Effects of magnetic treatment of different qualities of irrigation water on plant growth

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Abstract. This study aims at evaluating the effects of magnetic treatment of different qualities of irrigation water on growth of sunflower plant. Three different levels of water salinity were used to irrigate this plant. The electrical conductivity of these three different salinity irrigation were 0.7, 4, and 8 dS/m. The lower limit of the electrical conductivity represents the salinity of tap water. A magnetic treatment device was used to treat the irrigation water with two intensities of 1000 and 3000 Gauss. Replicated pot experiment sets were conducted in a field conditions environment. These experiments include irrigation sun flower plant with magnetically treated and untreated irrigation water. The experiments continued for 20 days after seeding. In general, the results showed that the low limit of EC of the used untreated irrigation water is the best for the plant growth in all its life stages among other used irrigation water. The growth of the sunflower is affected negatively by the salinity of the untreated irrigation water. Exposing the used irrigation water to a magnetic field has valuable effects on the sunflower growth. These effects are in different levels that depend on the salinity of used irrigation water. For the irrigation water of the three EC values of 0.7, 4, and 8 dS/m, the achieved maximum increase in germination was 7.2%, 57.3%, and 150.4%, the root depth increased by 14.3%, 10.2%, 16%, the stem height was increased by 29.6%, 60%, 28%, respectively, when compared to the sunflower plant irrigated by untreated water. Moreover, the maximum increases in the wet weight of the green part of the plant were 79.7%, 53.5%, and 82.7%, and that for the wet weight of the root part were 79.4%, 46%, and 3.8% for the three types of water, respectively. Finally, the overall conclusion that was achieved is that it is possible to use a magnetic field to treat salty water that can improve sunflower growth.

1. Introduction

The increased lack of fresh irrigation water in dry and semi-dry regions due to the increased demand and the impacts of global warming has forced farmers to use low quality irrigation water. This water is available as surface or underground water. The high salinity of this water can tolerate the growth of crops sensitive to the salinity.

Results of studies conducted on the treatment of saline water by a magnetic field indicated that some of the water properties can be enhanced as it passes through the magnetic field. This enhancement proved to have beneficial applications in many fields. Such improvement can be useful in increasing plant growth when irrigated with magnetically treated water.

Treating water within a magnetic field leads to a change and dissociation of the hydrogen bonds between molecules, which leads to a change in several properties such as electrical conductivity, increase the ratio of dissolved oxygen, increase the ability to dissolve salts and acids, reducing surface tension, a change in the rate of chemical reactions, especially evaporation and electrical isolation, and increase in permeability, the water becomes energy active and flows more than it was [1]. Moreover,
researches have indicated that applications of magnetically treated water in agriculture lead to an increase in the solubility of water, leaching salts from the soil and increasing the activity of nutrients such as nitrogen, phosphorus and potassium [2].

There are many studies related the magnetic treatment of irrigation water to the increase of the growth of crops. Such studies are the study of Maheshwari and Grewal [3]. They examined the effects of magnetic treatment of different irrigation water types on the productivity of snow pea, celery and pea plants. They used magnetically treated and non-magnetically treated tap water, recycled water and saline water. The experiments were conducted with replicated pots in a glasshouse under controlled environmental conditions. The results indicated valuable effects of magnetically treated irrigation water on productivity. The magnetic treatment of tap water, recycled water and saline water increased the productivity by 12%, 23%, and 12%, respectively for celery crop and 7.8%, 5.9%, and 6.0%, respectively for snow peas crop compared to that when using non-magnetized water.

The field experiments study conducted by Salim et al. [4] that investigated the growth of tomato crop by using drip irrigation of four different wells. The water of these wells has different levels of salinity that is 1.3, 3.8, 5.9 and 8.1 dS/m. They conducted their experiments by using two types of soils that is sandy loam and loamy sand. They showed that magnetized water positively affected plant growth by increasing the average plant length, leaf length and leaf area compared to plants irrigated by untreated water. The average product of tomato crop increased when irrigated by magnetized water. This increase reached 20.5% when compared to tomato crop irrigated by non-magnetized water.

