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Effect of magnetic water, foliar application with nano material and nitrogen levels on productivity and quality of head lettuce

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Abstract

Two field experiments were carried out at the Experimental Station Farm, Faculty of Agriculture, Mansoura University, Egypt, during seasons of 2015/2016 and 2016/2017 to study the effect of magnetic water irrigation (normal water and magnetic water), foliar spraying with nano material water as well as their interactions on growth, yield and quality of head lettuce (Big bell cultivar). The experiment was carried out in a strip-split plot design with three replications. The vertical-plots were allocated for water irrigation treatments. The horizontal plots were devoted for foliar spraying with and without lithovit at the rate of 0.5 g/liter. The sub-plots were included N-levels (100, 75 and 50 % N of the recommended doses). The obtained results could be summarized as follows:

- The maximum means of total leaf area/5 outer leaves, total yield/fed, dry matter percentage in inner and outer leaves, total soluble solids (TSS), total sugars, total carbohydrates and crude protein percentages, chlorophyll a, b and total chlorophylls contents and lowest values of nitrate (NO_3) and nitrite (NO_2) contents in head lettuce were recorded from irrigation head lettuce plants with magnetic water in both seasons.
- Head lettuce plants sprayed with nano materials (lithovit) gave the maximum means of all studied characters, except nitrate (NO_3) and nitrite (NO_2) contents in head lettuce in both seasons.
- The highest values of all studied characters were resulted from mineral fertilizing head lettuce plants with 100 % of the recommended doses (41 kg N/fed) in both seasons.

It could be recommended that irrigation head lettuce plants with magnetic water and foliar spraying with nano materials (lithovit at the rate of 0.5 g/liter water) in addition mineral fertilizing with 100 % of the recommended doses (41 kg N/fed) in order to maximizing head lettuce productivity and quality under the environmental conditions of Dakahlia Governorate, Egypt.

Keywords: Head lettuce, magnetic water, lithovit, nano material, nitrogen levels, yield, quality.

Introduction

Head lettuce (*Lactuca sativa* L.) belongs to the family *Asteraceae* (or alternatively Compositae). Head lettuce is a rich source of antioxidants, vitamin A and C and phytochemicals which are anti-carcinogenic. It also provides some dietary fiber, carbohydrates, protein and a small amount of fat. Lettuce also provides calcium, iron and copper, with vitamins and minerals largely found in the leaf. Lettuce is used to refer to the edible and succulent leaves, which commonly are eaten raw in salads. It is the most commonly used salad vegetables in Egypt and the world. It has become an important commercial crop for local market.

There is a great need for further studies under Egyptian condition to establish recommendation for reducing the amounts of mineral fertilizer especially

nitrogen, which is used in large a mounts and consequently causes decrease the product quality.

Magnetic water technology has been used to reduce the effect of salt concentration, increase the quantity and quality of yield and decrease the amounts of irrigation water. It improves the irrigation water quality such as surface tension, conductivity, solubility of salts and pH **(Grewal and Maheshwari, 2011)**. **Basant *et al.* (2007)** and **Maheshwari and Grewal (2009)** reported that some beneficial effects of magnetically treated irrigation water, particularly for saline water and recycled water on the yield and water productivity of celery and snow pea plants under controlled environmental conditions. **Tai *et al.* (2008)** pointed out that magnetized water prevents harmful metals such as lead and nickel from uptake by roots and reaching fruits and roots. However, it increases the percentage of nutrient elements like phosphorus, potassium and zinc. On chickpea, **Hozany and Qados (2010)** found that irrigation with magnetized water induced positive significant effect on all studied parameters. Magnetic water treatment could be used to enhance growth, chemical constituents and productivity of chickpea under green house condition. **Elsayed (2014**) reported that the irrigation of broad bean plant with magnetic water exhibited marked significant increase in the chloroplast pigments (chlorophyll a, chlorophyll b and carotenoids), photosynthetic activity, over the irrigated by tap water. **Yusuf and Ogunlela (2015)** found that magnetic treatment of the irrigation water (magnetically treated water) influenced the vegetative growth of tomato by increasing the rate of growth, reducing the time until maturity and increased yield.

