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Effect of Magnetically-Treated Water On Seed Germination and Seedling Growth of Lentil (*Lens Culinaris* L.)

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ABSTRACT

Application of magnetically-treated water is one of the most promising methods for the plants' growth stimulation. This study was carried out in order to evaluate the effects of magnetically-treated water on germination parameters of Lentil. For this purpose, 6 treatments were considered, (1: dry seed, irrigation with distilled water, 2: dry seed, irrigation with magnetically-treated water, 3: soaked seed with distilled water, irrigation with distilled water, 4: soaked seed with distilled water, irrigation with magnetically-treated water, 5: soaked seed with magnetically-treated water, irrigation with distilled water, 6: soaked seed with magnetically-treated water, irrigation with magnetically-treated water). The seeds were sterilized in surface and cultured in petri dishes. After 12 days, the germination parameters were measured (germination percentage, germination speed, germination index, seedling stamina index (or vigor index), hypocotyl and epicotyl length, root length, seedling fresh weight and seedling dry weight).The results showed that to promote hypocotyl and epicotyl length, root length and seedling fresh weight of Lentil seedlings the use of magnetically-treated water was more effective than distilled water. In addition, seedling stamina index significantly increased in soaked seed with magnetically-treated water, irrigation with magnetically-treated water when compared to dry seed, irrigation with distilled water. Irrigation with magnetically-treated water increases the speed of germination and thus, reduces the growth period in lentil. Due to the serious problem of water shortage in our country, irrigation with magnetically-treated water can be a great help to reduce the water used in irrigating the crops.

Keywords: *Germination Parameters, Lentil, Magnetically - treated water*

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INTRODUCTION

The lentil (*Lens culinaris* L., Fabaceae) is one of the major legumes crops all over the world. It is a cheap source of high quality protein being used in the diets of millions in developing countries (Hojjat and Galstayan 2011), and is considered as one of the most important traditional dietary components. Food and agriculture organization reported that world's production of lentils in 2008 was about 2.83 million metric tons , basically coming from Canada (36.9 %) and India (28.7 %), as well as Nepal, China and Turkey (Faris, et al 2012).

During the evolution process, all living organisms went under the pressure of of the earth's magnetic field (geomagnetic, GMF), being a natural component of their environments (Belyavskaya, 2004). Previously many scientists believed that permanent magnetic fields are not biologically active. However, it was revealed that the high sensitivity of plants towards permanent magnetic fields, in particular, varies in the intensity ranging from GMF level to very low levels (Belyavskaya, 2004). The use of MF has become a cost effective and a safe method to enhance plants' growth and productivity. However, all the metabolic activities are independent of energy exchange; the nature of the interaction of biological material varies, according to MF sources, exposure duration, filed intensities and plant species (Belyavskaya, 2004, Goodman, *et.al*, 1995, Miyakoshi, *et.al*, 1997) .

Researches revealed that some physical and chemical properties of water such as, uniformity of it's structural, surface tension, conductivity (Fathi, *et.al*, 2006), viscosity, activation energy, water molecule size, hydrogen bond formation, evaporation (Cai, *et.al*, 2009), and dissolved oxygen (Dandan& Yan,2013), change when it passes through the magnetic field (MF); the water passed through MF was called "magnetically-treated water" (MW) leading to special functions (Cai, *et.al*, 2009). Irrigation with magnetically-treated water or/and magnetic seed treatment are friendly environmental techniques (Nimmi& Madhu, 2009), and have been widely used in some countries,(Carbonell *et al.,* 2004). Therefore, they play an important role in the list of environmental clean methods and harmless technologies (Nimmi& Madhu, 2009), as well as dormancy-breaking (Carbonell *et al.,* 2004). There is not any uniform theory explaining the effects of MF on the water properties. According to Lorenz' force activity theory, polarization of external electron of water molecules and ions decrease the hydration of salt ions and colloids, having a positive effect on salt solubility, accelerating coagulation and salt crystallization (Bogatin, *et.al*, 1999). Biological theories explain the effects of MFs on the permeability of ion channels into the membranes and cells. MW may increase seed cell membranes' permeability and activity of calcium ions while upsetting the balance of ion concentration in the cell and changes of intracellular pH (Matwijczuk, *et.al*,2012). The MW improved the percentage and rate of germination of rice seeds (Carbonell, *et.al*, 2004). Treatment of seed with MW enhance emergence rate's index (42% for snow pea and 51% for chickpea), and shoot dry weight (25% for snow pea and 20% for chickpea) (Grewal & Maheshwari, 2011). MW increased the percentage and rate of the germination of signal grass (*Brachiaria decumbens*) up to 10% (Carbonell, *et.al,* 2004). Also it had significant effects on all traits (germination rate, plumule length, radicle length, seed vigor index, plumule weight) except for the effect of germination percentage and radicle of plumule ratio on the fennel seeds (Fateh, *et.al*, 2012). MW increased emergence index and emergence rate index values in maize seeds from 5.50 to 8.92 and from 10.06 to 12.84 it also reduced mean emergence time to 17.90% in contrast to non-MW. Practically, MW causes significant increase in seedling height and seedling weight (Mahmood & Usman, 2014). Moreover, after 12 days of soaking with untreated water on wheat, barley and triticale, the MW caused the full germination rate after 9 days as compared with 83, 86 and 86 % (Selim, 2008).

