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Magnetic water application for improving wheat (*Triticum aestivum* L.) crop production

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ABSTRACT

The technology of magnetic water has widely studied and adopted in field of agriculture in many countries (Australia, USA, China and Japan), but in Egypt available review on the application of magnetize water in agriculture is very limited. Therefore, the present work was carried out to study the response of growth, yield, yield components and some chemical constitute of wheat for irrigation with magnetized and tap water under green house condition during 2008/09 and 2009/2010 winter seasons. Based on results of our experiment plants irrigated with magnetic water exhibited marked increases in the most of vegetative growth, chemical constitute i.e. photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids), total phenols and total indole over the control plants. Also, the magnetized water treatment exhibited an increase in the number of protein bands as compared to the control. Moreover, the magnetized water treatment increased yield and yield component at harvest. On average, the increases in grain, straw and biological yield tiller $^{-1}$ reached to 31.33, 24.56 and 28.24%, respectively compared with tap water treatment. It appears that the preliminary study on utilization of magnetized water can led to improve quantity of wheat crop. So, using magnetic water treatment could be a promising technique for agricultural improvements but extensive research is required on different crops.

Keywords: Wheat, Magnetized Water, Growth, Yield, Chemical constitute.

INTRODUCTION

The magnetic technology has been cited in the literature and investigated since the turn of the 19th Century. The changes determined at the living systems which were exposed to different magnetic field strength and periods of magnetic field (MF) and electromagnetic field (EMF) with the lowest frequency have also been drawn the attention of the biologists, molecular biologists and chemists as physicists (Atak *et al.*, 2003).

The magnetic field influence on the seeds of various crops and trees species increased the germination of seeds and improved their qualities (Aladjadjiyan, 2002). MF affected the various characteristics of the plants like germination of seeds, root growth, rate seedlings growth, reproduction and growth of the meristem cells and chlorophyll quantities (Namba *et al.*, 1995; Atak *et al.*, 1997 and Reina *et al.*, 2001).

The researchers have shown that magnetic field changed the characteristics of cell membrane, effected the cell reproduction and caused some changes in cell metabolism. At the same time, it was put forward that magnetic field affected the growth characteristics and various functions like mRNA quality, gene expression, protein biosynthesis and enzyme activities and caused the changes concerning the various functions at the organ and tissue levels (Stein and Lian, 1992; Goodman *et al.*, 1995 and Atak *et al.*, 2003). The reason of this effect can be searched in the presence of paramagnetic properties in chloroplast which can cause an acceleration of seeds metabolism by magnetic treatment (Aladjadjiyan and Ylieve, 2003). In addition to, there were magnetic field increased yield and yield parameters of crops like cereal, sunflower and soybean (Özalpan *et al.*, 1999; Yurttas *et al.*, 1999 and Oldacay, 2002). It is important to carry on the determination of the biological effects formed in plants by magnetic field studies.

In the present study, we investigated the effects of magnetic water on the growth, yield and some metabolites of wheat plants.

MATERIAL AND METHODS

Two pot experiments were conducted in the screen green house of Agronomy Department, National Research Centre, Dokki, Giza, Egypt during two successive winter season (2008/09 and 2009/2010) to study the response of growth, yield and some biochemical constituents of wheat plant for irrigation with tap and magnetized water. Wheat grains (var. Giza-168) were obtained from Legume Research Department, Field Crops Institute, Agriculture Research Centre, Giza, Egypt. Grains without visible defect, insect damage and malformation were selected and planted in twenty pots (30 cm in diameter and 50 cm depth) containing a mixture of clay and sandy soil (2:1). Sowing date was in the first week of December and second week of November in first and second seasons respectively. Half of the pots were irrigated once a week interval with tap water, while the other ten pots were irrigated with the tap water after magnetization through passing in magnetic device (U050 mg, 0.5 inch, output 4-6 m^3/hr, production by Magnetic Technologies L.C.C., Russia, branch United Arab Emirates). The recommended NPK fertilizers were applied through the period of experiment.

At 55 days from sowing, plant height, fresh and oven dry weight of twenty wheat plants were determined. Relative water content was calculated according to Henson *et al.* (1981) by the following equation: 100 X (Fresh weight – Dry weight)/Fresh weight. Photosynthetic Pigments (chlorophyll a, chlorophyll b and carotenoids) of leaves were determined spectrophotometrically as the method described by Moran (1982). Total indole acetic acid (IAA) as described by Larsen *et al.*, (1962), and total phenol, as described by Malik and Singh (1980), were estimated in the fresh leaves. Electrophoresis protein profile of lentil shoots were analyzed according to sodium dodocyl sulphate poly acrylamide gel electrophoresis (SDS-PAGE) technique (Sheri, *et al.*, 2000). Polypeptide maps, molecular protein markers, percentage of band intensity, molecular weight and mobility rate of each polypeptide were related to standard markers using gel protein analyzer version 3 (MEDIA CYBERNE TICE, USA). On the first week of May in both seasons, data on wheat yield and its components were recorded.

