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Utilization of Magnetic Water Technologies in Agriculture: Response of Growth, Some Chemical Constituents and Yield and Yield Components of Some Crops for Irrigation with Magnetized Water

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Abstract: Agricultural sciences take an interest not only in the common and valued crop-forming factors, but also in those less expensive, safe environmentally and generally underestimated. 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 and yield components and some chemical constituents of monocotyledonous (wheat and flax) and dicotyledonous (chick pea and lentil) for irrigation with magnetized and tap water under green house condition. Based on the results of our experiments all crops which irrigated with magnetic water exhibited marked increases in the most vegetative growth, chemical constituents i.e. photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids), total phenols and total indole over the control plants. 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 traits of all crops. The increases in seeds yield/plant in monocotyledonous crops reached to 10.00 and 33.33% for flax and wheat, respectively and in dicotyledonous crops reached to 26.92 and 46.62%, for lentil and check pea, respectively compared with crops irrigated with tap water.It appears that the preliminary study on utilization of magnetized water can led to improving quantity and quality of crop production under Egyptian condition.

Key words: Magnetized water • Growth • Yield • Chemical constituents • Monocot and dicot crops

INTRODUCTION

Till 1980 a little were known about how the magnetic field can stimulate plant growth or even prevent it. Wojcik [1] reported that at the beginning of 1980s Japanese called Fujio Shimazaki working in Shimazaki Seed Company was the first, who reported that stationary magnetic fields can improve the germination of seeds and speed up the growth of plants.

The magnetic field (MF) influence on the seeds of various crops and trees species increased the germination of seeds and improved their qualities [2]. 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 [3]. It was also shown that, MF affected various characteristics of plants like germination of seeds, root growth rate, seedlings growth, reproduction and growth of the meristem cells and chlorophyll quantities [4-6]. In addition, other studies of magnetic field in yield and yield parameters of crops like cereal, sunflower and soybean,showed that the yield and its components of these crops were increased [7-9]. Also,the effect of magnetic field on the productivity of different crops has been studied by many authors [2,10-13]. It has been established that the proper combination of magnetic field

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induction and exposure accelerates the early stages of plant development and improves the productivity. Consequently, the magnetic field effect can be used as an alternative to the chemical methods of plant treatment for improving the production efficiency Aladjadjiyan [14]. Investigations of MFs on biological systems have demonstrated generalized increases in gene transcription and changes in the levels of specific mRNAs [15].

MATERIALS AND METHODS

A pot experiment was conducted in the greenhouse of Agronomy Department, National Research Centre, Dokki, Giza, Egypt during winter season **(….??)** to study the response of growth, yield and some chemical constituents of some crops for irrigation with tap and magnetized water. Grains of monocotyledonous crops (wheat var. Sakha-93 and 186 and flax var. Sakha 2) and dicotyledonous crops check pea var. Giza-4 and lentil var. Sainia-1 were obtained from Field Crop Research Department, Field Crops Institute, Agriculture Research Centre, Giza, Egypt. Grains of each crop without visible defect, insect damage and malformation were selected and planted in ten pots (30 cm in diameter and 50 cm depth) containing a mixture of clay and sandy soil (2:1). Half of the pots were irrigated twice on a week interval with tap water, while the other 5 pots were irrigated with the tap water after magnetization through a one inch Magnetron (U.T. 3). The recommended NPK fertilizers for each crop were applied through the period of experiment (120 days).

After 60 days from sowing, plant height, fresh and dry weight of 6 plants from each crop were determined. Photosynthetic Pigments (chlorophyll a, b and carotenoids) of leaves were determined spectrophotometrically as the method described by Moran [16]. Total indole acetic acid (IAA) as described by Larsen *et al*. [17] and total phenol, as described by Malik and Singh [18], were estimated in the fresh shoots. Electrophoresis protein profile of leaves was analyzed according to sodium dodocylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) technique [19]. Molecular protein markers, percentage of band intensity and molecular weight of each polypeptide were related to standard markers using gel protein analyzer version 3 (MEDIA CYBERNE TICE, USA).