The related literature has never studied the effect of magnetically-treated water on lentil germination parameters, the present study was carried out in order to analyze the effect of MW in six different treatments on Lentil seed's germination parameters.

Materials and methods

Lens (*Lens culinaris* L.) seeds were purchased from Iranian Biological Reserve Center (IBRC). The seeds were sterilized in surface in 0.5 % (w/v) sodium hypochlorite solution for 10 minutes followed by thoroughly rinsing with sterile deionized water. For investigation of magnetically-treated water's (MW) effect on germination parameters of Lentil seeds, six treatments were considered : 1:dry seed, irrigation with distilled water (Dry Seed/DW), 2: dry seed, irrigation with magnetically-treated water(Dry Seed/MW), 3:soaked seed with distilled water, irrigation with distilled water(DW/DW/), 4: soaked seed with distilled water, irrigation with magnetically-treated water(DW/MW),5: soaked seed with magnetically-treated water, irrigation with distilled water(MW/DW),6: soaked seed with magnetically-treated water, irrigation with magnetically-treated water(MW/MW). Tap water was treated by magnetic field of 110 mT being locally designed (FAPAN Co., Tehran, Iran). Lentil seeds were cultured in petri dishes container watt man papers and were put in a dark chamber with 25±2°C daily temperature. (The seeds were soaked for 24 h in treatments 3 to 6). This study was carried out with five replications each one with 10 seeds. Seeds were irrigated every day. After 12 days, the germination parameters were measured. The germination parameters included germination percentage, germination speed, germination index, seedling stamina index (or vigor index), hypocotyl and epicotyl length, root length, seedling fresh weight and seedling dry weight. The germination test was performed according to the guidelines issued by the International Seed Testing Association (ISTA Rules, 2007) with slight modifications. Three such seedlings were randomly selected from each replicate to measure root length, hypocotyl and epicotyl length, fresh weights and dried weights.

Cultured Seeds were observed daily and considered to be germinated when the radicle was approximately 2 mm long or more.

The germination percentage was calculated according to Eq. (1) The germination speed was calculated according to Eq. (2) (Vashisth and Nagarajan, 2010).

In addition to the germination index was calculated according to Eq. (3) (Hartmann *et al*., 1990).

Seedling stamina index was calculated following Vashisth and Nagarajan (2010) as Eq. (4).

Eq.1:Germination percentage = $\frac{\text{total germination speed after 12 days}}{\text{total cultured seeds}} \times 100$

Eq.2:Germination speed = $\Sigma \frac{n}{t} \times 100$

Where n represents the number of newly germinated seeds at the time of t, and t is days of sowing

Eq.3:Germination index = $\frac{\Sigma niTi}{N}$

ni = number of seeds germinated at day Ti, N = total number of seeds germinated, Ti = number of days after starting the test

Eq.4:Seedling stamina index = Germination percentage × Seedling dry weight (Root + Shoot)

Statistical analysis

All of the experiments were carried out with at least five independent repetitions. All values are shown as the mean ± standard deviation (SD). Statistical analysis was performed using Tuky and the differences between treatments were expressed as significant at the level of $P \leq 0.05$.

Results

Results showed that irrigation with MW did not significantly change the germination percentage and germination index (Fig .1 A, B), but significantly increased seedling stamina index in MW/MW compared with Dry Seed/DW (Fig 1. C); in addition, it significantly increased the germination speed of DW/MW and MW/MW compared with the rest (Fig .1 D).

