J. Plant Production, Mansoura Univ., Vol. 8(11): 1127 - 1133, 2017

Response of Tomato Plants to Irrigation with Magnetized Water and some Foliar Application Treatments under Drip Irrigation System: 1-Vegetative Growth and Chemical Constituents of Leaves.

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ABSTRACT

This experiment was conducted in summer seasons of 2016 and 2017 on tomato plants "6112" hybrid to evaluate tomato plants performance (vegetative growth characteristics and chemical constituents of leaves) in response to irrigation water treatments (magnetized and non-magnetized), foliar applications (chitosan, lithovit, selenium and yeast extract) and their interactions. Results indicated that the highest values of vegetative growth characteristics, *i.e.,* plant height, number of branches, number of leaves, leaf area, fresh and dry weights as well as chemical constituents of leaves as photosynthetic pigments (Chl. a, Chl. b, total Chl. a+b and carotenoids) and leaf minerals content (N, P, K, Ca, Mg, Zn, Mn) were recorded when plants irrigated with magnetized water as compared with plants irrigated with untreated water in both studying seasons. On the other hand, Fe content responded negatively to irrigation with magnetized water.Comparing the effect of foliar applications, all foliar application treatments significantly enhanced vegetative growth parameters, leaf minerals and pigments contents compared to the check treatment. Foliar application of chitosan at 250 ppm is the superior in its effect on all the aforementioned characteristics followed by yeast extract at 10 g/L then lithovit at 1.5 g/L in the two seasons except for Fe content. The best results of both vegetative growth attributes and chemical constituents of leaves were recorded when plants irrigated with magnetized water and sprayed with chitosan at 250 ppm in both seasons. Thus, this treatment could be recommended to improve tomato plants performance under similar conditions of this study.

Keywords: tomato plants, foliar application, chitosan, lithovit, selenium, yeast extract, vegetative growth, chemical composition.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill), belongs to the family Solanaceae. Most of fruits are sold fresh, but large amounts are also processed. Fruits are used as a fresh salad vegetable, in stews, sauces, soups and other various dishes. Tomato fruits are consumed like a functional food all over the world due to the health promoting compounds and the different antioxidant molecules such as carotenoids, ascorbic acid, vitamin E and polyphenol compounds such as flavonoids. Tomatoes also contain minerals such as calcium, magnesium, iron and potassium, as well as microelements such a copper, zinc and manganese in addition to selenium.

There are previous studies indicated that magnetic treatment of irrigation water offers many benefits in agriculture such as enhancing vegetative growth, increasing yield, early maturity of crops, improving crop quality, increasing fertilizers efficiency and reducing cost of farm operations (Maheshwari and Grewal, 2009).

Using bio stimulants (chitosan and yeast extract) to promote plant growth has recently gained increasing attention worldwide. Chitosan a co-polymer of N-acetyl-d-glucosamine and d-glucosamine, formed from chitin, and applied in horticulture as a bio stimulant to induce pathogen resistance, enhance plant growth and abiotic stress tolerance and to. some researchers reported that chitosan enhanced plants performance, thereby increasing key enzymes activities of nitrogen metabolism (nitrate reductase, glutamine synthetase) and improving transportation of nitrogen (N) in leaves which in turn enhanced plant growth and development (Chibu and Shibayama, 2003).

Selenium is a trace element essential for both animals and plants, but is toxic at higher concentrations. Selenium content in soils varies considerably, and its availability in agricultural soils is usually low, therefore, Se is often used in fertilizers for crops. Several researchers have described the effect of Se application on vegetable crops (Abul-Soud and Abd Elrahman, 2016; Andrejiova *et al.,* 2016 and Santos-Vázquez *et al.*, 2016) and showed positive effects on antioxidant activity, productivity and yield.

Yeast extract is the natural compound contains many compounds as proteins and cytokinins that enhance cell enlargement and cell division which are safe and non-pollutant. Also, it contains haloes-6-phosphate synthase which affects plant development (Amer, 2004).

Nanotechnology opens a large scope of novel application in the fields of agricultural industries and biotechnology, because nanoparticles have unique physicochemical properties as, high reactivity, high surface area, particle morphology and tunable pore size. Lithovit is a natural CO_2 nano fertilizer contains organic calcite carbonate from natural limestone deposits, suitable and recommended for use in organic farming in the European Community, harmless to humans and animals and not hazardous to water (Bilal, 2010).