Nano technology is one the most important tools in modern agriculture can be used as an alternative technology in a wide scientific area. It has been described as relating to materials systems and processes which operate at a scale of too nanometers or les **(Ditta, 2012)**. It is clear from the literature that these nano-materials have a great potential to avoid degradation of the agrochemicals in the environment, reduce the fertilizers doses, decrease costs and control excess chemicals **(Ditta, 2012 and Grover *et al*., 2012)**. **Artyszak *et al.* (2014)** studied the effect of marine calcite (containing calcium carbonate and silicon mainly) as foliar application on the sugar beet. They found that calcium and silicon foliar application resulted in increases in root yield about 13.1% to 21.0% and sugar yield about 15.5% - 17.7% as compared to the control treatment. **Byan (2014)** found that foliar spraying on snap bean plants with Lithovit (a natural intensified CO_2 foliar fertilizer) improved green pod characters, vegetative growth characters and chemical constituents of plant foliage *i.e.* chlorophyll reading, total nitrogen, phosphorus and potassium percentages as compared with the control (distilled water) during both seasons. **Hamoda *et al.* (2016)** showed that increasing Lithavit rates from zero (untreated) to 7.5 g/1 significantly increased cotton plant height at harvest, leaf area/plant, leaf area index, number of fruiting branches/plant, number of open bolls/plant, boll weight, seed cotton yield/plant and seed cotton yield/feddan in both seasons in favour of the high rate (7.5 g/l) of CO_2 fertilizer.

Nitrogen is one of the main three plant nutrients (*i.e.* NPK) which is used in large amounts. It is known that nitrogen has greater influence on growth and yield of crop plants than any other essential plant nutrient. It plays a vital role in many physiological and biochemical processes in plants. Nitrogen is a component of many important organic compounds ranging from proteins to nucleic acids. It is a constituent of the chlorophyll molecule and many enzymes, which plays an important role in plant photosynthesis. Nitrogen plays a key role in many metabolic reactions. Nitrogen is also a structural constituent of cell walls **(Marschner, 2012)**. **El-Bassyouni (2016)** revealed that the productivity of lettuce and most of chemical contents in lettuce heads were increasing with increasing application doses from 60 to 100 kg N/fed. The moderate application dose (80 kg N/fed) resulted in the highest values of dry matter and vitamin C in lettuce heads, and the same statistically productivity with less nitrate content compared to the highest application dose (100 kg N/fed). **Fu *et al.* (2017)** revealed that there was an obvious interaction between light intensity and nitrogen available for the photosynthesis, yield and quality of lettuce. The higher light and low nitrogen contributed to the accumulation of vitamin C and decrease of nitrate in lettuce leaves. **Gioia *et al.* (2017)** reported that nitrogen rates (0, 60, 120, 180 kg N/ha) influenced fresh and dry weights of lettuce plants, N accumulation, dry matter content, nitrogen use efficiency, soil residual N and the estimated N losses at the end of the crop season. **Souza *et al.* (2017)** stated that the commercial fresh matter and the number of commercial leaves per lettuce plant were affected by nitrogen fertigation and increased linearly with an increase in the dose of nitrogen, with the best responses observed at the highest dose (171 kg N/ha).

Therefore, the present investigation aimed to study the effect of magnetic water irrigation, foliar spraying with lithovit (nano material) and levels of nitrogen fertilizer as well as their interactions on growth, yield

and quality of head lettuce (Big bell cultivar) under the environmental conditions of Mansoura district, Dakahlia Governorate, Egypt.

Materials and Methods

Two field experiments were carried out at the Experimental Station Farm, Faculty of Agriculture, Mansoura University, Egypt, during seasons of 2015/2016 and 2016/2017 to study the effect of magnetic water irrigation, foliar spraying with lithovit (nano material) and three levels of nitrogen fertilizer as well as their interactions on growth, yield and quality of head lettuce (Big bell cultivar).

In both seasons of this study, soil samples were taken at random from the experimental field area at a depth of 0 - 30 cm from soil surface before soil preparation to estimate the mechanical and chemical soil properties table 1 according to **Chapman and Pratt (1971)** .

