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RESPONSE OF TOMATO PLANTS (*Lycopersicon esculentum L.*) TO MAGNETIC TECHNOLOGIES

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ABSTRACT: *Labor experiments were done in research labor of Agric. Botany Dept. and greenhouse experiments at the experimental farm of Faculty of Agriculture, Menofiya University, Shibin El-Kom, Egypt during the two growing seasons of 2006 and 2007 to study the effects of magnetic treatments (magnetized seeds, magnetized water and double magnetized seed and water treatments) on germination, some growth characters, water relation aspects, some physiological and chemical characters as well as some yield attributes of tomatoes plants.The obtained results showed that there was a significant increase in the germination percentage, speed and index of tomato seeds as respect of all magnetic tratments if compared with the control seeds. The highest increases in the germination percentage and speed were recoded by magnetized water treatment, while in the germination index was by the double magnetizing of water and seeds. Regarding the mean long period of germination (day) of tomato seeds the results showed a significant decrease as the result of magnetic treatments as compared with the control and the shortest period was recorded in the magnetized water treatment.*

The results indicated that the plant height, root length, leaves number per plant, total leaf area, relative growth rate, net assimilation rate, dry weights of root, stem, leaves and whole plants were increased with treating by all magnetic treatments in tomato plants as compared to control plants and the increment was generally more clear in the treated plants with the magnetized water .

Significant increases in some leaf water relations i.e. total water content (%), bound water (%), relative water content (%), leaf osmotic pressure and membrane integrity (%) in tomato plants treated with all magneic treatments as compared with the control but there was a reduction in leaf water deficit and transpiration rate . There was a significant increase in the water use efficiency for dry matter production of tomato plants as respect of magnetic treatments if compared with the control plants. The increase was more pronounced at the double of magnetized seeds and water treatment compared with the other treatments .

The concentrations of photosynthetic pigments i.e. chlorophyll a, b, total chl. (a+b) and carotenoids showed generally, significant increases when the tomato plants treated with all magnetic treatments if compared with the untreated control plants. Using magnetic technologies in tomato plant

resulted in increasing in carbohydrates, amino acids, enzymes activity (phenoloxidase and peroxidase) in leaves of tomato plants compared with the control plants and the increases were generally more pronounced by treating with double of magnetized seeds and water followed by magnetized water. Significant increases were recorded in the uptake of macro-elements (N, P and K) and micro-elements (Fe, Zn and Mn) in root, stem and leaves of tomato plants by the application of magnetic technologies compared with control plants and the best treatment was observed in the magnetized water treatment as compared with the other treatments.

The concentrations of GA_3, IAA, zeatin, kinetin and benzyladenine in leaves of tomato plants were significantly increased by treating with the three magnetic treatments but these technologies decreased the concentration of ABA. The double of magnetized seeds and water was more effective in increasing the concentrations of GA_3 and benzyladenine, meanwhile the magnetized water was more pronounced in increasing the concentration of IAA, zeatin, and kinetin and decreasing the ABA concentration of compared with the other treatments.

Treating with magnetized seeds, magnetized water and double of magnetized seeds and water caused a significant increase in the fruit yield of tomato plants compared with the other treatments and the best one was the magnetized water treatment than the others. Also these technologies led to an improvement in the chemical compositions i.e. titratable acidity (%), vitamin C, concentration of macro elements (N, P and K), micro-elements (Fe, Zn and Mn), carbohydrates, and amino acids if compared with the untreated control plants and the magnetized water was more effective than the other treatments.

Key words: *Magnetic technologies, tomato plants, germination, growth, yield, water relations, mineral uptake, chemical constituents, phytohormones.*

INTRODUCTION

Magnetic energy is one type of the energy which exists in the universes. The earth is surrounded with magnetic variable which has an effect on all things with leveled markers and this energy is very important for life in the land to the living parts.

Magnetic system changes the physico-chemical characteristics of natural water (Voznaya, 1981). In the agriculture, magnetized water has a positive effect on plant growth, is more solvent and has a lower surface tension (Takashenko, 1997), so the nutrient in the water are absorbed more readily (Durate-Diaz *et al.*, 1997), results in higher production and improved quality of the plants(DeSouza *et al.*, 2006& Kuderev *et al.*, 1997). Also, it was found that the magnetic treatments alters the water relations in seeds, in the ionic concentration and osmotic pressure and water uptake rate by seeds and this

affects in the germination rate of seeds (Garcia-Reina and Arza-Pascual, 2001; Garcia-Reina *et al* ., 2001; Hilal *et al*., 2002). Moreover, the magnetic field increases the germinating energy and germination of seeds (Aladjadjiyan, 2002).

Few information was found and rare researches also were done in this respect, therefore this work was done to study the effect of magnetic technologies on the germination, growth, some physiological and biochemical aspects as well as the yield and its quantity and quality characters of tomato plants.

MATERIALS AND METHODS

Two types of experiments were investigated to study the effect of magnetic technologies on the germination , growth, some physiological and chemical aspects as well as yield and its attributes of tomato plants. The first type: Labor experiments were done in Research labor of Agric. Botany Dept. with the aim to study the effect of magnetic technologies on the germination parameters: Germination percentage, germinatiom rate, germination index and mean long of germination period as follows: Ten seeds from each treatment for both tomato was conducted in Petri dishes containing wetted papper of Whatman No.1. in five replicates and The parameters of germination were determined according to Scott *et al*., (1984) and Bartlett (1937). The second one was greenhouse experiments: Two pot experiments were performed in a greenhouse at the experimental farm of Faculty of Agriculture, Menufiya University, Shibin El-Kom, Egypt during the two growing seasons of 2006 and 2007 with the aim to study the effects of magnetic treatments on some growth characters, water relation aspects, some physiological and chemical characters as well as some yield attributes of tomatoes and pepper plants. Clay loam soil was used in this work, the physical and chemical properties of it are shown in Table (1) .