This study was carried out to evaluate possible effects of irrigation with magnetized water and some foliar applications on plant growth as well as chemical composition of leaves of tomato plants.

MATERIALS AND METHODS

Theis experiment was conducted in the two successive summer seasons of 2016 and 2017 on tomato plants "6112" hybride at a private farm at Sahragt El-Soghra near Mansoura, Dakahlia Governorate, Egypt to evaluate tomato plants performance (vegetative characteristics and chemical constituents of leaves) in response to irrigation water treatments (magnetized and non-magnetized), foliar applications (chitosan, lithovit, selenium and yeast extract) and their interactions.

The experiment layout was split plot system in a randomized complete block design with three replicates. The main plots were for irrigation water treatments, while foliar application treatments were distributed in the sub plots. The experimental unit area was 64 m^2 (2 drip lines × 20 m long × 1.6 m width). The seedlings were transplanted on one side of drip line at 50 cm apart.

The experiment included 18 treatments which were arranged as water irrigation treatments (Irrigation with magnetized and non-magnetized water) and nine

foliar application treatments; chitosan (250 and 500 ppm), Lithovit (1.5 and 2 g/L), selenium as Sodium Selenite (5 and 10 ppm), yeast extract (5 and 10 g/L) and the control treatment. All foliar spraying solutions were applied three times within 10 days intervals starting from 30 days after transplanting.

Seedlings of 45 days old were transplanted into open field in February (15^{th} and 5^{th} in the first and second season, respectively). During the two growing seasons preparation of the experimental soil, fertigation and pest control were applied as recommended by Egyptian Ministry of Agriculture and land reclamation.

Data recorded

Microbiological status:

It was evaluated in both soil irrigated with magnetized and untreated water in the second season after 98 days from transplanting according to the method described by Seeley and Van Demark (1981) and shown in Table 1.

Soil status:

Some soil properties were determined in both soil irrigated with magnetized and untreated water in the second season after 103 days from transplanting and shown in Table 2.

Table 1. Types and names of some bacteria presented in the experimental soil.

Sample type	Bacteria	Population
Irrigation with non - magnetized water	*E. coli* *Bacillus sp.*	1×10^5 cells/g dry soil
Irrigation with magnetized water	*E. coli* *Bacillus sp.* *Enterobacter sp.* *Klebsiella sp.*	2×10^6 cells/g dry soil

Table 2. Some soil properties of the experimental soil during the second season:

No.	H.W	pH	EC	Anions(meq/L)		Cations (meq/L)			
			dSm^{-1}	HCO^{-3}	$SO4^{-2}$	K^{+1}	Na^{+1}	Ca^{+2}	Mg^{+2}
1	6.181	8.34	2.87	1.359	21.101	.315	12.80	11.11	8.689
2	6.231	8.52	1.78	1.456	12.184	.197	8.542	6.130	4.130

1: soil irrigated with untreated water.
2: soil irrigated with magnetized water.

Vegetative growth parameters:

Three plants were randomly taken from each treatment after 75 days from transplanting in the two seasons for measuring growth characters of tomato plants as plant height, number of branches/plant, number of leaves/plant, total leaf area /plant according to Koller (1972), fresh and dry weights.

Chemical constituents of leaves:

All studied chemical constituents parameters in tomato leaves were determined at 75 days after transplanting during both seasons. Chlorophylls a, b, total chlorophyll and carotenoids were determined according to the methods described by Wettstein (1957). In addition, nitrogen was determined according to piper (1947). Phosphorus was determined according to the method of Sandell (1950). Potassium was determined by the method described by Horneck and Hanson (1998). Calcium and magnesium were determined according to Jackson (1967). Iron, zinc and manganese were determined according to AOAC (1990).

Statistical analysis:

The obtained results were subjected to statistical analysis of variance according to Snedecor and Cochran (1967). The treatment means were compared using LSD test as described by Gomez and Gomez (1984).

RESULTS

Vegetative growth parameters

Effects of magnetic treatment of irrigation water:

Data presented in Table 3 show growth performance of tomato plants in response to irrigation with magnetized and non-magnetized water in the two seasons of study. The obtained results show that growth attributes like plant height, number of branches and leaves, fresh and dry weights as well as total leaf area differed significantly due to irrigation water treatments. Plants irrigated with magnetized water significantly recorded the highest values of all the aforementioned characteristics in both growing seasons as compared with those irrigated with untreated water.