The saturation percentage and water holding capacity of the soil were determined using method described by **Richards (1954)**, as shown in Table 2. Types and number of bacteria were estimated in both magnetic water and normal water by standard spread-plate dilution method described by **Seeley and Van Demark (1981)**, as shown in Table 3.

Table 1: Mechanical and chemical soil characteristics at the experimental soil during the two growing seasons of 2015/2016 and 2016/2017.

Soil analyses		2015/2016	2016/2017
A: Mechanical analysis			
Coarse sand		3.98	4.01
Fine sand		28.05	37.00
Silt		43.01	41.00
Clay		24.93	22.00
Texture class		SCL	SCL
B: Chemical analysis			
EC $dS.m^{-1}$(1:5)		1.11	0.92
pH (1:2.5)		7.81	8.5
OM %		1.62	1.59
Total $CaCO_3$ %		4.31	3.48
Available (mg/kg)	N	51.4	36.75
	P	6.01	7.80
	K	152.4	145.00
DTPA Extractable ppm	Zn	0.97	0.98
	Fe	3.13	3.15
	Mn	1.14	1.15

Table 2: Saturation percentage and water holding capacity of the soil.

Property	Magnetic soil	Normal soil
Saturation percentage	83.5 %	67.5 %
Water holding capacity	41.5 %	34.0 %

Table 3: Type and number of bacteria present in soil.

Bacteria	Irrigation soil with magnetic water		Irrigation soil with normal water	
	Present	Total number	Present	Total number
Bacillus spp.	+	2.960 meliar	-	4.800 million
Streptococcus spp.	+		+	
Staphylococcus spp.	+		+	

This experiment was carried out in a strip-split plot design with three replications. The vertical-plots were allocated to two water irrigation treatments (normal water and magnetic water).

The horizontal plots were devoted for two foliar spraying with lithovit and (without "control treatment" and foliar spraying with lithovit at the rate of 0.5 g/liter water). Lithovit is a bio foliar fertilizer. It is natural limestone consisting mainly of Ca (3 %), Mg (2 %) $CaCO_3$ "micron" (24 %) and $MgCO_3$ "micron" (41 %), which supplies plants with CO_2 in much higher concentration than that in the atmosphere and so increases their photosynthesis and important for plant physiology.

The sub-plots were included three levels of nitrogen fertilizer (100 % N, 75 % N and 50 % N of the recommended doses "41 kg N/fed") in the form of ammonium sulphate (20.5 % N), which used in two equal doses, the first one was after 21 days from transplanting, and the second one was 30 days takes.

Each experimental basic unit (sub- sub-plot) included three ridges, each of 70 cm width and 5 m length, resulted an area of 10.5 m^2.

Calcium super phosphate (15.5 % P_2O_5) at the rate of 200 kg/fed was applied during soil preparation.

Lettuce seedling were immediately planted in the moderately moist soil on 18th and 21th November in the first and second seasons, respectively. Seedlings were sown by hand in hills (30 cm apart) . Potassium fertilizer in the form of potassium sulphate (48.0 % K_2O) at the rate of 75 kg/fed were used in two equal doses with nitrogen fertilizer as mentioned before. During the growing seasons, all other agricultural practices were done according to the recommendations of Ministry of Agriculture and Land Reclamation .

After 100 days from the planting, a samples of 5 plants were randomly taken from each experimental unit to determine the following parameters:

1. Leaf area for 5 outer leaves (cm^2) was determined using Field Portable Leaf Area Meter AM-300 (Bio-Scientific, Ltd., Great Am well, Herefordshire, England).

2. Total yield (t/fed). It was calculated as the total weight of head lettuce (t/fed).

Samples from lettuce leaves after 100 days from sowing were dried in the oven at 70 $^{\circ}$C until constant weigh was reached then, dry matter percentage was calculated.

- Total soluble solids percentage (TSS %): It was measured in the juice of the leaves by using Gali 110 Refractometer according to **AOAC (1990).**

- Total sugars percentage: It was determined according to the method of **Forsee (1938)**.