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

RESULTS AND DISCUSSION

Growth Parameters: The changes of growth characters namely plant height, fresh and dry weight per plant and water content of some crops exposed to magnetic field are shown in Table (1). It is obvious that, magnetic treatment increased plant height, fresh and dry weights/plant and water content significantly over the untreated plant in both monocotyledonous and dicotyledonous plants. The percent of increments in fresh weight/plant of monocotyledonous plants ranged between 15.9-52.61% and ranged between 8.26-43.21% in dry weight/plant of wheat and flax plants, respectively. The percent of increments in fresh and dry weight/plant of dicotyledonous plants ranged between 11.36-17.86% and 4.28-15.94% in chick pea and lentil plants, respectively as compared with plants irrigated with tap water. Water content was the least affected parameters in both types of crops where the percent of increase ranged between 0.66-2.63 in all four crops (monocot. or dicot.). It is worthy to mention here that, the percent of increases in growth parameters which reflected in fresh and dry weight/plant in this study showed that, monocotyledonous plants (wheat and flax) surpassed dicotyledonous plants (chick pea and lentil) in their response to magnetic treatments.

The stimulatory effect of magnetic water may be attributed to their role in increasing absorption and assimilation of nutrients consequently increasing plant growth. These results are in good harmony with several investigators, who found that in studied paulownia tissue cultures and showed the positive effect of magnetic field on regeneration percentage [20]. Also, Alikamanoğlu *et al*. [21] suggested that, magnetic water treatment improved seed inhibition, vigor and germination rate and seedling treatment promoted NPK absorption and increased root no, stem thickness, dry weight/100 plants and tillers number. Moreover, Celik *et al.* [15] and Nasher [22] concluded that, magnetized water increased growth and consider an important factor for inducing plant growth. The stimulatory effect of MW on growth criteria of this study may be also attributed to the increase in photosynthetic pigment, endogenous promoters (IAA), total phenol (Table 2) and increase in protein biosynthesis (Table 4). In this connection, Shabrangi and Majd [23] concluded that, biomass increasing needs metabolic changes particularly increasing protein biosynthesis.

Table 1: Growth response of some monocot and dicot plants at 60 days after sowing for irrigation with magnetic water

	Monocot						Dicot					
	Wheat			Flax			Chick-pea			Lentil		
Treatment Character	Magnetic water	Tap water	P-value	Magnetic water	Tap water	P-value	Magnetic water	Tap water	P-value	Magnetic water	Tap water	P-value
Plant Height (cm)	29.200	26.200	0.013	25.000	24.000	0.406	26.200	24.200	0.131	18.400	15.200	0.013
Fresh Weight (cm)	1.210	0.793	0.001	0.709	0.612	0.001	1.731	1.554	0.001	0.660	0.560	0.001
Dry weight/plant(g)	0.294	0.205	0.001	0.163	0.150	0.227	0.382	0..374	0.016	0.194	0.167	0.001
Water contents(%)	75.600	74.040	0.177	77.073	75.470	0.282	77.928	75.934	0.001	70.568	70.107	0.534

Table 2: Effect of mahnetic water on chemical constituents of some monocor and dicot plants at 60 days after sowing