Effects of foliar applications:

Comparing the effect of foliar application treatments (chitosan, lithovit, yeast extract and selenium) on vegetative growth characteristics of tomato plants, it was found that all vegetative growth parameters increased in response to foliar application treatments in the two growing seasons as compared to the check treatment (sprayed with tap water). Data in Table 3 clearly indicate that higher significant values of all studied parameters were recorded with spraying chitosan at 250 ppm followed by spraying yeast extract at 10 g/L in both seasons. Foliar application of lithovit at 1.5 g/L came in the third order followed by other foliar application treatments. The control plants recorded the lowest values of all studied vegetative parameters in both seasons.

Effect of interaction between irrigation water treatments and foliar applications:

Data in Table 3 show that plant height, number of branches and leaves, fresh and dry weights and leaf area per plant significantly affected by the interaction between irrigation water and foliar application treatments (chitosan, lithovit, selenium and yeast extract) in the two growing seasons. Higher values of all the aforementioned characters were recorded by plants irrigated with magnetized water and sprayed with all foliar application treatments. Foliar application of chitosan at 250 ppm came in the first order followed by yeast extract at 10 g/L then lithovit at 1.5 g/L. On the other hand, the less values were recorded when plants irrigated with non-magnetized water and sprayed with tap water in the two growing seasons.

Chemical constituents of leaves

Effects of magnetic treatment of irrigation water:

Data presented in Tables 4 and 5 show the impact of irrigation with magnetized and non-magnetized water on leaf minerals content (N, P, K, Ca, Mg, Fe, Zn and Mn) and pigments (Chl. a, Chl. b, total chlorophyll and carotenoids) of tomato leaves. It was noticed higher significant values of all mentioned parameters were obtained by irrigation with magnetized water except for Fe in both seasons compared to irrigation with untreated water. Fe content recorded the highest values when plants irrigated with non-magnetized water in both seasons.

Table 3. Vegetative growth characteristics of tomato plants as affected by irrigation water treatments and foliar applications during summer seasons of 2016 and 2017 after 75 days from transplanting.

Treatments			Plant height(cm)		No. of leaves/plant		No. of branches /plant	
			2016	2017	2016	2017	2016	2017
A) Irrigation water treatments:								
Magnetized			64.7	72.8	88.2	93.4	14.6	16.5
Non-magnetized			49.0	56.9	63.2	68.4	10.3	12.2
F. test			*	*	*	*	*	*
B) Foliar applications:								
Chitosan		250 ppm	66.4	76.0	89.5	97.7	15.9	18.1
		500 ppm	53.5	61.4	75.1	80.3	12.1	14.4
Lithovit		1.5 g	62.1	70.0	79.8	87.9	13.0	14.9
		2 g	55.0	62.9	77.1	82.3	11.2	13.1
Selenium		5 ppm	55.0	62.9	76.4	81.6	12.2	14.1
		10 ppm	59.9	67.8	78.7	79.0	11.5	13.1
Yeast extract		5 g	50.0	57.8	64.3	69.5	11.0	12.9
		10 g	64.3	72.1	83.8	88.5	15.6	16.7
Control			45.7	53.0	56.5	61.3	9.7	11.6
L.S.D. at 5 %			2.1	2.3	4.6	4.3	0.5	0.6
Interaction between irrigation water treatments and foliar applications (A×B):								
Magnetized	Chitosan	250 ppm	80	91.2	106.4	115.0	20.2	22.8
		500 ppm	58.3	66.2	84.3	89.5	13.7	15.6
	Lithovit	1.5 g	71.4	79.3	94.1	98.8	15.2	17.1
		2 g	57.4	65.3	91.7	96.9	12.2	14.1
	Selenium	5 ppm	59.0	66.9	81.9	87.1	14.4	16.3
		10 ppm	69.3	77.2	84.1	89.3	12.2	13.5
	Yeast extract	5 g	55.8	63.6	78.8	84.0	12.6	14.5
		10 g	75.9	83.6	95.9	99.3	19.8	21.0
	Control		55.7	62.4	76.2	80.7	11.6	13.5
Non-magnetized	Chitosan	250 ppm	52.9	60.8	72.5	80.4	11.6	13.5
		500 ppm	48.7	56.6	65.9	71.1	10.5	12.4
	Lithovit	1.5 g	52.8	60.7	71.8	77.0	10.8	12.7
		2 g	52.7	60.6	62.5	67.7	10.2	12.1
	Selenium	5 ppm	51.0	58.9	70.9	76.1	10.1	12.0
		10 ppm	50.5	58.4	63.4	68.6	10.8	12.7
	Yeast extract	5 g	44.2	52.1	49.8	55.0	9.5	11.4
		10 g	52.7	60.6	75.5	77.7	11.3	13.2
	Control		35.8	43.7	36.8	42.0	7.8	9.7
L.S.D. at 5 %			2.9	3.3	6.5	6.2	0.7	0.8