- Total carbohydrates percentage: It was determined according to **Somogy (1952)**.

- Crude protein percentage: It was calculated by multiplying the total nitrogen by the factor 6.25.

- Chlorophylls content: Chlorophyll a, b and total chlorophyll were colorimetrically determined in the leaves of head lettuce during both seasons according to the methods described by **Wettstein (1957)** and calculated as mg/g fresh weight. Also total chlorophyll was calculated from values of a and b chlorophylls.

- Nitrate (NO_3) and nitrite (NO_2) contents: Determinations in dry leaves were measured as described by **Singh (1988)**.

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip-split plot design as published by **Gomez and Gomez (1984)** by using "MSTAT-C" computer software package. Least significant of difference (LSD) method was used to test the differences between treatment means at 5 % level of probability as described by **Snedecor and Cochran (1980)**.

Results and Discussion

1- Effect of water irrigation treatments:

Data in Tables 4, 6, 8 and 10 shows that water irrigation treatments (normal water and magnetic water) had significant effects on total leaf area/plant, total yield/fed, dry matter percentage in inner and outer leaves, total soluble solids (TSS), total sugars, total carbohydrates and crude protein percentages, chlorophyll a, b and total chlorophylls contents and nitrate (NO_3) and nitrite (NO_2) contents in head lettuce in the two growing seasons, except nitrate content in the second season only.

The maximum means of these characters were recorded as a result of irrigation head lettuce plants with magnetic water, excluding nitrate (NO_3) and nitrite (NO_2) contents in head lettuce which resulted from irrigation head lettuce plants with normal water in both seasons. While, the lowest values of all studied characters were produced from irrigation head lettuce plants with normal water, with exception nitrate (NO_3) and nitrite (NO_2) contents in head lettuce which resulted from irrigation head lettuce plants with magnetic water in both seasons. These results due to irrigation hean lettuce plants with magnetic water may be due to that magnetic water technology has been used to increase saturation percentage and water holding capacity of the soil (as shown in Table 2), increment number of bacteria present in soil (as shown in Table 3), reduce the effect of salt concentration, decrease the amounts of irrigation water, improve the irrigation water quality such as surface tension, conductivity, solubility of salts and decrease high pH. These results came in the similar point of view with those reported by **Tai *et al*. (2008), Hozany and Qados (2010), Elsayed (2014) and Yusuf and Ogunlela (2015)**.

2- Effect of foliar spraying with lithovit (as nano material):

The obtained data presented in Tables 4, 6, 8 and 10 indicates that foliar spraying head lettuce plants with lithovit (as nano material) significantly affected the measurements mentioned previously foliar spraying head lettuce plants with nano materials (lithovit) gave the maximum means of these characters, excluding nitrate (NO_3) and nitrite (NO_2) contents in head lettuce which resulted from control treatment (without spraying with lithovit) in both seasons. While, the lowest values of all studied characters were produced from control treatment (without spraying with lithovit), with exception nitrate (NO_3) and nitrite (NO_2) contents in head lettuce which resulted from foliar spraying head lettuce plants with lithovit in both seasons. These results as a result of foliar spraying head lettuce plants with nano materials (lithovit) may be due to the favourable effects of nano materials (lithovit) in avoiding degradation of the agrochemicals in the environment, reduce the fertilizers doses. Also, due to the effect of lithovit components *i.e.* mineral calcium (3%), magnesium (2%), calcium carbonate (24%) and magnesium carbonate (41%) which penetrate rapidly into the plant tissues through the stomata and play vital roles in biological and physiological processes of lettuce plants which reflected on increasing vegetative growth parameters and quality. The obtained results were parallel with those reported by **Artyszak *et al*. (2014), Byan (2014) and Hamoda *et al*. (2016)**.