Magnetic treatments were done as follows:

1. Normal seeds irrigated with normal tap water (control).
2. Magnetized seeds by passing them through the magnetic funnel irrigated with normal tap water.
3. Normal seeds irrigated with magnetizing water by passing it through a magnetron.
4. Magnetized seeds irrigated with magnetizing water.

Magnetized water was used during all the time of the experiment. A magnetron model U.T.I of one inch diameter was used for treating water and a magnetic funnel for treating seeds .

Polyethylene pots (30-cm inner diameter and 30-cm in depth) were used with three bottom drainage holes blocked with sponge to slow drainage. Each pot was filled with 8 kg soil. The plant was used in this study : tomatoes (*Lycopersicon esculentum L. cv* Peto 86) . The seeds were germinated in peatmoss media during March in a greenhouse. The uniform

seedlings of plants were transplanted in April in the above mentioned polyethylene pots with the same treatments. Five replicates of each treatment were used and the pots were arranged in a complete randomized block design .

Phosphorus and potassium fertilizers were added to the soil before sowing in the form of calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) at the rates of 1.8 and 0.6 gm / pot., respectively and the nitrogen was also added in the form ammonium sulphate (20.5% N), at the rates of 1.8 gm / pot in three doses .

Table (1): Some physical and chemical properties of soil used.

S.P %	PH	E.C. dS/m at 25°C	Particle size distribution < 2 mm %					Soil paste extract analysis meq / L						
			Coarse sand	Fine sand	Silt	Clay	Texture grade	Anions			Cations			
								HCO^-_3	CL^-	$SO^=_4$	Ca^{++}	Mg^{++}	Na^+	K^+
48.2	7.9	2.5	2.31	41.09	29	27.6	Clay loam	4.5	8.2	19.3	14.4	6.46	10.78	0.36

During the experimental period of both seasons, samples were successfully taken at random for each treatment after 81 days from sowing. The following characters were studied :

Growth characters: Root length (cm), plant height (cm), number of leaves per plant, dry weights of root, stem and leaves (dried in an electric oven at 70 C for 72 h) g/plant, the dry matter of these organs were ground to a fine powder and kept in small plastic bags for chemical analysis, leaf area (cm^2/plant) using the disk method of Brmner and Taha (1966), relative growth rate (RGR, $mg.g^{-1}.week^{-1}$) and net assimilation rate (NAR, $g.cm^{-2}.week^{-1}$) during the period of 60-81 days were estimated according to Simane *et al.*, (1993).

Water use efficiency (WUE), which is the weight of water used (kg) in producing one gram dry matter of a plant was determined, [(WUE= Total plant dry weight (g) / Weight of water used (kg)], where : total plant dry weight yield, are the dry matter produced by a plant up to the end of the experiment ; weight of water used by plants is the weight of water added to each pot up to the end of experiments minus the weight of water loss by evaporation from soil surface without plants during this period. The WUE was calculated by using the special formula according to Vites (1965).

Water relations: The total, free and bound water in leaves were determined using the method described by Gosev (1960). Relative water content (RWC) and leaf water deficit (LWD) were determined and calculated using the following formula according to Kalapos (1994):

RWC% = [(Turgid wt.- Fresh wt.) / (Turgid wt.- Dry wt.)] x 100

LWD % = 100 – RWC

Values of total soluble solids of the cell sap were obtained for the pressed sap of the fourth upper leaf tested plants using the Abbe Refrectometer and the osmotic pressure values (bar) were calculated by using special tables according to the method described by Gosev (1960). The transpirational lose water (transpiration rate) was determined using the weight method described by Kreeb (1990).

Membrane integrity(Permeability): The absorption of the leakage of solutes across the cell membrane of tissues was determined at the ultraviolet wavelength 273 nm following the method of Leopold *et al.,* (1981).

Photosynthetic pigments: Chlorophyll a, b and carotenoids were determined from middle fresh leaves using spectrophotometer method as described by Wettestein (1957) and Fadeel (1962).

Enzymes activity: Phenoloxidase activity was determined according the methods described by Broesh (1954). For the determination of peroxidase activity the method described by Fehrman and Dimond (1967) was used. Enzyme activity was expressed as increase in optical density from 60-120 seconds after the substrate was added.

Carbohydrates: Total carbohydrates in fine powder of dry leaves (previously prepared) was estimated using the phenol-sulphuric acid method described by Sadasivam and Monikom (1992). Soluble sugars in the fine powder dried leaves were estimated in 80% ethanolic extract using the colorimetric methods according to Dubios *et al.*, (1956) . Non-soluble carbohydrates were determined as the difference between the total and soluble carbohydrates.These determinations are calculated as mg/g dry weight of sample.

Total free amino acids: Free amino acids were determined in ethanolic extract of leaves according to the method described by Sadasivam and Monikom (1992).

Mineral elements: 0.2 gm of dried ground roots, stems and leaves of the tested plants was digested in H_2SO_4 (concentrated), H_2O_2 (5:1) for chemical.

Analysis of minerals: Nitrogen (N), phosphorus (P), potassium (K), iron (Fe), manganese (Mn) and zinc (Zn) according to A.O.A.C. (1995).

Endogenous phytohormones: The endogenous phytohormones in the leaves of tomatoes plants were determined after 80 days from sowing according to the method described by Shindy and Smith (1975).

At the harvest time, the measurements of yield attributes for tomatoes were recorded as follows: No. of fruits per plant, fruit weight (g), fruit and straw yield (gm/plant), percentage of titratable acidity according to A.O.A.C.