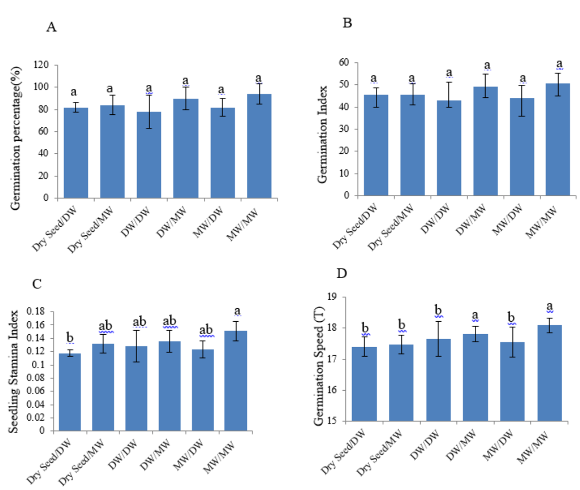

Fig1. Effect of MW on germination parameters (Germination percentage (A), Germination index(B), Seedling stamina index (C), Germination speed (D)) of *Lens culinaris* L. seeds.Data are means obtained from at least five different experiments in triplicate ±SD. Signs with different letters in each group indicate significant differences at $P \leq 0.05$ according to tukey. Dry Seed/DW: dry seed, irrigation with distilled water, Dry Seed/MW: dry seed, irrigation with magnetically-treated water, DW/DW: soaked seed with distilled water, irrigation with distilled water, DW/MW: soaked seed with distilled water, irrigation with magnetically-treated water, MW/DW: soaked seed with magnetically-treated water, irrigation with distilled water, MW/MW: soaked seed with magnetically-treated water, irrigation with magnetically-treated water.

As shown, the lengths of hypocotyl and epicotyl were higher than the MW/MW when comparing with the rest, except for MW/DW (Fig 2. A). Also MW/MW increased the root length compared with the Dry Seed/DW, Dry Seed/MW and MW/DW, but no significant difference was observed between MW/MW, DW/DW and DW/MW (Fig 2. B). The highest amount of seedling dry weight belonged to DW/MW, MW/MW, Dry Seed/MW, DW/DW and MW/DM (the last two were identical) and finally Dry Seed/MW, respectively (Fig 2. C). MW/MW significantly increased the fresh weight of seedling and the lowest of it were related to Dry Seed/DW and MW/DW (Fig 2. D).

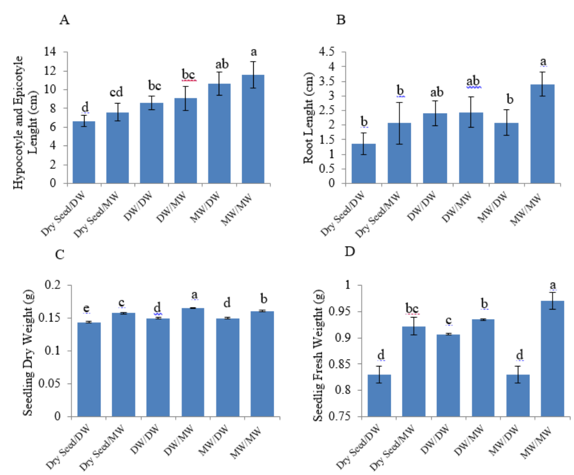

Fig2. Effect of MW on germination parameters (hypocotyl and epicotyl Length (A), root Lenght(B), seedling dry weight (C), seedling fresh weight (D)) of *Lens culinaris* L. seeds. Data are means obtained from at least five different experiments in triplicate ±SD. Signs with different letters in each group indicate significant differences at $P \leq 0.05$ according to Tukey. Dry Seed/DW: dry seed, irrigation with distilled water, Dry Seed/MW: dry seed, irrigation with magnetically-treated water, DW/DW: soaked seed with distilled water, irrigation with distilled water, DW/MW: soaked seed with distilled water, irrigation with magnetically-treated water, MW/DW: soaked seed with magnetically-treated water, irrigation with distilled

water, MW/MW: soaked seed with magnetically-treated water, irrigation with magnetically-treated water.

Table1. Effect of magnetically - treated water on germination parameters of Lentil.

Seedling Dry Weight	Seedling Fresh Weight	Root Length	Epicotyl and Hypocotyl Length	Seedling Stamina index	Germination Speed	Germination Index	Germination Percentage	
0.14^{e}	0.83^{d}	1.36^{b}	6.66^{d}	0.11^{b}	17.40^{b}	45.58^{a}	82.00^{a}	Dry Seed/DW
0.15^{c}	0.92^{bc}	2.06^{b}	7.60^{cd}	0.13^{ab}	17.48^{b}	45.58^{a}	84.00^{a}	Dry seed/MW
0.15^{d}	0.90^{c}	2.40^{ab}	8.58^{bc}	0.12^{ab}	17.65^{b}	43.10^{a}	87.00^{a}	DW/DW
0.16^{a}	0.93^{b}	2.44^{ab}	9.06^{bc}	0.13^{ab}	17.81^{a}	49.22^{a}	90.00^{a}	DW/MW
0.15^{d}	0.83^{d}	2.08^{b}	10.66^{ab}	0.12^{ab}	17.54^{b}	44.02^{a}	82.00^{a}	MW/DW
0.16^{b}	0.97^{a}	3.4^{a}	11.58^{a}	0.15^{a}	18.09^{a}	50.68^{a}	94.00^{a}	MW/MW