3- Effect of N-levels:

Regarding the effect of N-levels on the characters mentioned previously the obtained results in Tables 4, 6, 8 and 10 apparently cleared that there were significant effects in both seasons. It could be noticed that increasing N-levels from 50 up to 100% of the recommended doses (41 kg N/fed) was accompanied with significant increase in all studied characters. Therefore, the highest values of aforementioned traits were resulted from mineral fertilizing head lettuce plants with 100 % of the recommended doses (41 kg N/fed) in both seasons. These increases allied with increasing N-levels may be refer to the role of nitrogen in protoplasm and chlorophyll formation, enhancement meristematic activity and cell division (**Marschner, 2012**). These results are in harmony with those recorded by **El-Bassyouni (2016), Fu *et al*. (2017), Gioia et al. (2017) and Souza *et al*. (2017)**.

4- Effect of interactions:

The various interactions among the three studied factors *i.e.* water irrigation treatments, foliar spraying with lithovit (as nano material) and levels of nitrogen fertilizer had many significant effects on all studied characters in both seasons as presented in Tables 5, 7, 9 and 11.

Table 4: Total leaf area/5 outer leaves, total yield/fed and dry matter percentage in inner and outer leaves of head lettuce as affected by magnetic water irrigation, foliar spraying with lithovit (as nano material) and levels of nitrogen fertilizer as well as their interactions during 2015/2016 and 2016/2017 seasons.

Characters / Treatments	Total leaf area/5 outer leaves (cm^2)		Total yield (t/fed)		Dry matter (%)			
					Inner leaves		Outer leaves	
	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017
A- Water irrigation treatments:								
Magnetic water	303.0	302.6	17.53	17.36	11.04	10.98	13.62	13.59
Normal water	248.4	247.5	11.15	11.06	10.59	10.52	13.24	13.14
F. test	*	*	*	*	*	*	*	*
B- Foliar spraying with lithovit (as nano material):								
Lithovit (0.5 g/L)	286.3	286.4	15.85	15.72	10.97	10.90	13.56	13.48
Without	265.0	263.8	12.83	12.71	10.66	10.60	13.31	13.25
F. test	*	*	*	*	*	*	*	*
C- Levels of nitrogen fertilizer:								
100 % N	283.2	282.4	15.03	14.90	11.21	11.11	13.75	13.69
75 % N	276.5	276.4	14.27	14.14	11.05	11.01	13.63	13.58
50 % N	267.3	266.4	13.71	13.60	10.19	10.13	12.92	12.82
LSD (at 5 %)	2.77	2.91	0.36	0.34	0.04	0.07	0.05	0.04
D- Interactions (F. test):								
A × B	NS	NS	*	*	NS	NS	NS	NS
A × C	NS	NS	NS	NS	*	*	*	*
B × C	NS	NS	*	*	*	NS	NS	NS
A × B × C	*	*	*	*	*	*	*	*

Table 5: Total leaf area/5 outer leaves, total yield/fed and dry matter percentage in inner and outer leaves of head lettuce as affected by the interaction among magnetic water irrigation, foliar spraying with lithovit and levels of nitrogen fertilizer during 2015/2016 and 2016/2017 seasons.

Treatments			Total leaf area/5 outer leaves (cm^2)		Total yield (t/fed)		Dry matter (%)			
							Inner leaves		Outer leaves	
Water treatments	**Spraying with lithovit**	**N-levels**	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017
Magnetic water	Lithovit (0.5 g/L)	100 % N	323.6	323.4	19.37	19.15	11.69	11.49	14.09	14.03
		75 % N	313.4	314.2	18.46	18.40	11.53	11.49	13.99	13.97
		50 % N	305.2	305.9	17.82	17.66	10.46	10.43	13.13	13.11
	Without	100 % N	298.5	298.7	16.88	16.70	11.35	11.30	13.90	13.85
		75 % N	294.1	293.2	16.37	16.17	11.17	11.15	13.79	13.74
		50 % N	283.1	280.6	16.26	16.11	10.09	10.06	12.85	12.82
Normal water	Lithovit (0.5 g/L)	100 % N	263.8	263.0	14.20	14.10	11.02	10.99	13.64	13.57
		75 % N	259.7	259.8	13.18	13.02	10.86	10.81	13.51	13.46
		50 % N	252.4	252.1	12.06	11.98	10.28	10.21	12.98	12.73
	Without	100 % N	247.1	244.7	9.68	9.64	10.79	10.65	13.39	13.32
		75 % N	238.7	238.5	9.05	8.99	10.66	10.61	13.23	13.17
		50 % N	228.8	227.2	8.71	8.64	9.93	9.84	12.71	12.60
LSD (at 5 %)			3.11	3.45	0.71	0.68	0.06	0.12	0.08	0.09