Abd et al. [5] carried out field experiments on three types of crops, Iraq Oasis wheat, Abu Ghraib wheat, and white barley, irrigated by untreated and magnetically treated medium saline well water. They showed that the magnetic treatment of both irrigation water and seeds have a positive effect on germination compared to untreated water.

Surendran et al. [6] conducted pot field experiments and evaluated magnetic treatment of irrigation water on the growth of cow pea and brinjal and the impact of magnetic treatment on water properties and soil moisture. The treatment was conducted with normal water, hard water of 150 and 300 ppm, and saline water of 500, 1000, and 2000 ppm under two magnetic intensities of 1800 and 2000 Gauss. They showed that magnetic treatment of irrigation water led to an improvement in crop growth, reduced dissolved solids and salinity levels of all used different irrigation water, and increased pH in all treatments. They proved that involving magnetized irrigation water caused higher soil moisture compared with the non-magnetized for different saline water. They substantiated the benefits of magnetically treated irrigation water on growth and yield of crops, the properties of water and the possibility of using low quality water for agriculture.

Abedinpour and Rohani [7] showed that the use of magnetically treated irrigation water led to a decrease in the pH of soil and increase electrical conductivity when used to improve the growth of the corn crop by using different levels of saline water after its magnetization.

Liu et al. [8] conducted a field experiment on grape seedlings. Three different concentrations of NaCl solutions of tap water were used to irrigate grape seeds before and after the magnetic device. The growth parameters and photosynthesis characteristics were analyzed during the treatments under field conditions. They compared the plants irrigated with untreated saline water, the growth of the aboveground parts and the root growth, with those plants irrigated with treated saline water. They noticed that treatment with magnetized saline water reduced the damage of saline water to the photosynthetic mechanism in grape, supported maintain the photosynthetic activity in the mesophyll cells, and enhanced efficient electron transport between the photosystems, thus enhancement the production of grape.

Moreover, there are many studies on the relation between magnetized irrigation water and soils such as Hindal [9] who showed an increase in the accumulated infiltration depth and the hydraulic conductivity when using magnetized water. She noticed that the higher effects were achieved with the minimum water flow velocity through the magnetization device and with the highest number of used magnets. Raheem and Azzubaidi [10] verified the efficiency of magnetized water in leaching salt affected silty loam soil. They noticed that as the magnetic intensity and the time of exposure are
increased, the more salts were leached out of the soil. They obtained a maximum increase in the value of EC of the drained water of 73.8% compared to that when using untreated water. Al-Hadidi [11] mentioned that magnetizing of water helped in increasing the rate of dissolving of salts. This rate is increased as the time of exposure to the magnetic field. Placing magnets around the mixture of soil-water was the most effective method in reducing the time required to obtain the total dissolved salts within soils.

The above studies are examples indicating the valuable benefits of using magnetized water in the irrigation of crops. More information is needed on the effects of using treatment of different saline irrigation water on specific crops. This study aims at investigating and evaluating the effectiveness of using magnetic treatment of irrigation water at different levels of salinity on the growth of the valuable sunflower crop. This crop is an extraordinary oil seed crop, contains a high percentage of protein, and is considered one of the crops of high nutritional value.

2. The procedure of experiments

The same weight of soil was used to fill 17 cm in diameter pots. Untreated and magnetically treated irrigation water with three different salinity levels of electrical conductivity were used to irrigate these pots depending on each experiment conditions. Pots irrigated with untreated water are considered as control experiments to be compared to those with magnetically treated irrigation water. The process of magnetization of irrigation water was carried out by passing it with a variable intensity magnetized device. Two intensities were used to magnetically treat the irrigation water that is 1000 and 3000 Gauss. Five seeds of Sunflower plant were planted in each pot. Three replicates of each pot under same condition of the irrigation water were made to ensure the validity of the results. So that the number of pots included in the experiments is 27 pots. The percentage and rate of germination of the seeds were measured. The seedlings continued to grow for twenty days, after which measurements were taken on the developing seedlings included measuring the length and weight of the green and root parts.

