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STATIC MAGNETIC FIELD WITH 2 MT STRENGTH CHANGES THE STRUCTURE OF WATER MOLECULES AND EXHIBITS REMARKABLE INCREASES IN THE YIELD OF *PHASEOLUS VULGARIS*

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ABSTRACT

In this study, we aimed to examine the effects of a 2 mT strength static magnetic field, which is generated by placing a permanent magnet in water for 1 h, on the physical properties of magnetized water, such as its viscosity, conductivity, and pH value. The growth and yield of *Phaseolus vulgaris* irrigated with tap water and magnetized water were also examined and compared. We further evaluated its morphological characteristics, such as plant height, number of pods per plant, number of seeds per pod, and fresh and dry weight of seeds, and physiological parameters (i.e., chlorophyll content, total sugar content, some elements, and crude protein concentration). As per our findings, the measured parameters of plants irrigated with magnetized water exhibited remarkable increases compared to those irrigated with tap water, in addition to increased seed production at harvest and changes in the concentration of elements. Despite the weak strength of the magnetic field, the pH value increased by 11.6%, viscosity by 10%, and conductivity by 10%.

Keywords: Histology, biology, *Withania frutescens,* Solanaceae

INTRODUCTION

In Egypt, using magnetized water in agriculture remains to be a rare practice, unlike in many countries where it has become popular, achieving remarkable improvements in many fields.

The physical and chemical properties of water have been determined to change due to magnetization (Samir 2008, Gaafar *et al.,* 2015, Deng and Pang 2007).

Water properties can become very fertile and active causing high oxygen ratio after passing through a magnetic field or putting a magnet in water (Batmanghelidj 2005).

Increasing the strength of the magnetic field increases the number of dipoles, attaining a different orientation (Quinn *et al.,* 1997).

Kotab (2013) has shown that water flows through a closed loop, affected by a magnetic field with a flux density of 170 mT, increasing its pH value by 15.65%.

Hasaani *et al.,* (2015) have examined the interaction of the magnetic field with flowing water and measured the pH value and other properties. As per this study, it was found that the pH value increased by 12 % in magnetized water, compared to ordinary tap water.

Meanwhile, Gholizadeh *et al.,* (2008) and Pang and Deng (2008) used ultraviolet and infrared to record the absorbance and interaction of light with water molecules after and before magnetization. In their study, they have explained the variations in the optical properties of water under a static magnetic field.

The biological benefits of magnetized water include increased commercial crop, increased yield, increased total lipid content, and increased flowering and fruit sets (Samaneh *et al.,* 2016). A marked improvement in seedling growth after germination of *Pinus* tropical seeds was also observed from 43 % in the control to 81 % in magnetically treated irrigation water (Morejon *et al.,* 2007).

Irrigation using magnetized water has been determined to increase element concentrations in onion, sunflower, and tomato seedling growth compared to irrigation with tap water (Abdelaziz *et al.,* 2014). Hozayn *et al.,* (2013) have also noted an improvement in the growth of many plants after irrigation using magnetized water.

Several molecular phenomena have been documented on magnetically treated water, affecting crop growth and productivity in conjunction with improved irrigation and water use efficiency (Orlando Zuniga *et al.,* 2016). Based on these results, this study investigated the physical properties of magnetic water of a very small magnetic field (2 mT). We have further examined and compared the growth and yield of tap water- and magnetic water-irrigated *Phaseolus vulgaris*.

Magnetically treated water exhibits various phenomena at the molecular level, affecting crop growth and productivity, besides greater efficiency in irrigation and water use (Orlando Zuniga *et al.,* 2016).

Based on these results, this study investigated the effect of a very weak magnetic field (2 mT) on the physical properties of magnetized water and further examined the growth and yield of *P. vulgaris* irrigated with tap water and magnetized water. This study is of importance in Egypt, especially in the agricultural field.

MATERIALS AND METHODS

Static magnetic field device

Water magnetization was performed by putting a static magnetic field device in tap water as shown in Picture 1 (UO 50 mg. OS inch, output 4–6 m^2/h production; Magnetic Technologies L.C.; magnetic treatment scheme; Khoshravesh *et al.,* 2012).

Picture 1. Static magnetic field device.

The glass flask was washed carefully and filled with tap water. The magnetic device was then put in the flask at room temperature for 1 h and repaired for each irrigation. The magnetic field intensity was measured at 2 mT using a SE-8606 digital Gauss-Tesla meter.

Viscosity measurements

The viscosity of tap water before and after magnetization was measured using Ostwald viscometer. The viscosity of a fluid is its quantitative property. Viscosity arises from the direct motion of molecules past others and the transfer of momentum. An appropriate Ostwald viscometer was then selected and clamped vertically in a water beaker at 25°C. To equilibrate the temperature of the test water sample, the viscometer was then placed inside a constant temperature bath.

Conductivity measurements

Electric conductivity is defined as a measure of the ability of a solution to conduct an electric current, depending on the concentration of dissolved ions. The electric conductivity was measured using USER MANUAL Waterproof EC/TDS Testers.

pH value measurements

To measure the pH value of both tap water and magnetized water, a bench pH meter was used.