Table 6: Total soluble solids (TSS), total sugars, total carbohydrates and crude protein percentages in head lettuce as affected by magnetic water irrigation, foliar spraying with lithovit (as nano material) and levels of nitrogen fertilizer as well as their interactions during 2015/2016 and 2016/2017 seasons.

Characters / Treatments	TSS (%)		Total sugars (%)		Total carbohydrates (%)		Crude protein (%)	
	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017
A- Water irrigation treatments:								
Magnetic water	4.73	4.40	7.77	7.69	16.00	15.81	10.49	10.45
Normal water	4.50	3.45	7.39	7.31	15.25	15.17	8.87	8.84
F. test	*	*	*	*	*	*	*	*
B- Foliar spraying with lithovit (as nano material):								
Lithovit (0.5 g/L)	4.69	4.16	7.71	7.63	15.88	15.81	10.17	10.13
Without	4.54	3.69	7.45	7.37	15.37	15.17	9.19	9.16
F. test	*	*	*	*	*	*	*	*
C- Levels of nitrogen fertilizer:								
100 % N	4.83	4.06	7.90	7.83	16.25	15.99	11.03	10.99
75 % N	4.74	3.94	7.77	7.69	16.00	15.95	10.36	10.33
50 % N	4.27	3.77	7.08	6.98	14.62	14.53	7.66	7.63
LSD (at 5 %)	0.02	0.05	0.05	0.06	0.06	0.11	0.25	0.24
D- Interactions (F. test):								
A × B	NS	*	NS	NS	NS	NS	NS	NS
A × C	*	NS	*	*	*	*	*	*
B × C	NS	*	NS	NS	NS	NS	NS	NS
A × B × C	*	*	*	*	*	*	*	*

Table 7: Total soluble solids (TSS), total sugars, carbohydrates and crude protein percentages in head lettuce as affected by the interaction among magnetic water irrigation, foliar spraying with lithovit and levels of nitrogen fertilizer during 2015/2016 and 2016/2017 seasons.

Treatments			TSS (%)		Total sugars (%)		Total carbohydrates (%)		Crude protein (%)	
Water treatments	**Spraying with lithovit**	**N-levels**	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017
Magnetic water	Lithovit (0.5 g/L)	100 % N	5.06	4.75	8.29	8.21	17.02	17.01	12.57	12.57
		75 % N	4.96	4.58	8.17	8.09	16.76	16.73	11.92	11.86
		50 % N	4.40	4.36	7.26	7.20	15.02	14.93	8.47	8.42
	Without	100 % N	4.90	4.31	8.04	7.99	16.49	15.60	11.46	11.40
		75 % N	4.83	4.26	7.87	7.79	16.24	16.22	10.98	10.94
		50 % N	4.24	4.13	7.01	6.86	14.48	14.36	7.57	7.54
Normal water	Lithovit (0.5 g/L)	100 % N	4.78	3.94	7.77	7.71	15.98	15.90	10.54	10.49
		75 % N	4.68	3.80	7.65	7.57	15.77	15.66	9.73	9.69
		50 % N	4.30	3.56	7.12	6.99	14.73	14.64	7.82	7.79
	Without	100 % N	4.58	3.25	7.51	7.42	15.51	15.45	9.54	9.50
		75 % N	4.52	3.14	7.38	7.32	15.25	15.20	8.83	8.82
		50 % N	4.16	3.05	6.92	6.87	14.25	14.20	6.78	6.76
LSD (at 5 %)			0.16	0.08	0.11	0.12	0.17	0.15	0.39	0.35

Table 8: Chlorophyll a, b and total chlorophylls contents in head lettuce as affected by magnetic water irrigation, foliar spraying with lithovit (as nano material) and levels of nitrogen fertilizer as well as their interactions during 2015/2016 and 2016/2017 seasons.