(1995), total soluble solids (T.S.S using a hand Abbe refractometer, Vitamin C content according to the method reported in A.O.A.C. (1995), Mineral elements: N, P, K, Fe, Mn and Zn according the methods of A.O.A.C. (1995) and Carbohydrates and free amino acids according to the methods mentioned before.

Statistical analysis : The collected data were statistically analyzed using COSTAT software (1985) and treatment means by using L.S.D test according to the procedure outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1. Seed germination:

Data presented in Table (2) indicate that treating with magnetic technologies significantly increased the germination of tomato seeds. Magnetic treatments (magnetizing of seeds, magnetizing of water and double magnetizing of seeds and water) caused a significant increase in the germination percentage by about 11.0, 17.7 & 17.7 %, in the speed of germination by about 7.8, 8.4 & 7.4%, and in the germination index by about 17.8, 42.6 & 22.5 %, respectively over the control plants. It is evident from these result that the germination percentage, speed and index of tomato seeds reached to the maximum value by the magnetized water treatment as compared with the control seeds. Concerning the effect of magnetic treatments on the mean long period of germination (day) of tomato seeds, the results recorded in the same table indicate that there was a significant decrease in the mean long period of germination (day) of tomato seeds due to the application of magnetizing of seeds, magnetizing of water and double magnetizing of seeds and water by about 0.7, 0.8 & 0.5 days, respectively compared to the untreated control seeds. It can be observed that the shortest mean long period of germination (day) was obtained by the double of magnetized seeds and water.

Similar results for the effect of the magnetic treatments on germination percentage, rate and speed were found by Moon and Chung (2000) on tomato seeds, Hilal and Hilal (2000a) on tomato, cucumber, pepper and wheat, Fischer *et al.,* (2004) on sunflower and wheat, who found that germination rate and percentage increased as a result of magnetic treatments compared with the control untreated plants. Moreover, Aladjadjiyan (2002) found that the magnetic field increased the germinating energy and germination of *Zea maize* .

The accelerating effect of magnetic treatments on increase the germination of tomato seeds may be due to the magnetic field alters the water relations in seeds, the ionic concentration and osmotic pressure and water uptake rate by seeds and this effect in the seed germination rate (Garcia-Reina *et al* ., 2001), or due to the change in physiochemical characters of magnetic water (Takashenko, 1997). Also, Hilal and Hilal (2000)

indicated that the magnetic field affects seeds is the activation of energy influx and stimulation of metabolism. Magnetic field also, decrease the effect of germination inhibitors due to increase in the pH of the cell juice and can substitute for such expensive material.

Table (2):Effect of magnetic treatments on seed germination of tomato.

Characters / Magnetic Treatments	Germination (%)	Mean long period of germination (day)	Speed of germination	Germination index (GI)
Contr.	85.000	7.041	5.051	5.633
Seed	94.333	6.367	5.447	6.633
Water	100.00	6.259	5.477	8.033
Seed + Water	100.00	6.567	5.422	6.900
LSD 5%	4.831	0.417	0.295	0.377

2. Growth characters:

Data presented in Table (3) indicate that there was significant increases in plant height, root length, No. of leaves, leaf area, dry weights of different organs, relative growth rate and net assimilation rate of tomato plants as a result of the application of magnetic technologies. It can be observed from the calculated increase percentages that the highest increase in plant height was in magnetized seed treatment, magnetized water in root length, double magnetized seeds and water in leaf area, RGR and NAR as compared with other magnetic treatments. In the second season, similar findings were reported. The obtained results are in agreement with those obtained by Kuderev *et al.,* (1997) on maize, sunflower, soya, tomatoes and cucumbers plants, Atak *et al.,* (2003) on soybean, Fischer *et al.,* (2004) on sunflower and wheat plants, DeSouza *et al.,* (2005) on tomatoes, Dardenniz *et al.,* (2006) on grape, DeSouza *et al.,* (2006) on tomato seeds .

The dry weight of different plant organs were significantly increased in the plants treated with all magnetic treatments. The increases were about 183.3, 753 & 522.7 % in roots, about 334.3, 504.9 & 303.9 % in stems, 271.8, 486.7 & 355.1 % in leaves and about 272.9, 526.3 & 367 % in the whole plant in the plants treated with magnetized seeds, magnetized water and magnetized water and seeds, respectively . From the obtained results, it was found that, the best treatment in improving and increasing the dry weights of root, shoot and whole plants was magnetized water in generally in the first season and the magnetized seeds and water treatment in the second (). These results are in conformity with those obtained DeSouza *et al.,* (2005) on tomatoes (c.v.Vyta), DeSouza *et al.,* (2006) on tomato (c.v Campbell-28), who found a significant increase in dry weights of root, shoot and whole plants as a result of treating plant with magnetic technologies.

3. Water use efficiency (WUE):

Data presented in Table (3) show that water use efficiency for dry matter production of tomato plants was significantly increased as the result of application of magnetic technologies (magnetized seeds, magnetized water and double of magnetized seeds and water) in the two growing seasons. The increase was more pronounced at the double of magnetized seeds and water treatment compared with the other treatments .

Table (3): Effect of magnetic treatments on some vegetative growth characters of tomato plants after 81 days from sowing during the growing seasons 2006 and 2007.