Treatments			Fresh weight (gm/plant)		Dry weight (gm/plant) af area (m^2/plant)			
			2016	2017	2016	2017	2016	2017
A) Irrigation water treatments:								
Magnetized			817.9	868.1	90.1	95.1	22.82	24.95
Non-magnetized			456.6	507.2	53.8	58.8	10.82	13.62
F. test			*	*	*	*	*	*
B) Foliar applications:								
Chitosan		250 ppm	766.3	825.2	90.3	96.8	25.03	26.64
		500 ppm	619.0	669.5	65.9	72.9	16.93	19.21
Lithovit		1.5 g	660.8	711.4	81.6	86.6	19.53	20.98
		2 g	599.0	660.6	69.4	74.4	14.68	16.63
Selenium		5 ppm	625.4	676.0	69.2	74.2	12.64	14.92
		10 ppm	608.7	646.0	67.3	69.9	16.72	19.33
Yeast extract		5 g	631.5	682.0	69.6	74.2	12.79	19.07
		10 g	695.5	746.0	82.7	87.0	20.94	23.22
Control			529.1	572.1	51.6	56.5	12.13	13.57
L.S.D. at 5 %			19.9	19.1	1.2	1.3	1.09	0.99
Interaction between irrigation water treatments and foliar applications (A ×B):								
Magnetized	Chitosan	250 ppm	982.3	1049.6	118.1	124.8	35.55	36.49
		500 ppm	806.8	857.4	85.5	94.6	23.42	25.70
	Lithovit	1.5 g	821.0	871.5	102.0	107.0	26.35	28.63
		2 g	818.6	869.1	78.8	83.7	16.74	18.35
	Selenium	5 ppm	776.0	826.5	80.8	85.8	16.11	18.39
		10 ppm	816.3	856.9	89.7	89.8	25.04	27.99
	Yeast extract	5 g	784.4	834.9	82.1	86.4	18.61	20.89
		10 g	882.4	933.0	101.6	106.6	28.40	30.63
	Control		673.6	714.1	72.6	77.6	15.14	17.42
Non-magnetized	Chitosan	250 ppm	550.2	600.8	63.8	68.8	14.51	16.79
		500 ppm	431.1	481.7	46.3	51.3	10.43	12.71
	Lithovit	1.5 g	500.7	551.2	61.2	66.2	12.72	13.33
		2 g	379.4	452.0	60.0	65.0	12.63	14.91
	Selenium	5 ppm	474.9	525.5	57.7	62.7	9.17	11.45
		10 ppm	401.4	435.2	45.0	49.9	8.40	10.68
	Yeast extract	5 g	478.5	529.1	57.1	62.1	9.11	17.25
		10 g	508.5	559.1	62.4	67.4	13.48	15.79
	Control		384.6	430.0	30.5	35.5	6.97	9.73
L.S.D. at 5 %			28.2	27.2	1.6	1.9	1.54	1.40

Table 4. Mineral contents of tomato leaves as affected by irrigation water treatments and foliar applications during summer seasons of 2016 and 2017 after 75 days from transplanting.