		Monocot						Dicot					
		Wheat			Flax			Chick-pea			Lentil		
Treatment Character		Magnetic water	Tap water	P-value	Magnetic water	Tap water	P-value	Magnetic water	Tap water	P-value	Magnetic water	Tap water	P-value
Photosynsetic pigmen (mg/100 g fresh weight)	Cholorophyll a	9.684	8.235	0.001	7.200	6.130	0.001	7.239	5.720	0.001	4.215	3.711	0.017
	Cholorophyll b	5.539	4.973	0.121	3.960	2.360	0.002	3.741	3.071	0.001	1.804	1.247	0.013
	Cholorophyll a+b	15.223	13.208	0.008	11.160	8.490	0.001	10.980	8.791	0.001	6.019	4.958	0.015
	Carotonelods	5.844	5.672	0.455	4.993	4.600	0.135	4.502	4.483	0.745	4.902	4.773	0.569
	Total pigments	30.446	26.417	0.008	22.320	16.980	0.001	15.482	13.274	0.001	12.038	9.916	0.015
	Total phenol (mg/100g fresh weight)	288.051	215.619	0.001	246.073	208.190	0.001	434.130	312.287	0.003	215.017	179.177	0.002
	Total Indols (mg/100g fresh weight)	9.796	2.937	0.001	1.594	1.195	0.001	1.367	1.258	0.009	2.055	0.282	0.001

Table 3: The relative area percentage of protein bands in leaves at 60 days after sowing of some monocot and dicot plants irrigated with magnetied and normal water

	Monocot				Dicot			
	Wheat		Flax		Chickpea		Lentil	
342	4.54	2.24					1.76	1.83
339		5.28	2.54	3.58				
327	5.07	4.16			3.54	2.51		2.44
323					3.61	1.47	2.72	2.58
322					16.97	1.46		
316			4.49	3.03		2.32		
307				3.42				2.00
301								1.27
286	8.73	8.21	2.43	3.03				
267				3.22				
253	8.21	7.34	2.37	3.26				
245						7.80	10.23	12.75
233			4.61	3.15		1.31		
224				3.65		2.51		
204		10.32		2.40		2.68		
189					2.32	2.32		
146	13.79	6.80	7.40	7.60	4.23	5.38	8.60	4.97
135						1.99	4.55	2.15
125					2.06	2.06	6.17	
114		6.11		3.86				
107				2.56				

Table 3: Continued

	Monocot				Dicot			
	Wheat		Flax		Chickpea		Lentil	
95				5.49				10.35
87		4.55	15.70		4.27	5.24		
73			6.21	2.75				7.85
66	9.67	9.81			6.89	7.70	17.32	2.85
56		3.92		6.77	6.15			6.05
52	8.08		10.61	6.03	2.76	5.69	8.11	4.73
47			11.22	10.44		5.08	13.30	14.96
45	15.47	12.84		5.96	10.45	7.76		
41			11.36	4.75	8.80	7.17		
37	5.16		7.26	2.45	8.79	6.15		6.59
35					5.34	2.25		
33	11.67	9.23	13.80	12.60		10.68	18.31	16.63
30					5.60	8.47		
22		4.24						
20	9.61	4.95					8.93	
Band number	11	15	13	21	15	22	11	16
Number of new band		6		9		8		7

Table 4a: Effect of magnetic water on yield and yield comonents of some monocot plants

Treatment	Monocot						
	Wheat				Flax		
Characer	Magnetic water	Tap water	P-value	Character	Magnetic water	Tap water	P-value
Plant height (cm)	47.00	39.80	0.012	Plant height (cm)	58.20	56.80	0.029
Spike length (cm)	6.60	5.00	0.004	Tecenical length (cm)	48.80	43.40	0.012
Spikeletes no./spike	12.00	9.00	0.001	Based branches no/plant	2.80	2.40	0.242
Spike weight (g)	0.75	0.64	0.004	Fruit branches. No/plant	6.00	5.60	0.347
Seed yield (g/plant)	0.40	0.30	0.001	Cabsules no/plant	10.80	9.20	0.024
Straw yield (g/plant)	0.80	0.59	0.001	Seed no/cabsula	8.40	8.00	0.524
Biological yield (g/plant)	1.20	0.89	0.001	Cabsules weight/plant (g)	0.53	0.44	0.008
HI (%)	33.80	33.76	0.984	Seeds no/plant	79.60	66.00	0.046
CI (%)	51.33	51.28	0.993	Seeds yield (g/plant)	0.38	0.32	0.046
				100 Seeds weight (g)	0.70	0.68	0.116

Table 4b: Effect of magnetic water on yield and yield comonents of some dicot plants