1. Discussion

Recent researches have introduced MW as a physical factor which usually stimulates plant growth and development and increases yield of certain crops (Hozayn and Qados, 2010; Ghanati et al., 2015). The stimulatory impact of MW may be due to the increase of nutrients' uptake and assimilation. Physical techniques based on the application of magnetic fields, are being developed in agriculture. A systematic and extensive study is necessary to locate the mechanisms of magnetic action in vegetal tissues and identification of its useful application (Aghamir, et al 2015). In line with the previous results, this study showed that the irrigation with magnetically-treated water increases germination speed, seedling stamina index, hypocotyl and epicotyl length, root length and seedling fresh weight of Lentil. Also these results are in line with, Aghamir (2015) who showed, the roots and shoots length, fresh and dry weight of shoots and roots and roots to shoots ratio, chlorophyll content index, water uptake, tissue water content of corn were significantly affected by magnetically-treated water; he also found that the irrigation with magnetically-treated water significantly increases the physiologic factors such as germination percentage and index, vigor index, and salt tolerance index, compared to untreated control seeds. Belyavskaya (2001) reported that the magnetically-treated water significantly induces cell metabolism and mitosis meristematic cells of pea, lentil and flax. Moreover, the formation of new protein bands in plants being treated with magnetically-treated water may be responsible for the stimulation of all growth, and promoters in treated plants. Hilal and Hilal (2000) reported that magnetically-treated water has more tripled seedling emergence of wheat than tap water. Reina *et al*. (2002) found a significance increase in the rate of water absorption accompanied by an increase in total mass of lettuce as well as the increase in magnetic force. Moreover, Nasher (2008) found that chick pea plants being irrigated with magnetically-treated water were taller than plants being irrigated with tap water. Significant increases in pigment fractions were recorded in chickpea plants being irrigated with magnetically-treated water when compared to control treatment. These results may be due to the effect of magnetic field on alteration of the key cellular processes such as gene transcription which play an important role in altering cellular processes (hozayn & Abdul Qados, 2010). In this respect, Tian *et al*., (1991) and Atak *et al*., (2003) found an increase in chlorophyll content specifically being appeared after exposure to a magnetic field for a short while. Moreover, Atak *et al*., (2003) suggested that, the increase in all photosynthetic pigment through the increase in cytokinin synthesis which are induced by MF. They also added that cytokinin plays an important role in chloroplast's development, shoot formation, axillary bud's growth, and induction of a number of genes involved in chloroplast development and nutrient metabolism.

It also may be due to the increase in growth promoters (IAA). Similar results were observed regarding rice and chick-pea when irrigated with magnetically-treated water (Tian *et al*., 1991). The formation of new protein bands in plants treated with magnetically-treated water was accompanied by an increase in the growth promoters (IAA) (hozayn & Abdul Qados, 2010). In this respect, Kuba and Kakimoto (2000) found that IAA has an effect on DNA replication. Moreover, Celik *et al*., (2008) and Shabrangi and Majd (2009) reported that magnetic field is known as an environmental factor which affects gene expression. Therefore, by augmentation of biological reactions like protein synthesis Chickpea yield and its components were increased significantly under magnetic irrigation. These results are logical ways in improving growth parameters and growth promoters (IAA) as well as photosynthetic pigments. Fernandez *et al*., (1996) reported that onion seedlings raised by magnetically-treated water are more robust and healthier because the treated water increases the nutrient uptake. Magnetized water increased pests' and diseases' resistance (Diaz *et al.,* (1997). It could be concluded from this study that lentil seeds irrigation with magnetically-treated water could effectively increase growth parameters, yield and some chemical constituents.

Conclusion

The effect of magnetic treatment of irrigation water on the total water used for germination percentage and the germination index of lentil seeds was not found to be significant in this study. While using magnetically-treated water for irrigation was more effective than distilled water in promoting germination speed, hypocotyl and epicotyl length, root length and seedling fresh weight of lentil seedlings. Also seedling stamina index significantly increased in soaked seed with magnetically-treated water, irrigation with magnetically-treated water compared to dry seed, irrigation with distilled water that maybe due to better absorption of water magnetized by Plant. The irrigation with magnetically treated water increased speed germination and consequently speed growth of lentil; therefore, it reduced growth period and water consumption. Magnetically-treated water is considered to be eco-friendly physical presoaking seed germination. Although, the magnetic treatment of irrigation water resulted in significant increases in the yield and water productivity for much plants, but, it had no significant effect on the yield and water productivity for some plants in some instances (Ghanati et al., 2015). This means, before recommending this technology to farmers, it will be critical to clearly understand the mechanisms and processes affecting plant yield and water productivity through the magnetic treatment, the conditions under which it will work and the extent of its effectiveness under field situations.

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