Plant materials

P. vulgaris seeds were obtained from the Agriculture Research Center of Giza town . A mixture of clay and sandy soil (2:1) was used. These were then placed into 10 pots, which measure 30 cm in diameter and 50 cm deep. Irrigation of half-pots was done for 2-week intervals using tap water, whereas the other half was irrigated with magnetized water until harvest.

Through irrigation with tap water and magnetized water, the pots were placed in the greenhouse of the Botany and Microbiology Department, Faculty of Science, Zagazig University.

Morphological and physiological measurements

1. At harvest, 10 main plants from each treatment were used. Plant height (cm), number of pods per plant, number of seeds per pod, and fresh and dry weight of seeds were measured.

2. The chlorophyll contents were determined according to Moran (1982) at the vegetative stage.

3. Total sugar contents were measured colorimetrically according to Nelson (1944).

4. Concentration of some elements, such as Ca, K, Mg, P, Na, and N, was determined by the technique of Jackson (1962) using atomic absorption.

5. The crude protein concentration was determined by multiplying the total nitrogen concentrations by a factor 6.25 (A. O. A. C 1970).

Statistical analysis

All plant measurements were repeated five times at room temperature. The results were then expressed as the mean ± standard deviation. Statistical analysis was carried out using the commercially available statistical package SPSS-10.

RESULTS AND DISCUSSION

Changes in the physical properties of magnetized water

The pH of the magnetized water was alkaline, and the pH value increased by magnetic treatment (Fathia *et al.,* 2006). In tap water without the magnets attached, the pH values still fluctuated to about 7.7; in contrast, the pH of water increased when treated with the magnetic field as it reached 8.6 (see Table 1). This effect has been determined to be dependent on the changes of water element concentrations due to the polarization of water molecules and the decrease of hydrogen ion concentrations (Deng and Pang X.F. 2007). With increasing magnetic field, the water molecules are arranged in one direction, and the pH value also increases.

Table 1. Changes in the pH value, viscosity, and conductivity of tap water and magnetized water

Measurements	Tap water	1 h exposure to magnetized water
pH value	7.7 ± 0.2	8.6 ± 0.05
Viscosity	1.5 ± 0.004	1.6 ± 0.006
Conductivity, μS/cm	0.410 ± 0.01	0.433 ± 0.02

The increase in conductivity of magnetized tap water may be explained by Lorentz force. Lorentz force has been determined to cause polarization and displacement of water molecules and different ions found in tap water. The weakening of the intra-cluster hydrogen bonds forming new smaller clusters with less molecular energy is due to the polarization effect. This effect causes an increase in its viscosity and pH value, which, in turn, decreases its acidity.

As shown in Table 1, the viscosity of tap water increased by magnetization. Such increase may be due to the molar activation energy of water molecules.

Ran cai *et al.,* (2008) suggested that the change in η of magnetized water might be due to the increase in the activation energy, which means that the molecular energy of magnetized tap water decreased.

Changes in the morphological and physiological parameters of *P. vulgaris*

In terms of the effect of magnetized water on *P. vulgaris* crop yield, there was good agreement with the physical and biological results. Pictures 2 and 3 show the differences between *P. vulgaris* irrigated with tap water and magnetized water at vegetative and yield stages.

Picture 2. Differences between *P. vulgaris* irrigated with tap water and magnetized water at the vegetative stage.

Picture 3. Difference between *P. vulgaris* irrigated with tap water and magnetized water at the yield stage.

As per our findings, it was determined that all growth and yield characteristics improved due to irrigation using magnetized water, as shown in Table 2.

Table 2: Morphological characteristics of plants irrigated with magnetized water compared to tap water.

Characteristics	Treatment	
	Tap water	Magnetized water
Plant height (cm)	29.1 ± 1.22	31.4 ± 1.3
No. of pods/plant	4.32 ± 0.12	6.10 ± 0.13
No. of seeds/pod	5.80 ± 0.13	7.20 ± 0.15
Gram weight of 100 seeds	20.20 ± 1.1	22.84 ± 1.1
Gram fresh weight	3.52 ± 0.09	4.30 ± 0.11
Gram dry weight	0.80 ± 0.002	0.99 ± 0.015

The highest values of plant growth and yield are consistent with the findings of Samir (2008), who found that chickpea plants irrigated with magnetized water had higher growth and yield compared to those irrigated with tap water. Hozayen *et al.,* (2011) found that magnetized water had a significant and consistent effect on the growth of different plants. This was further supported by a study

