have a positive effect on immobile plant nutrient uptake. Overall, the data collected in this preliminary study, under controlled conditions in glasshouse situation, suggest that the magnetic treatment of irrigation water might produce beneficial effects on the basil plant. As such, the results should be further tested under field conditions so as to evaluate the usefulness of magnetic water treatment in crop production.

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