Treatment	Dicot					
	Wheat			Flax		
Characer	Magnetic water	Tap water	P-value	Magnetic water	Tap water	P-value
Plant height (cm)	41.800	32.400	0.001	20.600	16.400	0.001
Branches no./plant	4.400	3.200	0.005	3.600	2.710	0.010
Pods no/plant	11.500	7.600	0.001	6.400	4.780	0.001
Pods weight (g/plant)	2.755	1.964	0.001	6.400	4.78	0.001
Seed no/plant	10.200	7.132	0.001	10.500	8.750	0.001
Seed yield (g/plant)	2.104	1.435	0.001	0.660	0.520	0.002
Straw yield (g/plant)	2.946	1.985	0.001	1.366	1.056	0.004
Biological yield (g/plant)	5.050	3.420	0.005	0.706	0.536	0.001
Harvest index (%)	41.977	41.956	0.995	48.379	49.301	0.745
Crop index (%)	74.536	72.374	0.839	94.872	98.497	0.756
100 seed wt (%)	19.174	19.130	0.901	5.620	5.200	0.001

Chemical Constituents: Photosynthetic pigments (Chlorophyll a, Chlorophyll b, total chlorophyll a+b and carotenoids), total phenols and total indole contents in plant shoots exhibited great alterations in response to the irrigation with magnetized water than the controls (plants irrigated with tap water) as shown in Table (2). The magnitude of increments in total pigment content ranged from 15.25-31.45 % in monocot. (wheat and flax) and from 16.64-21.4 % in dicot (chick pea and lentil), respectively. Total phenol content was increased by 18.2-33.59 % in monocot and by 20.0-39.02 % in dicot, respectively. The results also showed that, total indole acetic acid content of monocot plants irrigated with magnetic water was increased by 33.35-233.5 %, while their content in dicot plants was increased by 8.66-148.19 %.

These results may be due to the effect of MT on alteration the key of cellular processes such as gene transcription which play an important role in altering cellular processes. It also may be due to the increase in growth promoters IAA (Table 2). Similar results were obtained by Tian *et al*. [24] and Atak *et al*. [25] and [26] who found that an increase in chlorophyll content specifically appeared after exposure to a magnetic field for a short time. Moreover, Atak *et al*. [26] suggested that, increase all photosynthetic pigment through increasing cytokinin synthesis which induced by MF. They also added cytokinin play an important role on chloroplast development, shoot formation, axillary bud growth and induction of number of genes involved in chloroplast development nutrient metabolism. Atak *et al*. [26] showed that, the increase in shoot regeneration, chloroplast rate, root formation and fresh weight were accompanied by the increase in auxin synthesis which induced by MF treatment of soybean plants. Moreover, Goodman *et al*. [27] and Atak *et al*. [26] described the role of MF in changing the characteristics of cell membrane, affecting the cell reproduction and causing some changes in cell metabolism. So the increase in total phenol under this study may be attributed to the role of MT in changing the cell membrane properties. Also, Carimi *et al*. [15] and Celik *et al*. [28] conclude that, MF stimulates protein synthesis via increase cytokinins and auxins and they can promote the maturation of chloroplast. Growth, development and plants productivity are usually affected by photosynthetic pigments activity. Magnetic fields are known to induce biochemical changes and could be used as a stimulator for growth related reactions including affecting photosynthetic pigments [29].

Protein Electrophoretic Pattern: The changes in protein electrophoretic pattern of plant leaves treated with magnetic water is analyzed and recorded in Table (3). In the control leaves the separation of 12, 13, 15 and 11 protein bands were appeared in wheat, flax, chick pea and lentil, respectively. Their molecular weights ranged between 346 K Da. and 20 K Da. Magnetic water treatment of plants showed an increase in the number of protein bands to 16, 21, 22 and 16 bands in wheat, flax, chick pea and lentil, respectively. These results indicated 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 in wheat at molecular weights 340, 194, 116, 88, 57 and 22 KDa. The nine new protein bands appeared in flax at molecular weights 301, 267, 223, 210, 113, 107, 98, 59 and 45 KDa. Also, the new protein bands appeared in chick pea at molecular weights 314, 248, 235, 226, 192, 135, 49 and 32 KDa. While in lentil, the new protein bands appeared at molecular weights 332, 307, 301, 93, 75, 55 and 38 KDa.