Characters / Magnetic Treatments	Plant height (cm	Root length (cm)	Leaves No. per plant	Leaf area (cm^2/ plant)	RGR (mg/g/ week)	NAR (g/m^2/ week)	Dry weight (g/plant)				Water use efficiency (g/kg H_2O)
							Root	stem	leaves	whole	
2006											
Control	42.16	11.16	7.00	158.30	0.226	0.151	0.066	0.102	0.323	0.491	1.14
Seeds	54.66	15.16	9.33	673.60	0.334	0.256	0.187	0.443	1.201	1.831	1.25
Water	53.66	19.83	9.00	702.31	0.361	0.216	0.563	0.617	1.895	3.075	1.62
Seeds+ Water	53.00	17.33	9.66	721.21	0.372	0.315	0.411	0.412	1.470	2.293	1.71
LSD 5%	5.973	1.41	1.98	54.7	0.193	0.318	0.241	0.477	0.227	0.627	0.249
2007											
Control	47.00	10.00	10.00	183.56	0.561	0.430	0.094	0.404	0.96	1.469	0.72
Seeds	64.00	17.00	13.33	547.27	0.717	0.558	0.109	0.697	1.40	2.206	0.87
Water	58.33	16.33	13.66	557.42	0.631	0.599	0.107	0.448	1.34	2.009	1.02
Seeds+ Water	62.00	15.66	13.33	583.38	0.944	0.739	0.142	0.774	1.56	2.480	1.06
LSD 5%	2.77	1.96	1.98	49.62	0.131	0.015	0.046	0.110	0.24	0.492	0.231

4. Water relations:

Data recoded in Table (4) indicate that the application of magnetic technologies (magnetized seeds, magnetized water and double of magnetized seeds and water) improved some leaf water relations i.e. total water content (%), free water (%), bound water (%), leaf water deficit, relative water content (%), leaf osmotic pressure c.s. (bar) and transpiration rate (mg / cm^2 . h) and membrane integrity (M.I.) (%) of tomato plants. Data presented in Table (4) indicate clearly that using magnetic technologies in tomato plants caused a slight increase in TWC. The percentage of free water was decreased with treating by the three magnetic treatments (magnetized seeds, magnetized water and double of magnetized seeds and water) in

tomato by about -48.4, -45 and -30.2%, respectively. A significant increase in the percentage bound water (BW) in the leaves of tomato plants by using magnetic technologies was noticed by about 13.9, 10.2 and 9.4 %, respectively comparing with their owing controls. The relative water content percentage was significantly increased by about 8.8, 4 and 18.7 %, as compared with the control plants. The leaf osmotic pressure significantly increased in tomato plants by treating with the magnetized seeds, magnetized water and double of magnetized seeds and water treatments as compared with the control plants. Transpiration rate was significantly decreased on tomato plants as the result of application of magnetic technologies. The reduction was about -1.9, -17.5 and -15.4 with magnetizing of seeds, magnetizing of water and double of magnetized seeds and water, respectively, as compared with the control plants (Table,). The membrane integrity percentage was increased by about 58.7, 54.4 and 55.9 %with treating plants with magnetized seeds, magnetized water and double of magnetized seeds and water, respectively, compared with the control plants in the first season (Table, 4). The results obtained in the second season were similar to those of the first one .

Table (4): Effect of magnetic treatments on water relations in leaves of tomato plants after 81 days from sowing during the growing seasons 2006 and 2007.

Characters / Magnetic Treatments	T. Water content (%)	Free water (%)	Bound water (%)	Leaf water def.(%)	Rel.water content (%)	Osmotic Pressure C.S.(bar)	Transpiration rate mg/cm2.h	M.I. %
2006								
Contr.	89.515	3.325	86.190	36.352	63.648	5.012	5.378	16.560
Seed	91.305	2.634	88.670	30.731	69.269	5.164	5.275	26.280
Water	90.833	2.848	87.985	33.786	66.214	5.991	4.436	25.562
Seed+Water	90.105	1.584	88.521	24.436	75.564	5.477	4.552	25.819
LSD 5%	2.355	0.424	1.606	1.973	1.887	0.129	0.795	0.697
2007								
Contr.	90.350	3.219	87.131	39.180	60.820	5.406	7.845	19.657
Seed	90.673	2.741	87.932	33.006	66.994	5.510	3.990	29.395
Water	90.428	1.195	89.234	33.667	66.333	5.685	5.767	30.005
Seed+Water	90.734	1.162	89.572	26.450	73.550	5.825	5.259	24.276
LSD 5%	NS	0.356	0.622	0.273	0.217	0.180	0.251	0.360

The previous mentioned results are in accordance with those reported by Rokhinson and Baskin (1996) who found that when passing water through non homogeneous magnetic fields change the natural water properties and improves the moisture supply of plant. Bondarenko *et al.*, (1996) found that seed treated magnetically showed that the plant cell membranes become

more permeable, the amount of free water in the seeds was increased. Garcia-Reina and Arza-Pascual (2001) found that treated water with magnetic field causes alternations in the osmotic pressure and in the capacity of the cellular tissues to absorb water. Also, the increase in water uptake rate due to the applied magnetic field were observed.

5. Photosynthetic Pigments

Data presented in Tables (5) indicate that the concentrations of photosynthetic pigments i.e. chlorophyll a, b, total chl. (a+b) and carotenoids showed generally, a significant increase when the tomato plants treated with the three magnetic treatments if compared with the untreated control plants in both seasons. The obtained results are confirmed with those reported by Bogoescu *et al.,* (2000) on cabbages plants, Atak *et al.,* (2003) on soybean plants, who found a significant increase in concentrations of photosynthetic pigments as a result of treating plants with magnetic technologies.

The increase in the concentration of chlorophyll pigments due the magnetic treatments may be attributed to the increase in GA_3 content in plants as shown from our results in Table (8), which led to increase in the green pigments in the treated plats by stimulating the production of chlorophyll in leaves (Bethke and Drew, 1992; Wasfy, 1995).

Table (5): Effect of magnetic treatments on the concentrations of photosynthetic pigments in the leaves of tomato plants after 81 days from sowing during the growing seasons 2006 and 2007.