Statistical analysis was conducted using SPSS program Version 16. A student test (*t*-test) was done to find the significant differences between magnetic and nonmagnetic water treatments.

RESULTS

Growth criteria: The changes of growth characters (plant height, fresh and dry weight per plant and water content) of wheat plants irrigated with magnetic water are shown in table (1). Wheat plants irrigated with magnetic water exhibited highly significant increases in plant height, fresh and dry weights/plant over the control. On average over both seasons, these increases reached to 13.85%; 48.36% and 39.25% at the above parameters, respectively. Also, the water content showed a slight significant increase (2.07%) as compared to control plant.

Photosynthetic pigment contents:

The results in table (2) show that magnetic water significantly increased all photosynthetic pigment (Chl a, Chl b, Chl a+b, carotenoids and total pigment content) over the control. The percent of increments reached to 17.6%; 11.37%; 15%; 25%; 3.03% and 15.25% in the above parameters, respectively.

Indole and phenol contents: Magnetic water treatment induced significant increases in total indole and phenol contents as compared to control plant. The percent of increase reached to more than two folds in indole and to 33.59% in phenol over the control value

Table 1. Response of wheat growth at 55 days after sowing for irrigation with magnetic and tap water at 2008/09 and 2009/2010 winter seasons.

Treatment / Character	2008/09 season		*t*-sign.	2009/2010 season		*t*-sign.
	Tap water	Magnetic water		Tap water	Magnetic water	
Plant height (cm)	20.75	24.12	**	26.20	29.20	**
Fresh weight (g $tiller^{-1}$)	0.68	0.98	**	0.79	1.21	**
Dry weight (g $tiller^{-1}$)	0.17	0.23	**	0.21	0.29	**
Water contents (%)	75.00	76.53	ns	74.04	75.60	Ns

*, ** *t* is Significant at the 0.05 and 0.01 levels, respectively, ns: non significant

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Table 2. Response of photosynthetic pigment, total indole and phenol contents in fresh wheat shoot at 55 days after sowing to irrigation with magnetic and tap water (2008/09 season).

Treatment / Character		Tap water	Magnetic water	t-sign.
Photosynthetic pigments (mg/100 g fresh weight)	Chlorophyll a	8.24	9.68	**
	Chlorophyll b	4.97	5.54	ns
	Chlorophyll a+b	13.21	15.22	**
	Carotenoids	5.67	5.84	ns
	Total pigments	18.88	21.07	**
Total Indols (µg/100 g fresh weight)		2.94	9.80	**
Total phenol (mg/100 g fresh weight)		215.62	288.05	**

*, ** *t* is Significant at the 0.05 and 0.01 levels, respectively , ns: non significant.

Protein electrophoratic pattern: The changes in protein electrophoratic pattern of wheat leaves treated with magnetic water is analyzed and recorded in Table (3). In the control leaves, the separation of 12 protein bands were appeared, their molecular weights ranged between 346 K Da. and 20 K Da. Magnetic water treatment of wheat plants showed an increase in the number of protein bands to 16 bands. These results indicate that the leaves of plants treated with magnetic water characterized by disappearance of certain bands and the appearance of new ones as compared with that of the control plant (Table 3). The six new protein bands appeared at molecular weights 340, 194, 116, 88, 57 and 22 KDa. However, the protein bands at molecular weights 51 and 37 were disappeared in response to magnetic water treatment.

Wheat yield and its components:
The results in Table 4 show that, irrigation wheat plants with magnetized water induced significant marked increase in all yield and yield components compared to control treatment. The increases reached to 24.56, 31.33 and 27.68 % in seed, straw and biological yield per teller over the control (average two seasons).

Table 3. Relative area percent of wheat leaves at 55 days after sowing irrigated with magnetic and tap water (2008/09 season).

M wt. K.Da.	control	Magnetic
346	4.54	2.24
340		5.28
325	5.07	4.16
283	8.73	8.21
256	8.21	7.34
194		10.32
141	13.79	6.80
116		6.11
88		4.55
67	9.67	9.81
57		3.92
51	8.08	
44	15.47	12.84
37	5.16	
32	11.67	9.23
22		4.24
20	9.61	4.95
Total Band number	12	16
Number of new band		6

Table 4. Response of wheat yield and its components for irrigation with magnetic and tap water at 2008/09 and 2009/2010 winter seasons.