On the other hand, the protein bands at molecular weights 51 and 37 K Da in wheat, at 56 K KDa in chick pea and at 127 and 20 K Da. In lentil were disappeared in response to magnetic water treatment.

The induction of new protein bands in response to MWT may be as a result of the effect of MFs in increases proliferation, gene expression and protein biosynthesis [30]. Also, Celik *et al.* [15] found that the increase in the percentage of plant regeneration is due to the effect of MF of cell division and protein synthesis in paulownia node cultures and concluded that, investigations of MF on biological systems have demonstrated generalized increases in gene transcription and changes in the levels of specific mRNAs. Moreover, Shabrangi and Majd [23] concluded that, biomass increasing needs metabolic changes particularly increasing protein biosynthesis. They also add magnetic field is known as an environmental factor which affects on gene expression. Therefore, by augmentation of biological reactions like protein synthesis, biomass would increase too.

Yield and Yield Component: With respect to the effect of MT on the yield and yield components of monocot and dicot plants data in Table (4) cleared that MT increased all yield characters in all crops over the untreated controls. The percentage of increase in seed yield /plant reached to 10-33.33 % in monocotyledonous crops (flax and wheat, respectively) and to 26.92-46.62 % in dicotyledonous crops (lentil and chick pea, respectively) over the control treatment.

It is worthy to mention here that, with the contrast with growth results, the percent of increases in all yield parameters which reflected in the seed yield / plant in this study showed that, dicotyledonous plants (chick pea and lentil) surpassed monocotyledonous plants (wheat and flax) in their response to magnetic treatments. These results may be attributed to the percent of increasing photosynthetic pigment and growth promoters IAA in monocot is surpassed dicot as shown in Table 2. Where the magnitude of increments in total pigment content ranged from 15.25-31.45 % in monocot. (wheat and flax) and from 16.64-21.4 % in dicot (chick pea and lentil), respectively. Also, total indole acetic acid content of monocot plants irrigated with magnetic water was increased by 33.35-233.5 %, while their content in dicot plants was increased by 8.66-148.19 %, respectively.

Generally, the stimulatory effect of magnetic treatment may attributed to their role in increasing growth (Table 1), photosynthetic pigment and growth promoters (Table 2), consequently increasing yield characters. These results are in agreement with those obtained by Tian *et al*. [24], who indicated that, MW increased yield of rice by 13.23%. This was accompanied the stimulation effect of MW on leaf chlorophyll content. Kordas [31] found that, the exposure of green tops and root systems of wheat plant to MF increased quantity of coarse grain by 10.6% and 6.3% respectively. In this connection, Dodlesny *et al*. [32,33] suggested that, the gain in seed yield resulting from the pre-sowing treatment of seeds with MF for broad bean and pea was due to the higher number of pods per plant and the fewer plant losses in the unit area in the growing season. Moreover, Souza *et al*. [34] showed that, MT on tomato increased significantly the mean fruit weight, the fruit yield/plant, the fruit yield per area and the equatorial diameter of fruits in comparison with the controls. Moreover, MF was shown to induce fruit yield per plant and average fruit weight [35]. 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 [23,36] on chickpea and lentil, respectively.

CONCLUSION

In summary, growth parameters and yield components of monocotyledonous (wheat and flax) and dicotyledonous (chick pea and lentil) plants is concomitantly increased when plants treated with magnetic water through increasing photosynthetic pigment; endogenous total indole; total phenol and protein synthesis. The variation in the response of plants should need continuous efforts from researchers to explore the mode of magnetic treatment action in monocot and dicot crops.

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