All of the required tests were conducted at the laboratory of Water Research Center of Environment and Water Directorate of the Ministry of Higher Education and Scientific Research, and Science and Technology.

3. Results and analysis

The tests showed that the soil is a homogeneous loamy soil having an electrical conductivity of 1.73 dS/m. EC was used as an indicator for the salinity level of the used irrigation water. The EC of the three types of irrigation water was tested to be 0.7, 4, and 8 dS/m. Table 1 shows the tested of some physical properties of the three different salinity levels of irrigation water before and after magnetization. No difference was found on these properties when the water is magnetically treated with intensity 1000 or 3000 Gauss. The value of the acidic function pH the electrical conductivity EC and the surface tension of water was slightly reduced after magnetization.

| Tested Parameter       | 0.7 dS/m before | 0.7 dS/m after | 4 dS/m before | 4 dS/m after | 8 dS/m before | 8 dS/m after |
|------------------------|----------------|---------------|---------------|--------------|---------------|--------------|
| pH                     | 7.47           | 7.65          | 7.73          | 7.80         | 7.84          | 7.87         |
| EC (dS/m)              | 0.75           | 0.78          | 4.00          | 4.90         | 8.00          | 8.50         |
| Surface tension (dyne/cm) | 70.07        | 68.60         | 74.55         | 73.12        | 76.67         | 74.14        |

Generally, the growth of the sunflower is greatly affected negatively by the salinity of the untreated irrigation water. When comparing the growth of plants irrigated by the untreated water having EC of 0.7 dS/m with the plants irrigated by the untreated irrigation water having EC values of 4 and 8 dS/m, the percentage of reduction in germination was 50% and 85.7%, in root depth was 6.7% and 52.4%, in stem height are 43.2%% and 62.7%, in weight of the total green are 4% and 72.2%, in the wet weight
of the total root are 11.3% and 65.8%, respectively, these values of percentages reduction in the growth of the sunflower were significantly reduced when the irrigation water was treated by using the magnetic field. The growth of the sunflower is significantly affected by magnetizing of irrigation water compared to the untreated water. This affection depends on EC value and the intensity of the magnetic field.

The growth of the sunflower is significantly affected by magnetizing of irrigation water compared to the untreated water. This affection depends on EC value and the intensity of the magnetic field.

The recorded rate of germination increased when using all types of magnetized water compared to the untreated water of the same electrical conductivity as shown in Table 2. The achieved maximum increases in germination were 7.2%, 57.3%, and 150.4% for the three types of water, respectively. The highest percentage of increase in the germination was achieved when treating the irrigation water having an EC of 8 dS/m treated by a magnetic intensity of 3000 Gauss. It clear that treatment of water with 1000 Gauss magnetic intensity increases the germination more than that increase treatment with 3000 Gauss.

| Magnetic treatment condition | Percentage of germination (%) | EC of the irrigation water |
|-----------------------------|-------------------------------|---------------------------|
|                             | Untreated                     | Treated with 1000 Gauss   | Treated with 3000 Gauss   |
|                             | 93.3                          | 100.0 (7.2%)*             | 93.3 (0%)                 |
|                             | 46.6                          | 73.3 (57.3%)              | 60.0 (28.8%)              |
|                             | 13.33                         | 33.3(150.4%)              | 26.6 (100%)               |

* represent the difference in increase compared to the untreated irrigation water.

Table 3 shows the measured root depth of the sunflower crop irrigated with the three different irrigation water. It was noticed that the average root depth of the seedlings was affected by the levels of magnetized water used in irrigation and the measured root depths were improved when applying magnetic treatment to the irrigation water. The maximum achieved percentages of increase in root depth were 14.3%, 10.2%, and 16% when irrigation with magnetized water of the three types, respectively. The highest percentage of increase in root depth was achieved when treating the irrigation water having an EC of 8 dS/m treated by a magnetic intensity of 3000 Gauss.

| Magnetic treatment condition | Root depth (cm) | EC of the irrigation water |
|-----------------------------|----------------|---------------------------|
|                             | Untreated      | Treated with 1000 Gauss   | Treated with 3000 Gauss   |
|                             | 10.5           | 12.0 (14.3%)*             | 10.5 (0%)                 |
|                             | 9.8            | 10.8 (10.2%)              | 10.0 (2%)                 |
|                             | 5.0            | 5.8 (16%)                 | 5.0 (0%)                  |

* represent the percentage of increase compared to the untreated irrigation water.