Treatments			N (%)		P (%)		K (%)		Ca (%)	
			2016	2017	2016	2017	2016	2017	2016	2017
A) Irrigation water treatments:										
Magnetized			3.63	4.04	0.534	0.576	2.96	2.45	0.208	0.219
Non-magnetized			2.36	2.77	0.246	0.288	1.54	1.03	0.103	0.116
F. test			*	*	*	*	*	*	*	*
B) Foliar applications:										
Chitosan		250 ppm	4.24	4.65	0.630	0.672	2.95	2.44	0.199	0.213
		500 ppm	2.80	3.21	0.341	0.383	2.15	1.64	0.150	0.161
Lithovit		1.5 g	3.21	3.62	0.412	0.454	2.62	2.11	0.161	0.172
		2 g	2.87	3.28	0.349	0.391	2.21	1.70	0.145	0.161
Selenium		5 ppm	3.04	3.45	0.339	0.383	2.01	1.50	0.145	0.156
		10 ppm	2.78	3.19	0.363	0.405	2.37	1.87	0.152	0.163
Yeast extract		5 g	2.68	3.09	0.362	0.404	1.92	1.41	0.157	0.168
		10 g	3.29	3.70	0.495	0.537	2.68	2.17	0.166	0.177
Control			2.07	2.48	0.221	0.263	1.33	0.82	0.122	0.133
L.S.D. at 5 %			0.28	0.28	0.047	0.047	0.23	0.23	0.007	0.008
Interaction between irrigation water treatments and foliar applications (A × B):										
Magnetized	Chitosan	250 ppm	5.66	6.07	0.965	1.007	3.85	3.34	0.271	0.282
		500 ppm	3.02	3.43	0.408	0.450	3.12	2.61	0.204	0.215
	Lithovit	1.5 g	3.82	4.23	0.540	0.582	3.37	2.86	0.209	0.221
		2 g	3.23	3.64	0.464	0.506	2.70	2.19	0.201	0.212
	Selenium	5 ppm	3.43	3.84	0.447	0.489	2.55	2.04	0.193	0.204
		10 ppm	3.24	3.65	0.482	0.524	3.29	2.78	0.207	0.218
	Yeast extract	5 g	3.35	3.76	0.498	0.540	2.26	1.75	0.209	0.220
		10 g	3.94	4.35	0.699	0.741	3.42	2.91	0.214	0.225
	Control		2.99	3.40	0.306	0.348	2.07	1.56	0.160	0.171
Non-magnetized	Chitosan	250 ppm	2.82	3.23	0.295	0.337	2.05	1.54	0.126	0.143
		500 ppm	2.59	3.00	0.274	0.316	1.19	0.68	0.096	0.107
	Lithovit	1.5 g	2.64	3.05	0.285	0.327	1.87	1.36	0.113	0.124
		2 g	2.51	2.92	0.235	0.277	1.71	1.20	0.089	0.111
	Selenium	5 ppm	2.60	3.01	0.231	0.274	1.46	0.95	0.098	0.109
		10 ppm	2.32	2.73	0.244	0.286	1.46	0.95	0.098	0.109
	Yeast extract	5 g	2.02	2.43	0.225	0.267	1.58	1.07	0.106	0.117
		10 g	2.64	3.05	0.291	0.333	1.94	1.43	0.118	0.129
	Control		1.16	1.57	0.136	0.178	0.60	0.09	0.085	0.096
L.S.D. at 5 %			0.40	0.40	0.067	0.067	0.330	0.331	0.010	0.011