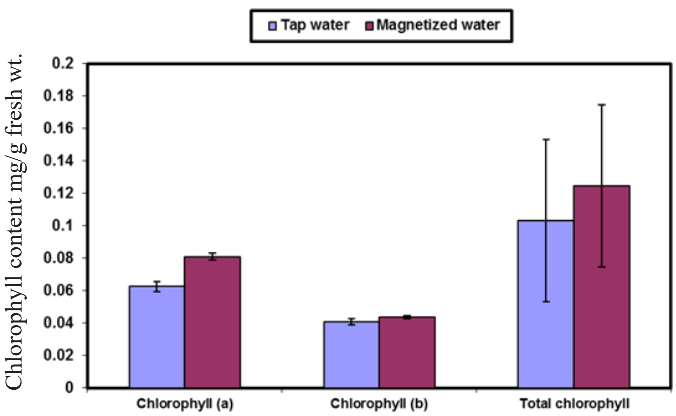

Fig. 1. Changes in total chlorophyll in plant leaves.

conducted by Shahin *et al.,* (2016), who demonstrated that magnetic treatment of water (40 mT) improved the plant height and yield of cucumber plants compared to control treatments. They reported that the improvement of cucumber yield productivity using magnetized water technology is a promising technique.

Figure 1 shows that the contents of chlorophyll a and b and total chlorophyll have significantly increased with irrigation with magnetized water compared to tap water. These results are in good agreement with Hozayen *et al.,* (2010 a and b), who showed significant increases in chickpea (*Cicer arietinum L.*) chlorophyll content. Mahmood and Usman (2014) reported that the increase in plant productivity and change in its water and mineral metabolism could be attributed to prior exposure of irrigation water to MF. Meanwhile, Safwan shiyab *et al.,* (2020) found that using magnetic water in irrigating plants induces a positive effect on all studied parameters, such as on its chemical constituents, nutrient uptake, and soil properties, especially on the fourth week of harvest, compared to potable and saline water. Further, Zia ul haq *et al.,* 2016 noted that the growth parameters, such as seedling length, fresh and dry weight, and chlorophyll content, have improved in response to irrigation using magnetically treated water.

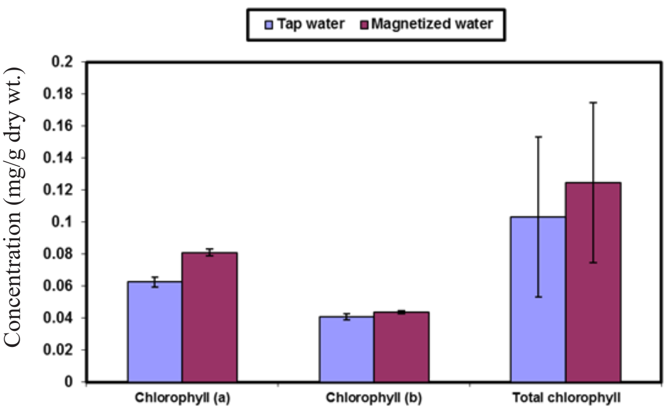

Fig. 2. Changes in total sugars, total protein, and total lipids of *P. vulgaris* irrigated with magnetized water compared to tap water.

Figure 2 shows the increase in protein contents in plants irrigated with magnetized water accompanied by an increase in sugar content and growth promoters (IAA). These results are in consistent with that of Kuba *et al.,* (2000), who found that indole acetic acid affects DNA replication. These results are also in good agreement with that of Belyavskaya (2001), who reported that magnetized water significantly induces cell metabolism and meiosis of meristem tip cells of pea lentil and flax compared to tap water.

Irrigation with magnetized water and tap water

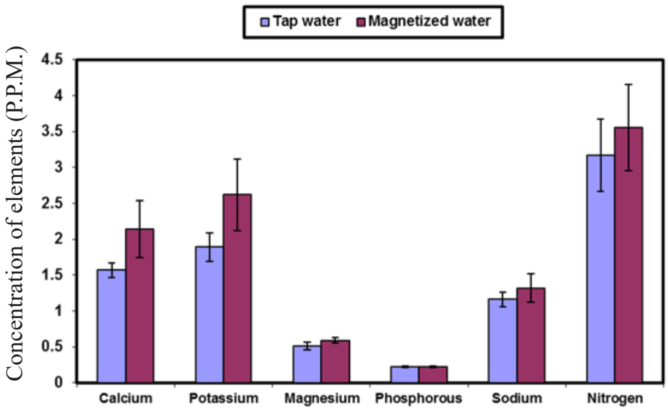

Fig. 3. Changes in the elements in plants.

Figure 3 shows the concentrations of calcium, potassium, magnesium, sodium, and nitrogen. These results are in accordance with those reported by Abdel Aziz *et al.,* (2014). The increase in Ca, K, F, and Zn concentration in seeds of plants irrigated with magnetized water led to significant increases in terms of production quality compared to plants irrigated using tap water (Mokari Ghahroodi *et al.,* 2013). These results are also in good agreement with Aladjadjiyan (2012), who showed that the absorption of harmful metals such as Pb and Ni via the roots was prevented using magnetized water and further increased the concentration of nutrient elements such as P, K, and Zn in plants (Aladjadjiyan 2012).

CONCLUSION

Despite the weak magnetic field strength (2 mT), magnetized water has been determined to have significant effect on the yield (quantity and quality) of *P. vulgaris*. Our findings only strongly suggest that traditional methods should be replaced with efficient ones, that is, irrigation using magnetized water instead of just using tap water.

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