The effects of water magnetization levels and salt concentrations on the green height of sunflower seedlings are shown in Table 4. It is indicated that there is a clear increase in the stem height of the seedlings when using magnetized irrigation water. The stem height was increased by 29.6%, 60%, and 28%, respectively. The percentage of increase of 60% is achieved in plants irrigated by using water of 4 dS/m treated by 1000 and 3000 Gauss compared to plants irrigated untreated water.

| Magnetic treatment condition | Stem height (cm) | EC of the irrigation water |
|-----------------------------|------------------|---------------------------|
|                             | Untreated        | Treated with 1000 Gauss   | Treated with 3000 Gauss   |
|                             | 22.0             | 28.50 (29.6%)*           | 28.00 (27.3%)            |
|                             | 12.50            | 20.00 (60%)               | 20.00 (60%)              |
|                             | 8.2              | 10.50(28%)                | 10.50 (28%)              |

* represent the percentage of increase compared to the untreated irrigation water.
Table 5 shows the wet weight of the green part of the sunflower plant. The wet weight is increased when using magnetized water to irrigate the plant. Maximum percentages of increase in the stem height of 79.7%, 53.5%, and 82.7% were obtained when using magnetized water of the three types, respectively. The highest percentage of 82% achieved when treating the irrigation water having an EC of 8 dS/m treated by a magnetic intensity of 1000 Gauss.

**Table 5.** The wet and dry weights of the green part of the sunflower plant.

| Magnetic treatment condition | Wet weight (g) | EC of the irrigation water |
|-----------------------------|----------------|---------------------------|
|                             |                | 0.7 dS/m | 4 dS/m | 8 dS/m |
| Untreated                   |                | 325.7    | 312.8  | 90.4   |
| Treated with 1000 Gauss     |                | 585.2 (79.7%)* | 480.3 (53.5%) | 165.2 (82.7%) |
| Treated with 3000 Gauss     |                | 448.7 (37.8%) | 472.3 (51%)  | 160.1 (77%)  |

* represent the percentage of increase compared to the untreated irrigation water.

The obtained results on measuring the wet weight of the roots of the sunflower plant indicate that the wet weight of the root part increased when magnetizing the irrigation water as shown by table 6. 79.4%, 46%, and 3.8% are the maximum achieved percentages of increase in the wet weight of the roots of the sunflower plant when irrigation the plant. The maximum value of 79.4% was achieved when using irrigation water having an EC of 0.7 dS/m when treated by the magnetic intensity of 1000 Gauss.

**Table 6** The wet weight of the root of the plant.

| Magnetic treatment condition | Wet weight (gm) | EC of the irrigation water |
|-----------------------------|----------------|---------------------------|
|                             |                | 0.7 dS/m | 4 dS/m | 8 dS/m |
| Untreated                   |                | 220.4    | 195.5  | 75.3   |
| Treated with 1000 Gauss     |                | 395.5 (79.4%)* | 285.3 (46%) | 78.2 (3.8%)  |
| Treated with 3000 Gauss     |                | 370.2 (68%) | 271.3 (38.8%) | 74.8 (0.7%)  |

* represent the percentage of increase compared to the untreated irrigation water.

4. Conclusions

From the achieved results, it was concluded that the growth of the sunflower is greatly affected negatively by the salinity of the untreated irrigation water. It is concluded that the magnetization of irrigation water can reduce the effects of high saline irrigation water and positively affects sunflower growth. The use of saline water with magnetic treatment can increase the germination, root depth, stem height, the wet of both the green party and the roots of the sunflower plant in different levels depending on the part of the plant, the EC value of the irrigation water, and the intensity of the magnetic field.

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