Treatment	2008/09 season		*t*-sign.	2009/2010 season		*t*-sign.
Character	Tap water	Magnetic water		Tap water	Magnetic water	
Plant height (cm)	39.80	47.00	*	56.40	59.60	*
Spike length (cm)	5.00	6.60	**	8.50	9.20	**
Spike weight (g)	0.48	0.53	**	0.64	0.75	**
Spikeletes (no. spike $^{-1}$)	9.00	12.00	**	14.40	16.00	**
100-grain weight (g)	4.03	4.31	ns	4.14	4.42	ns
Grain yield (g tiller $^{-1}$)	0.30	0.40	**	0.75	0.97	**
Straw yield (g tiller $^{-1}$)	0.59	0.80	**	0.93	1.06	**
Biological yield (g tiller^{-1})	0.89	1.20	**	1.68	2.03	**

*, ** *t* is Significant at the 0.05 and 0.01 levels, respectively, ns: non significant

DISCUSSION

In this study, the results showed the positive effects of magnetic water on growth, photosynthetic pigment, total indole, total phenol and yield of wheat plants compared to control treatment.

The stimulatory effect of magnetic water on the growth data reported in this study may be due to the increase in photosynthetic pigments, endogenous promoters (IAA) (Table 2); increase protein biosynthesis (Table 3). In this connection, Fomicheva *et al.,* (1992 a & b) and Belyavskaya (2001) reported that magnetic water significantly induces cell metabolism and mitosis meristematic cells of pea, lentil and flax. Also, Aladjadjiyan (2002) showed that exposure of zea mays seeds to magnetic water has a favorable effect on the development of shoots in the early stage. Atak *et al.* (2003) and Aycih and Alikamanoglu (2005) concluded that magnetic field increased the shoot and root regeneration rate and their fresh weight in soybean and paulownia organ cultures. Moreover, Celik *et al.* (2008) and Nasher (2008) concluded that, magnetized water increased growth and consider an important factor for inducing plant growth. In earlier study Phirke *et al.* (1996) reported that the mechanisms of magnetic field may be including biochemical changes or altered enzyme activities.

Photosynthetic pigments content in fresh wheat at 55 DAS have shown a significant increase in response to irrigation with magnetic water. This increment may be attributed to Increasing ions mobility and ions uptake improved under MF which leads to a better photo stimulation in wheat plants (Pietruszewski, 1999). Moreover, magnetic field has the ability to change water properties, thus magnetized water increased rice chlorophyll content (Tian *et al.*, 1989) Several studies reported Similar results for different plants; (Rochalska M. 2005) found that MF treatment increased the chlorophyll content in sugar beet (*Beta vulgaris* L.) leaves and content of chlorophyll a, b and carotenoids in potato (*Solanum tuberosum* L.) (Rakosy-Tican *et al.*, 2005). Additionally, studies by Atak *et al.* (2003 and 2007) involving MF impact on soybean (*Glycine max* L.) confirmed that MF significantly increased chlorophyll a, chlorophyll b and total chlorophyll contents.

The significant increases in photosynthetic pigment contents were accompanied with significant increase in total indole content (Table 2). In this regard, Atak *et al.* (2003) summarized that; chloroplast rate was increased at the explants exposed to MF in accordance with control. As a consequence, the increase in cytokinin and auxin synthesis may be induced by magnetic field.

The increment in total phenol content in wheat plants treated with magnetic water reached to 33.59% compared to control treatment, this increase may be attributed to the role of magnetic treatment in changing the characteristic of cell membrane, effecting the cell reproduction and causing some changes in cell metabolism (Goodman *et al.*, 1995 and Atak *et al.*, 2003).

Auxins have been used in order to induce the rooting in the produced shoots. They also increased the growth of shoot tip explants. Cell division has been arranged the interaction of auxin and cytokinins together. Each of these has been effecting the different phases of the cell cycle. While auxins effect

on DNA replication, cytokinin are effective on some events causing mitosis (Kuba *et al.,* 2000).
Also, Atak *et al.* (2003) summarized that, shoot regeneration and chloroplast rate were increased at the explants exposed to MF and root formation rate and fresh weight were also increased at the explants exposed to MF in accordance with control. As a consequence, the increase in cytokinin and auxin synthesis may be induced by magnetic field.