Treatments			Mg (%)		Fe ppm		Zn ppm		Mn ppm	
			2016	2017	2016	2017	2016	2017	2016	2017
A) Irrigation water treatments:										
Magnetized			0.558	0.546	182.2	181.1	11.937	13.278	192.15	182.06
Non-magnetized			0.162	0.149	372.4	339.6	7.466	8.807	107.08	97.00
F. test			*	*	*	*	*	*	*	*
B) Foliar applications:										
Chitosan		250 ppm	0.497	0.483	308.2	283.5	13.280	14.620	187.11	177.01
		500 ppm	0.339	0.326	275.4	264.2	9.115	10.456	131.83	121.73
Lithovit		1.5 g	0.392	0.380	304.2	279.8	9.775	11.115	170.03	159.98
		2 g	0.373	0.361	269.7	263.1	9.140	10.481	137.95	127.90
Selenium		5 ppm	0.342	0.330	246.4	236.2	8.962	10.303	142.53	132.43
		10 ppm	0.354	0.342	273.7	252.1	9.901	10.242	145.81	135.71
Yeast extract		5 g	0.361	0.349	265.8	255.8	9.340	10.681	147.28	137.18
		10 g	0.408	0.394	389.3	395.6	11.256	12.597	178.63	168.53
Control			0.173	0.161	162.8	113.0	7.547	8.887	105.40	95.30
L.S.D. at 5 %			0.063	0.063	26.31	44.07	0.994	0.993	5.870	5.864
Interaction between irrigation water treatments and foliar applications (A × B):										
Magnetized	Chitosan	250 ppm	0.794	0.782	167.7	204.7	17.191	18.529	244.20	234.10
		500 ppm	0.565	0.553	182.2	172.2	11.284	12.625	166.23	156.13
	Lithovit	1.5 g	0.604	0.592	208.7	200.8	11.492	12.833	214.63	204.53
		2 g	0.572	0.560	199.8	189.8	11.085	12.426	166.23	156.23
	Selenium	5 ppm	0.516	0.504	194.1	184.1	11.313	12.654	187.63	177.53
		10 ppm	0.533	0.521	210.8	199.1	10.728	12.069	149.20	184.10
	Yeast extract	5 g	0.576	0.564	183.4	173.4	11.207	12.548	178.43	168.33
		10 g	0.616	0.604	214.7	237.3	13.270	14.611	231.60	221.50
	Control		0.247	0.235	78.40	68.4	9.864	11.205	146.23	136.13
Non-magnetized	Chitosan	250 ppm	0.201	0.185	405.6	362.2	9.369	10.710	130.03	119.93
		500 ppm	0.113	0.099	368.7	356.3	6.947	8.288	97.43	87.33
	Lithovit	1.5 g	0.181	0.168	399.6	358.7	8.057	9.398	125.43	115.43
		2 g	0.174	0.161	339.7	336.4	7.195	8.536	109.66	99.56
	Selenium	5 ppm	0.169	0.157	298.7	288.3	6.611	7.952	97.43	87.33
		10 ppm	0.175	0.163	379.7	305.0	7.075	8.416	97.43	87.33
	Yeast extract	5 g	0.145	0.133	348.2	338.2	7.473	8.814	116.13	106.03
		10 g	0.199	0.185	563.9	553.9	9.241	10.582	125.66	115.56
	Control		0.100	0.088	247.3	157.7	5.230	6.569	64.56	54.46
L.S.D. at 5 %			0.089	0.089	37.21	62.33	1.405	1.405	8.301	8.293

Effects of foliar applications:

The obtained results in Tables 4 and 5 show that all foliar application treatments significantly enhanced minerals and photosynthetic pigments in tomato leaves as compared with check plants in both growing seasons. Chitosan application at the lowest concentration (250 ppm) is the superior in its effects on all studied parameters, followed by decline with the highest concentration (500 ppm) but still higher than the control except for Fe. On the other hand, Foliar application of yeast extract at 10 g/L came in the first order in enhancing Fe content followed Chitosan (250 ppm) then lithovit at 1.5 g/L in both growing seasons.

Effect of interaction between irrigation water treatments and foliar applications:

Tomato leaf minerals (N, P, K, Ca, Mg, Fe, Zn and Mn) and pigments (Ch. a, Ch. b, total chlorophyll and carotenoids) in response to the interaction between irrigation water treatments and foliar applications are presented in Tables 4 and 5. Data indicated that the best values of all the aforementioned parameters significantly enhanced in response to irrigation with magnetized water and foliar applications (chitosan, lithovit, selenium and yeast extract) except for Fe in both seasons. The highest values of N, P, K, Ca, Mg, Zn, Mn, Chl. a, Chl. b, total chlorophyll and carotenoids were obtained specially with chitosan at 250 ppm. On the other hand, both the lowest values of the previous parameters and the best value of Fe were recorded with the control treatment (irrigation with untreated water in the absence of foliar applications) in both seasons.

Table 5. Photosynthetic pigments of tomato leaves as affected by irrigation water treatments and foliar applications during summer seasons of 2016 and 2017 after 75 days from transplanting.