Characters / Magnetic Treatments	Chl.a	Chl.b	Total Chl.a+b	Caroten.
	mg/g dwt.			
2006				
Contr.	2.403	1.481	3.884	2.653
Seed	5.083	2.696	7.780	5.563
Water	4.901	3.567	8.468	5.473
Seed+Water	3.256	1.636	4.892	3.529
LSD 5%	0.282	0.096	0.120	0.519
2007				
Contr.	4.130	2.280	6.410	4.668
Seed	5.180	3.330	8.510	6.562
Water	8.778	4.906	13.684	9.778
Seed+Water	5.711	3.593	9.303	6.420
LSD 5%	0.190	0.196	0.162	0.498

6. Chemical constituents

Carbohydrates: Data concerning the effect of different magnetic treatments (magnetized seeds, magnetized water and double of magnetized water and seeds) on soluble, non soluble and total sugars concentration in leaves of tomato plants were presented in Table (6) . There was a significant increase in the total sugars concentrations in leaves of tomato plants as compared with the untreated plants. The previous mentioned results are in general accordance with those reported by many researchers, Harari and Lin (1989) on muskmelons plants, Bogoescu *et al.,* (2000) on cabbages plants, who observed that the magnetic treatments led to a significant increase in some biochemical aspects such as soluble sugars, non soluble and total sugars concentration.

Table (6): Effect of magnetic treatments on chemical constituents in leaves of tomato plants after 81 days from sowing during the growing season 2006.

Characters / Magnetic Treatments	Carbohydrates			Amino Acids (mg/g dwt.)	Enzymes	
	Soluble	Non Soluble	Total		Phenoloxidase OD/g fwt.	Peroxidase OD/g fwt.
	(mg/g dwt.)					
Contr.	14.500	110.250	124.750	40.090	0.433	0.225
Seed	29.688	113.125	142.813	44.010	0.523	0.269
Water	35.325	163.269	198.594	43.335	0.506	0.232
Seed+Water	38.438	172.188	210.625	46.305	0.847	0.257

Amino acids: Results given in Table (6) indicate clearly that the application of magnetic technologies (magnetized seeds, magnetized water and double of magnetized seeds and water) resulted in a significant increase in amino acids concentration in the leaves of tomato plants if compared with the untreated control plants. Savin *et al.,* (1987) postulated that the treatment of sour cherry softwood cutting with water exposed to a magnetic field accelerated metabolic processes.

Enzymes activity: The obtained results recorded in Table (6) indicate that, the enzyme activity of both phenoloxidase and peroxidase in the leaves of tomato plants was increased by treating with the magnetic technologies when compared with the control plants.. These results are agreement with the results reported by Xiao-ju and Guo (1999) who found that an increase in the activity of the catalase and peroxidase in magnetically treated tomato seeds.

7.Mineral uptake:

a.Macro-elements:

Nitrogen (N): Data concerning the effect of magnetic technologies on the N uptake in root, stem and leaves of tomato plants were recorded in Table (7) showed that in general there was a significant increase in N uptake comparing with the control plants by all the three treatments. In roots, the increase was more pronounced at the double magnetized seeds and water treatment and it was about 76.5, in stem was 259.7% by treating with magnetized water and in leaves, the best one was noticed by the magnetized water treatment compared with the other treatments and this increase was about 205.8 % over the control plants. In this concern, these results go hand in hand with the results of Durate-Diaz *et al.*, (1997) who found that irrigation with magnetically treated water increased nutrient uptake. Monedero *et al.*, (2002b) found that irrigation potato with magnetic water and N increased soil nutrient availability, N uptake. Saadallah and Wa (2006) indicated that the magnetizing of water (river water and drainage water) increased the concentration of N in flag leaves of corn (*Zea mays L).*

Phosphorus (P): The obtained results in Tables (7) indicate that the uptake of P in root, stem and leaves of tomato plants was greatly affected by magnetic technologies In the root, the best treatment was observed by the double of magnetized seeds and water if comparing with the different treatments. In stem and leaves we can said that, the best treatment in increasing the uptake of (P) was the magnetizing water. These results are in conformity with those reported by Roberts (1995) who mentioned that the markers of polar magnetic treatment improves nutrient uptake. Hilal *et al .,* (2002) found that the leaves content of P was tripled increased by irrigation citrus with magnetic water treated by magnetron. Durate-Diaz *et al.*, (1997) found that irrigation with magnetically treated water increased nutrient uptake.

Potassium (K): Data illustrated in Table (7) show that treating with a magnetized seeds, magnetized water and double of magnetized seeds and water generally increased the K uptake in root, stem and leaves of tomato plants if compared with the control plants. The results revealed that the best uptake in roots occurred by the double of magnetized seeds and water treatment, in stem by magnetized water and in leaves by magnetized water compared with the control plants. The obtained results are in harmony with those demonstrated by Tian *et al.*, (1989), Roberts (1995) and Durate-Diaz *et al.*, (1997) who found that irrigation with magnetically treated water increased nutrient uptake. Also, Hilal *et al .,* (2002) found that the citrus leaves content of K was considerably increased by irrigation citrus with magnetic water treated by magnetron.

b.Micro-elements (Fe, Zn and Mn):

Data presented in Table (7) show that there was a marked increase in the uptake of Fe, Zn and Mn in different tomato plant organs by using all magnetic technologies . The highest values of the Fe-, Zn- and Mn- uptake in roots, stem and leaves were genrally observed by the treatment of the magnetized water and seeds. The obtained results are in agreement with those reported by Hilal *et al* ., (2002) found that irrigation citrus with magnetic water treated by magnetron showed maximum increase in Mn content of leaves, followed by Zn while that of Fe was the least affected.