The formation of new protein bands in plants treated with magnetic water was accompanied with increasing growth promoters (IAA) in treated plants (Table 3). In this respect, Kuba *et al.*, (2000) found that IAA 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 on gene expression. Therefore, by augmentation of biological reactions like protein synthesis.

Regarding to yield and yield components, the results clear that all yield parameters increased significantly when irrigation occurred using magnetic water. These results are the logical to improvement growth parameters (table1), growth promoters (Table 2) and protein synthesis (Table 3). The stimulatory effect of magnetic water on yield and yield components reported in this study is in agreement with that obtained by other researchers. Tian *et al.* (1991) indicated that, magnetic water increased yield of rice by 13-23%. This increase was accompanied the stimulation effect of MW on leaf chlorophyll content. Kordas (2002) found that, the exposure of green tops and root systems of wheat plant to magnetic field brought about increased quantity of coarse grain by 10.6% and 6.3%, respectively. De Souza *et al.* (2006) showed that magnetic treatments on tomato increased significantly the mean fruit weight; the fruit yield per plant; the fruit yield per area and the equatorial diameter of fruits in comparison with the controls.

Exposure of plants to MW is highly effective in enhancing growth characteristics. This observation suggests that there may be resonance-like phenomena which increase the internal energy of the seed that occurs. Therefore, it may be possible to get higher yield (Vashisth and Nagarajan, 2008 and Shabrangi and Majd, 2009) on chickpea and lentil respectively.

In summary, growth parameter and yield components of wheat plants is concomitantly increased when wheat plants irrigated with magnetic water with increasing photosynthetic pigment; endogenous total indole; total phenol and protein synthesis.

We hope to attract the attention of scientific community to study this important phenomenon. Collaboration with physicists; biologists and physiologists are necessary in order to understand the mechanism of magnetic water action. Generally, using magnetic water treatment could be a promising technique for agricultural improvements but extensive research is required on different crops.

REFERENCES

Aladjadjiyan, A. (2002). Study of the Influence of Magnetic Field on Some Biological Characteristics of *Zea mais*. J. of Central Europ. Agric. 3(2). 89-94.

Aladjadjiyan,A. and Ylieva, T. (2003). Influence of stationary magnetic field on the early stages of the development of tobacco seeds (*Nicotiana tabacum* L.). J. of Central Europ. Agric.,132 ,4 (2): 131-138.

Atak C, Celik O, Olgun A, Alikamanolu S, Rzakoulieva A. (2007). Effect of magnetic field on peroxidase activities of soybean tissue culture. Biotechnology ; 21: 166-71.

Atak C, Danilov V, Yurttas B, Yalç›n S, Mutlu D and Rzakoulieva A. 1997. Effects of magnetic field on soybean (*Glycine max* L.Merrill) seeds. Com JINR. Dubna, 1-13.

Atak C, Emiroglu O¨, Aklimanoglu S, and Rzakoulieva A. (2003). Stimulation of regeneration by magnetic field in soybean (*Glycine max* L. Merrill) tissue cultures. J Cell Mol. Biol., 2:113–119.

Aycih, O. and Alikamanoğlu, S. (2005). The effect of magnetic field on Paulownia tissue cultures Plant Cell. Tissue and Organ Culture 83 (1): 1109-1114.

Belyavskaya N.A. (2001). Ultrastructure and calcium balance in meristem cells of pea roots exposed to extremely low magnetic field. Adv Space Res. 28: 4, 645-650.

Çelik Ö., Ç.Atak, Rzakulieva, A. (2008). Stimulation of rapid regeneration by a magnetic field in paulownia node cultures. J. of Central Europ. Agric., 9 (2): 297 – 303.

De Souza A., Garcia D., Sueiro L., Gilart F., Porras E., and Licea L., 2006. Pre-sowing magnetic treatments of tomato seeds increase the growth and yield of plants. Bioelectromagnetics, 27, 247-257.

Formicheva VM, Govorun RD and Danilov VT. (1992a). Proliferative activity and cell reproduction in the root meristem of pea lentil and flax in the conditions of screening the geomagnetic field. Biophysics, 37: 645-648.

Formicheva VM, Zaslavskii VA, Govorun RD and Danilov VT. (1992b). Dynamics of RNA and protein synthesis in the cel1s of the root meristems of the pea, lentil and flax. Biophysics, 37: 649-656.

Goodman EM, Greenabaum B and Morron TM. 1995. Effects of electromagnetic fields on molecules and cells. International Review of Cytology, 158: 279-325.