Treatments			Chl. (a) (mg/100gm F.Wt.)		Chl. (b) (mg/100gm F.Wt.)		Total chl. (a+b) (mg/100gm F.Wt.)		Carotenoids (mg/100gm F.Wt.)	
			2016	2017	2016	2017	2016	2017	2016	2017
A) Irrigation water treatments:										
Magnetized			1.144	1.233	0.716	0.775	1.861	2.009	0.668	0.672
Non-magnetized			0.600	0.680	0.536	0.597	1.136	1.278	0.503	0.507
F. test			*	*	*	*	*	*		
B) Foliar applications:										
Chitosan		250 ppm	1.270	1.356	0.767	0.822	2.038	2.178	0.709	0.697
		500 ppm	0.795	0.890	0.547	0.600	1.343	1.491	0.570	0.581
Lithovit		1.5 g	0.953	1.034	0.657	0.737	1.610	1.772	0.605	0.617
		2 g	0.858	0.944	0.600	0.659	1.458	1.603	0.557	0.569
Selenium		5 ppm	0.883	0.975	0.605	0.661	1.488	1.628	0.550	0.550
		10 ppm	0.798	0.879	0.595	0.651	1.393	1.531	0.561	0.572
Yeast extract		5 g	0.793	0.873	0.622	0.685	1.415	1.559	0.575	0.587
		10 g	0.955	1.036	0.737	0.800	1.693	1.836	0.665	0.665
Control			0.545	0.632	0.505	0.561	1.050	1.193	0.482	0.470
L.S.D. at 5 %			0.024	0.030	0.062	0.064	0.075	0.081	0.045	0.045
Interaction between irrigation water treatments and foliar applications (A × B):										
Magnetized	Chitosan	250 ppm	1.485	1.577	0.955	0.885	2.370	2.517	0.848	0.837
		500 ppm	1.075	1.185	0.704	0.620	1.695	1.857	0.637	0.648
	Lithovit	1.5 g	1.165	1.163	0.833	0.750	1.915	2.081	0.687	0.700
		2 g	1.070	1.248	0.706	0.655	1.725	1.870	0.616	0.628
	Selenium	5 ppm	1.145	0.243	0.724	0.670	1.815	1.958	0.637	0.625
		10 ppm	1.065	1.148	0.758	0.700	1.765	1.906	0.620	0.630
	Yeast extract	5 g	1.135	1.216	0.736	0.685	1.820	1.952	0.628	0.640
		10 g	1.170	1.251	0.940	0.880	2.050	2.206	0.773	0.785
	Control		1.056	1.136	0.671	0.605	1.595	1.736	0.571	0.559
Non-magnetized	Chitosan	250 ppm	0.990	1.078	0.657	0.650	1.706	1.840	0.570	0.558
		500 ppm	0.516	0.596	0.529	0.475	0.991	1.125	0.503	0.515
	Lithovit	1.5 g	0.741	0.821	0.642	0.565	1.306	1.463	0.523	0.535
		2 g	0.646	0.726	0.611	0.545	1.191	1.337	0.498	0.510
	Selenium	5 ppm	0.621	0.701	0.598	0.540	1.161	1.299	0.463	0.475
		10 ppm	0.531	0.611	0.544	0.490	1.021	1.155	0.503	0.515
	Yeast extract	5 g	0.451	0.531	0.635	0.560	1.011	1.166	0.523	0.535
		10 g	0.741	0.821	0.646	0.595	1.336	1.467	0.558	0.546
	Control		0.100	0.185	0.464	0.406	0.506	0.650	0.393	0.381
L.S.D. at 5 %			0.034	0.42	0.090	0.088	0.107	0.115	0.064	0.064

DISCUSSION

The stimulating effect of irrigation with magnetized water may be due to improving and increasing Free-living micro-organisms population and activity in soil (Table 1), which in turn enhance root development, increase water and mineral uptake and produce plant hormones that might be responsible for better growth of tomato plants. Also, magnetic treatments enhance the activation of phyto-hormone and bio-enzyme systems, affects cell membranes structures and in this way increases their permeability and ion, which then affects various metabolic pathway activities as well as increasing the rate of water absorption. Also, there are some changes occurred in the chemical and physical properties of water according to magnetic treatment, mainly hydrogen bonding, surface tension, conductivity, polarity and solubility of salts, these changes in water properties may affec plants growth (Turker *et al.,* 2007and Maheshwari and Grewal, 2009). Changing water and soil properties in response to magnetized water (Table 2) increased the availability and absorption of nutrients causing higher contents of them in plant tissue. Also,

increasing all photosynthetic pigments may be through the increase in cytokinin synthesis which induced by magnetic field (Atak *et al.,* 2003). Similar enhancing effects were obtained by Abou El-Yazied *et al.* (2012); Yusuf *et al.* (2016) and Yusuf and Ogunlela (2017) on tomato plants.

The stimulatings effect of chitosan on plant growth performance (vegetative growth parameter, leaf minerals and pigments content) may be attributed to improving uptake of water and availability of essential nutrients through adjusting cell osmotic pressure and reducing accumulating the harmful free radicals by increasing antioxidants and enzymatic activities (Guan *et al.,* 2009). Also, chitosan enhance key enzymes activity of nitrogen (N) metabolism (glutamine and nitrate reductase) and improve the transportation of nitrogen in the functional leaves as well as increase photosynthesis efficiency which in turn enhance plant growth and development (Mondal *et al.,* 2016). These results are in harmony with the findings of Borkowski *et al.* (2007); El-Tantawy (2009) and Mondal *et al.* (2016) on tomato plants.