The enhancing in the concentration and uptake of N, P, K, Fe, Zn, and Mn in roots, stem and leaves of tomato plants treated with magnetizing of seeds, magnetizing of water and the double magnetizing of seeds and water may be attributed to the enhancing effect of magnetic system on the absorption of essential elements specially the iron (Fe^{++}), magnesium (Mg^{++}) and nitrogen (NH_4^+) cations, that are necessary for enzymes activation and formation of chloroplasts and chlorophyll (Hassouna, MG. and Madkour, A.M., 1991; Takachenko, 1995 and Hellal, 1998).

Table (7): Effect of magnetic treatments on the uptake of the N, P and K elements(mg/plant) and Fe, Zn and Mn (µg/plant) in the roots, stem and leaves of tomato plants during the growing 2006.

Characters / Magnetic Treatments	N	P	K	Fe	Zn	Mn
Roots						
Contr.	3.934	0.561	1.200	15.93	4.5	3.8
Seed	5.357	0.772	1.431	20.77	5.9	5.1
Water	4.622	0.770	1.381	25.14	5.5	4.9
Seed+Water	6.942	1.104	1.985	29.94	7.6	5.5
Stem						
Contr.	22.736	3.338	6.651	84.0	25.2	20.0
Seed	34.153	5.293	10.661	167.4	34.4	54.5
Water	53.445	6.533	18.289	92.8	41.6	27.0
Seed+Water	43.363	5.880	11.189	130.6	37.7	76.0
Leaves						
Contr.	33.647	8.506	11.925	284.5	44.5	40.8
Seed	78.400	15.415	22.002	567.67	79.2	58.0
Water	102.879	19.310	25.663	337.15	61.7	48.4
Seed+Water	87.603	15.554	21.955	864.3	79.8	120.4

8.Endogenous Phytohormones

The effect of magnetic technologies (magnetized seeds, magnetized water and double of magnetized seeds and water) on the concentration of endogenous phytohormones such as GA_3, IAA, Zeatin, Kinetin, Benzyladenin and ABA, in tomato leaves are recorded in Table (8) .

Gibberellic acid (GA_3): With regard to the concentration of GA_3 in tomato plants, it can be noticed that, there was a significant increase in the concentration of GA_3 in leaves of tomato plants as a result of the application of magnetic technologies (magnetized seeds, magnetized water and double of magnetized seeds and water.

Indole acetic acid (IAA): Data in Table (8) indicate clearly that the treatments of magnetic technologies (magnetized seeds, magnetized water and double of magnetized seeds and water) showed a significant increase in the concentration of IAA in leaves of tomato plants as compared to the untreated control plants . The increase in IAA for tomato plants treated with magnetized water, magnetized seeds and double of magnetized seeds and water was about 63.9, 108.3 and 83.4%, respectively as compared with the untreated control plants. Data showed that the best treatment was observed in magnetized water treatment as compared with the other treatments.

Zeatin: Data illustrated in Table (8) show that treating with a magnetic technologies (magnetized seeds, magnetized water and double of magnetized seeds and water) generally increased the concentration of zeatin in leaves of tomato plants compared with the control plants. From these results, we can noticed that the highest concentration of zeatin in leaves of tomato plants was recorded by treating with magnetic water. *Kinetin:* Concentration of kinetin in leaves of tomato plants was greatly affected by magnetic technologies (Table,). Results showed that the increases were about 220.2, 298.5 and 50.7 % by treating with magnetized seeds, magnetized water and double of magnetized seeds and water, respectively compared to the control plants.

Benzyladenine (BA): Results in Table (8) demonstrate clearly that the concentration of benzyladenine (BA) in leaves of tomato plants showed a marked increase by treating with magnetic treatments as comparing to the untreated control plants and the best one was by treating with double of magnetized seeds and water followed by magnetizing of water.

Abscisic acid (ABA): Data recorded in Table (8) show that the concentration of ABA in leaves of tomato plants was decreased at the three magnetic treatments (magnetized seeds, magnetized water and double of magnetized seeds and water) comparing with control plants by about -68.9, -81.6 and -78.5 %. respectively. As shown from the result the treatment of double magnetizing seed and water was more effective in decreasing the ABA, followed by the magnetizing of water then the magnetizing of seeds. The obtained results are in agreement with those obtained by Xia and Guo (2000) who observed that magnetic treatments could increase the auxin content of tomato plants .

Table (8): Effect of magnetic treatments on the concentrations of plant phytohormones in leaves of tomato plants at 80 days from sowing during the two growing season 2006.

Characters / Magnetic Treatments	Gibberellic acid (GA_3)	Indole acetic acid (IAA)	Zeatin	Kinetin	Benzyladenine	Abscisic acid (ABA)
	mg / 100 g FW		µg / 100 g FW			
Contr.	25.757	5.54	22.897	122.09	31.98	122.24
Seed	39.656	9.08	113.49	390.98	64.01	37.956
Water	43.213	11.54	133.89	486.49	140.84	22.519
Seed+Water	62.992	10.16	65.392	184.97	193.0	26.047

9. Yield and its attributes:

Yield : Data presented in Table (9) show clearly that using magnetic technologies in tomato plant resulted in a significantly increase in the fruit number and weightas well as fruit yield compared with the control plants. The results showed that the maximum increase was observed by treating with magnetized water and double of magnetized seeds and water.

Titratable acidity (%): As for noticed from the Table (9) that, percentage of titratable acidity of tomato plants was decreased with treating by the three magnetic treatments (magnetized seeds, magnetized water and double of magnetized seeds and water) at the first season and the reduction was about -42.2, -15.6 and -15.6 %, respectively if compared to the control plants. From these results we can be said that the lowest value was observed in magnetizing of seeds treatment compared with the other treatments. In the second season, the obtained results confirmed with those of the first one.