Henson, I. E. ; V. Mahalakshmi, F.R. Bidinger and G. Alagars-Wamy (1981). Genotypic variation in pearl miller (*Pennisetum americanum* L.) Leeke in the ability to accumulate abscisic acid in response on water stress. J. Exp. Bot., 32: 899-910.

Kordas, L. (2002). The effect of magnetic field on growth, development and the yield of spring wheat. Polish J. of Environmental Studies, 11 (5): 527-530.

Kuba M and Kakimoto T. (2000). The cytokinin hyposensitive genes of Arabidopsis negatively regulate the cytokinin signalling pathway for cell division and chloroplast development. The Plant J., 23(1): 385-394.

Larsen , P. Harbo, A., Klungron, S. and Ashein, T. A. (1962). On the biosynthesis of some indole compounds in *Acetobacter xylinum.* Physiol. Plant., 15: 552-565.

Malik, C.P. and Singh, M.B. (1980). Plant Enzymology and Histoe-nzymology. Kalyani Publishers. New Delhi.

Moran, R. (1982). Formulae for determination of chlorophyllous pigments extracted with N, N-dimethylformamide. Plant Physiol. 69:1371-1381.

Namba K, Sasao A and Shibusawa S. 1995. Effect of magnetic field on germination and plant growth. Acta Horticulture. 399: 143-147.

Nasher , S. H. (2008). The Effect of magnetic water on growth of chick-pea seeds. Eng. & Tech. 26,(9).

Oldacay, S. and. Erdem, G. (2002). Evaluation of chlorophyll contents and peroxides activities in I (*Helianthus annuus* L.) genotypes exposed to radiation and magnetic field. Pak. J. of Appl. Sci*., 2*(10): 934-937.

Özalpan A., Atak, C., Yurttas, B**.,** Alikamanoglu, S., Canbolat, Y., Borucu H., Danilov V. and Rzakoulieva A. (1999). Effect of magnetic field on soybean yield (*Glycine max* L. Merrill). Turkish Association of Biophysics, XI National Biophysics Congress, Abstract Book, pp: 60.

Phirke P.S., Kudbe A.B., and Umbarkar S.P., (1996). The influence of magnetic field on plant growth. Seed Sci. Technol., 24, 375-392.

Pietruszewski S. (1999). Influence of pre-sowing magnetic biostimulation on germination and yield of wheat. Int. Agrophys., 13: 241-4.

Rakosy-Tican L, Aurori CM, and Morariu VV. (2005). Influence of near null magnetic field on in vitro growth of potato and wild Solanum species.Bioelectromagnetics, 7: 548-57.

Renia F.G., Pascual L.A., Fundora I.A. (2001). Influence of a Stationary Magnetic Field on water relations in lettuce Seeds. Part II: Experimental Results. Bioelectromagnetics 22:596-602.

Rochalska M. (2005). Influence of frequent magnetic field on chlorophyll content in leaves of sugar beet plants. Nukleonika ; 50: 25-8.

Shabrangi, A. and Majd, A. (2009). Effect of magnetic fields on growth and antioxidant systems in agricultural plants. PIERS Proceedings, Beijing, China, March 23-27.

Sheri L.H., Ncolas E.S., Michae T.K. and Joanna B.G. (2000). Comparison of protein expressed by *Pseudomonas aeruginosa* strains representing initial and chronic isolates from a cystic fibrosis patient: an analysis by 2 – D gel electrophoresis and capillary coloumn liquid chromatograph tandem mass spectrometry. Microbiology. 146: 2495 – 2508.

Stein GS and Lian J.B. (1992). Regulation of cell cycle and growth control. Bioelectromagnetics Supplement., 1: 247-265.

Tian WX, Kuang YL and Mei ZP., (1991). Effect of magnetic water on seed germination, seedling growth and grain yield of rice. Field Crop Abstracts, 044-07228.

Tian WX, Kuang YL, and Mei ZP. (1989). Effect of magnetic water on seed germination, seedling growth and grain yield of rice. J Jilin Agric Univ., 11: 11-6.

Vashisth, A. and Nagarajan, S. (2008). Exposure of seeds to static magnetic field enhances germination and early growth characteristics in chickpea (*Cicer arietinum* L.). Bioelectromagnetics, 29:571-578.

Yurttas B, Atak C, Gökdoan G, Canbolat Y, Danilov V. and Rzakoulieva A. (1999). Detection of the positive effect of magnetic field on sunflower plants (*Helianthus annuus* L.). Turkish Association of Biophysics, XI National Biophysics Congress, Abstract Book, pp: 59.