The increment in the studied parameters that achieved with foliar application of lithovit as compared to the control may be through the role as a long term reservoir supplying plants with CO_2, so it can enhance plant growth, where elevated CO_2 concentrations generally increased carbon assimilation, photosynthesis intensity, biomass and leaf area of plants (Bilal, 2010 and Maswada and Abd El-Rahman, 2014). Also, lithovit consisting mainly of Ca (3%), Mg (2%), $CaCo_3$ (24%) and $MgCo_3$ micron (41%) which penetrate rapidly into plant tissue and play vital roles in physiological and biological processes in plants in which reflected positively on crop productivity. Similar findings were reported by Byan (2014); Moisa and Berar (2015) and recently Abd El-Nabi *et al.* (2017).

Concerning the beneficial effect of yeast extract, it is a natural source of cytokinins that stimulate cell enlargement and cell division as well as the synthesis of nucleic acid, protein, and chlorophyll pigments. In addition, yeast extract contains protective agents as sugars, proteins, amino acids, several vitamins as well as most of nutritional elements and organic compounds. The enhanced effects of foliar application of yeast extract on tomato plants were also obtained by Abou El-Yazied and Mady (2011); Abd El-Fatah *et al*. (2014) and Shabana *et al.* (2015).

Also, exogenous foliar application of Se has already shown to enhance vegetative growth and chemical constituents of leaves by Abul-Soud and Abd Elrahman (2016) on eggplant; Andrejiova *et al.* (2016) and Santos-Vázquez *et al.* (2016) on tomato plants.

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استجابه نباتات الطماطم للري بالماء الممغنط وبعض معاملات الرش الورقي تحت نظام الري بالتنقيط:
١- النمو الخضري والمحتوى الكيماوي للأوراق.

كوثر كامل ضوه ، حسام محمد السعيد عبد النبي و ولاء محمد السعيد سويلم
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أجريت هذه الدراسة خلال موسمي صيف ٢٠١٦ و٢٠١٧ بمزرعة خاصة بقرية صهرجت الصغرى قرب مدينة المنصورة- محافظة الدقهلية بهدف دراسة تأثير الري بالماء العادي والماء الممغنط وبعض معاملات الرش الورقي (الشيتوزان, الليثوفيت, السيلينيوم, مستخلص الخميرة) والتفاعل بينهم على النمو الخضري والمحتوى الكيماوي للأوراق لنباتات الطماطم هجين ٦١١٢. أعطت معاملة الري بالماء الممغنط أعلى القيم لصفات النمو الخضري والممثلة في ارتفاع النبات, عدد الأوراق, عدد الأفرع, المساحة الورقية, الوزن الطازج والجاف وكذلك المحتوى الكيماوي للأوراق مثل كلوروفيل أ, كلوروفيل ب, الكلوروفيل الكلي أ+ ب,الكاروتين, النسبة المئوية للنيتروجين والفوسفور والبوتاسيوم والكالسيوم والماغنسيوم وكذلك الزنك والمنجنيز عند المقارنة بمعاملة الري بالماء العادي في حين سجلت معاملة الري بالماء العادي أعلى قيمة لمحتوى الأوراق من عنصر الحديد في موسمي الزراعة. أدت جميع معاملات الرش الورقي الى زيادة معنوية في جميع الصفات المدروسة عند المقارنة بمعاملة الكنترول في موسمي الزراعة. بينما جاءت معاملة الرش بالشيتوزان (٢٥٠ جزء بالمليون) في المرتبة الأولى ثم الرش بمستخلص الخميرة (١٠ جرام/لتر) في المرتبة الثانية ثم الرش بالليثوفيت (١.٥ جرام/لتر) في المرتبة الثالثة. كانت أفضل النتائج بالنسبة لصفات النمو الخضري وكذلك المحتوى الكيماوي ناتجة عن الري بالماء الممغنط مع استخدام جميع مواد الرش الورقي خاصة الشيتوزان بتركيز ٢٥٠ جزء بالمليون في موسمي الدراسة ماعدا محتوى الأوراق من الحديد حيث كانت أفضل نتائجه مع الري بالماء العادي.