Vitamin C and TSS : Data recorded in Table (9) show that the vitamin C and TSS of tomato fruits were increased at the almost of three magnetic treatments (magnetized seeds, magnetized water and double of magnetized seeds and water) comparing with control plants in both seasons, at the first season the increases in vitamin C were about 16.7, 33.3 and 33.3 %, respectively over the control plants but in the second one were about 16.7, 50 and 33.3 %, respectively.

Carbohydrates: The experimental results in Table (10) indicate that a marked increase in soluble and non soluble carbohydrates concentrations in tomato fruits by treating with magnetized seeds, magnetized water and double magnetized seeds and water was recorded compared with control plants. The highest values was recorded by magnetizing of water treatment.. Also there was a significant increase in the total carbohydrates in tomato fruits as compared with the untreated plants .

Table (9): Effect of magnetic treatments on yield attributes of tomato plants during the two growing seasons 2006 and 2007.

Characters / Magnetic Treatments	Fruit Weight (gm)	No. Fruits per plant	Fruit yield/ plant (gm)	Fruit yield/ m2 (gm)	Straw yield (g/plant)	Titratable acidity (%)	Vit.C (mg ascorbic acid/100g fwt.)	T.S.S (%)
2006								
Contr.	8.231	30	246.938	3495.227	7.750	0.045	36.036	5.6
Seed	12.584	50	629.203	8905.922	10.036	0.026	42.042	6.6
Water	12.611	57	718.836	10174.611	11.041	0.038	48.048	7.0
Seed+Water	10.239	44	450.531	6376.938	11.616	0.038	48.048	6.8
LSD 5%	1.421	6.59	11.904	79.502	1.933	0.014	0.747	0.815
2007								
Contr.	7.982	8	63.853	903.789	4.783	0.083	36.036	5.2
Seed	9.442	20	188.842	2672.929	5.761	0.064	42.042	6.4
Water	14.141	24	339.372	4803.567	6.710	0.051	54.054	7.4
Seed+Water	14.388	25	359.705	5091.366	6.959	0.077	48.048	6.6
LSD 5%	1.685	5.60	10.284	55.039	0.912	0.016	0.659	0.595

Table (10): Effect of magnetic treatments on some chemical constituents in tomato fruits during the growing season 2006.

Characters / Magnetic treatments	Total Carbohydrates (mg/g dwt.)	Amino acids (mg/g dwt.)	Macro-elements (%) N	P	K	Micro-elements (ppm) Fe	Zn	Mn
Contr.	175.695	27.540	1.40	0.615	1.84	191.2	24.0	126
Seed	198.125	31.590	1.65	0.623	1.88	366.0	26.5	137
Water	216.563	37.800	1.68	0.761	1.92	486.2	59.7	181
Seed+Water	195.000	31.860	1.45	0.695	1.97	379.8	37.5	170

Amino acids: It is found from the obtained results in Table (10) that, the total free amino acids concentration in tomato fruits were greatly affected by magnetic technologies. The best treatment in increasing the concentration of amino acids was the magnetizing water comparing with the different treatments.

Concentration of macro and micro-elements: The obtained results recorded in Table (10) indicate that, in general the concentration of N, P, K, Fe, Zn and Mn in tomato fruits was increased as the result of the application of nagnetic technologies at almost of three treatments. The results showed

that the values of increasing were more clear by treating with magnetized water for N, P, Fe, Zn and Mn, whereas by double of magnetized seeds and water for K .

It is evident from the previous results that the effect of the magnetized water treatment was the greatly and the best treatment on the characters on yield quantity and quality of tomato plants followed by double of magnetized seeds and water treatment at both seasons. Similar findings have been previously reported by Kuderev *et al.,* (1997) who found that water and nutrient solutions after magnetic treatments caused an increase in the yields of maize, sunflower, soya, tomatoes and cucumbers. Also, the obtained results are in accordance with those by Bondarenko *et al.,* (1996), Durate-Diaz *et al.*, (1997) on tomato plants, Makhmoudov (1998) on cotton plants, Hilal *et al .*, (2002) on citrus plants, Monedero *et al.,* (2002a) on potato plants, Wachowiak and Kierzek (2002) and Saadallah and Wa (2006) on corn plant (*Zea mays L),* who found that the yields and its quality of many crops increases by treatments irrigated with magnetic treated water were higher than in the other treatments. Bogoescu *et al.,* (2000) found that irrigation of cabbages with magnetic treated water led to a significant increase in yield, marketable quality and some biochemical and histological quality indicators of yield. DeSouza *et al.,* (2005) found that by exposed seed of tomatoes c.v.Vyta to a dynamic magnetic field led to significant increases in the number of fruits, mean fruits weight, fruit yield per plant and fruit yield per area . DeSouza *et al.,* (2006) found that pre-sowing magnetic treatments of tomato seeds led to a significant increase in relative growth rates of fruits, the mean fruit weight, the fruit yield per plant, the fruit yield per area, the equatorial diameter of fruits, total dry matter than those shown by the control plants.

From the above mentioned results, it could be noticed that the enhancement in yield of tomato plants derived from magnetically treated seeds and treated water may be attributed to an energetic excitement of one or more parameters of the cellular substratum (proteins and carbohydrates) or water inside the dry seeds and when passing water through a magnetic fields change the natural water properties and improves the moisture supply of plant (Rokhinson and Baskin, 1996), also the plant cell membranes become more permeable, the amount of free water in the seeds was increased in the seed treated magnetically (Bondarenko *et al.,* 1996) by the direct effect of magnetic treatment. Once the magnetically exposed seeds acquire water, the activation and production process of enzymes and hormones and the level of seed-store auxin could be enhanced as a result of the initial stimulation, leading to an improvement of the seed germination, vegetative growth, and yield as shown in our previous results (De Souza *et al.*, 1999, 2005).

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استجابة نباتات الطماطم لتقنيات المغنطة

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الملخص العربي

أجريت تجارب معملية وأخرى في الصوبة الزجاجية بكلية الزراعة بشبين الكوم – جامعة المنوفية خلال موسمي ٢٠٠٦و ٢٠٠٧ لدراسة تأثير معاملات المغنطة وهي (بذور ممغنطة – الري بماء ممغنط – بذور ممغنطة + ري بماء ممغنط معاً) بجانب الكنترول (بذور غير ممغنطة + ري بماء عادي) على الإنبات و بعض صفات النمو الخضري و العلاقات المائية و بعض الصفات الفسيولوجية والبيوكيميائية و كذلك بعض صفات محصول لنباتات الطماطم وكانت أهم النتائج:

- أدت معاملات المغنطة المختلفة إلى زيادة معنوية في نسبة وسرعة ومدلول لبذور الطماطم إذا ما قورنت ببذور المقارنة وسجلت معاملة الري بالماء الممغنط أعلى نسبة وسرعة إنبات بينما سجلت معاملة البذور الممغنطة + الري بالماء الممغنط أعلى مدلول إنبات. كما أظهرت البذور المعاملة بمعاملات المغنطة المختلفة متوسط طول فترة إنبات أقصر عن بذور المقارنة وسجلت البذور التي رويت بماء ممغنط أقصر فترة إنبات.
- أوضحت النتائج أن معاملات المغنطة أدت إلى زيادة معنوية في صفات النمو الخضري والتي تتمثل في طول الجذر و إرتفاع النبات و عدد و مساحة الأوراق ومعدل النمو النسبي ومعدل صافي التمثيل و الوزن الجاف لجذر وساق و أوراق نبات الطماطم إذا ما قورنت بنباتات المقارنة وسجلت المعاملة بالري بالماء الممغنط أعلى زيادة في معظم صفات النمو في نبات الطماطم.
- أدت معاملات المغنطة المختلفة إلى زيادة معنوية في محتوى الماء الكلي و النسبي و الماء المرتبط و الضغط الإسموزي في العصير الخلوي و نفاذية الأغشية لأوراق نبات الطماطم بينما إنخفض معنويا كلاً من نقص الماء الورقي ومعدل النتح في النبات. كما أدى استخدام معاملات المغنطة إلى زيادة معنوية في كفاءة استخدام الماء لإنتاج المادة الجافة في الطماطم وأعطت معاملة البذور الممغنطة + الري بالماء الممغنط معا الكفاءة الأعلى في إنتاج المادة الجافة .

- إزداد تركيز صبغات البناء الضوئي (كلوروفيل أ , كلوروفيل ب , الكلورورفيل الكلي , الكاروتنويدات) في أوراق نبات الطماطم المعاملة بمعاملات المغنطة المختلفة عند مقارنتها بالنباتات .
- سببت معاملات المغنطة زيادة فى تركيز الكربوهيدرات والأحماض الأمينية كما ازداد نشاط إنزيمات الفينول أوكسيديز و البيروكسيديز في أوراق نباتات الطماطم مقارنة بنباتات الكنترول وكانت الزيادة أكثر وضوحاً باستخدام معاملة البذورالممغنطة +الري بماء ممغنط معاً ويليها معاملة الري بالماء الممغنط .
- سجلت زيادة ملحوظة في امتصاص العناصر الكبرى (النيتروجين , الفسفور , البوتاسيوم) في جذر وساق و أوراق نباتات الطماطم عندما عوملت بمعاملات المغنطة المختلفة مقارنة بنباتات الكنترول وكانت أفضل المعاملات الري بالماء الممغنط, كما أدت هذه المعاملات إلى زيادة امتصاص العناصر الصغرى (الحديد , الزنك , المنجنيز) في الجذر والساق و الأوراق لنباتات الطماطم مقارنة بنباتات الكنترول.
- استخدام معاملات المغنطة أدت إلى زيادة معنوية في تركيز الهرمونات النباتية (حمض الجبريلليك, حمض الإندول أسيتك, الزياتين, الكينتين, البنزيل أدينين) في أوراق نباتات الطماطم بينما أدت إلى نقص تركيز حمض الأبسسيسك, و كانت معاملة البذور الممغنطة +الري بماء ممغنط معاً أكثر تأثيراً على زيادة تركيز حمض الجبريلليك و البنزيل أدينين بينما معاملة الري بالماء الممغنط أكثر تأثيراً على زيادة تركيز حمض الإندول أسيتك و الزياتين و الكينتين كما أدت هذه المعاملة إلى نقص ملحوظ في تركيز حمض الأبسسيسك مقارنة بمعاملات المغنطة الأخرى.
- ازداد معنويا وزن الثمار, عدد الثمار, محصول الثمار, محصول القش لنباتات الطماطم باستخدام معاملات المغنطة مقارنة بنباتات الكنترول وكانت أكثر المعاملات تأثيرا الري بالماء الممغنط, كما أدت هذه المعاملات إلى تحسين الصفات الكيماوية المتمثلة فى نسبة الحموضة الكلية, فيتامين ج, نسبة المواد الذائبة الكلية, تركيز العناصر الكبرى (النيتروجين , الفسفور , البوتاسيوم), تركيز العناصر الصغرى (الحديد , الزنك , المنجنيز), الكربوهيدرات, الأحماض الأمينية مقارنة بنباتات الكنترول وكانت أفضل معاملة هي الري بالماء الممغنط .

* ويمكن التوصية باستخدام معاملة البذور الممغنطة على مستوى المساحات الصغيرة الموجودة في القرى و استخدام الماء الممغنط على مستوى المساحات الكبيرة و الأراضي الجديدة والمشاريع الضخمة لما لهذه المعاملات من تأثيرات على زيادة معنوية عالية للنمو وإنتاجية المحاصيل.