Characters / Treatments	Chlorophyll a (mg/g FW)		Chlorophyll b (mg/g FW)		Total chlorophylls (mg/g FW)	
	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017
A- Water irrigation treatments:						
Magnetic water	0.578	0.577	0.414	0.412	0.992	0.989
Normal water	0.546	0.544	0.388	0.387	0.935	0.941
F. test	*	*	*	*	*	*
B- Foliar spraying with lithovit (as nano material):						
Lithovit (0.5 g/L)	0.572	0.570	0.410	0.408	0.982	0.989
Without	0.552	0.551	0.393	0.391	0.945	0.942
F. test	*	*	*	*	*	*
C- Levels of nitrogen fertilizer:						
100 % N	0.586	0.585	0.423	0.420	1.008	1.005
75 % N	0.576	0.573	0.414	0.414	0.990	0.988
50 % N	0.525	0.523	0.367	0.365	0.892	0.903
LSD (at 5 %)	0.003	0.004	0.003	0.003	0.004	0.006
D- Interactions (F. test):						
A × B	NS	NS	NS	NS	NS	NS
A × C	*	*	*	*	*	*
B × C	NS	NS	NS	NS	NS	NS
A × B × C	*	*	*	*	*	*

Table 9: Chlorophyll a, b and total chlorophylls contents in head lettuce as affected by the interaction among magnetic water irrigation, foliar spraying with lithovit and levels of nitrogen fertilizer during 2015/2016 and 2016/2017 seasons.

Treatments			Chlorophyll a (mg/g FW)		Chlorophyll b (mg/g FW)		Total chlorophylls (mg/g FW)	
Water treatments	**Spraying with lithovit**	**N-levels**	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017
Magnetic water	Lithovit (0.5 g/L)	100 % N	0.617	0.616	0.449	0.448	1.066	1.061
		75 % N	0.608	0.607	0.440	0.439	1.048	1.048
		50 % N	0.540	0.538	0.380	0.378	0.920	0.919
	Without	100 % N	0.597	0.595	0.430	0.428	1.027	1.020
		75 % N	0.587	0.587	0.422	0.421	1.009	1.006
		50 % N	0.518	0.518	0.363	0.360	0.882	0.882
Normal water	Lithovit (0.5 g/L)	100 % N	0.573	0.572	0.413	0.409	0.986	0.986
		75 % N	0.565	0.559	0.405	0.406	0.970	0.969
		50 % N	0.529	0.526	0.370	0.368	0.899	0.949
	Without	100 % N	0.555	0.555	0.398	0.396	0.954	0.952
		75 % N	0.544	0.539	0.389	0.388	0.933	0.928
		50 % N	0.510	0.511	0.355	0.352	0.865	0.862
LSD (at 5 %)			0.007	0.008	0.07	0.007	0.09	0.017

Table 10: Nitrate (NO_3) and nitrite (NO_2) contents in head lettuce as affected by magnetic water irrigation, foliar spraying with lithovit (as nano material) and levels of nitrogen fertilizer as well as their interactions during 2015/2016 and 2016/2017 seasons.

Characters / Treatments	NO_3 (ppm)		NO_2 (ppm)	
	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017
A- Water irrigation treatments:				
Magnetic water	103.8	102.2	1.228	1.193
Normal water	106.1	103.2	1.354	1.281
F. test	*	NS	*	*
B- Foliar spraying with lithovit (as nano material):				
Lithovit (0.5 g/L)	102.6	101.3	1.184	1.137
Without	107.2	104.1	1.398	1.337
F. test	*	*	*	*
C- Levels of nitrogen fertilizer:				
100 % N	114.2	111.6	1.624	1.552
75 % N	104.5	102.1	1.325	1.278
50 % N	96.0	94.4	0.925	0.879
LSD (at 5 %)	1.1	1.6	0.089	0.095
D- Interactions (F. test):				
A × B	NS	NS	NS	NS
A × C	NS	NS	NS	NS
B × C	*	NS	NS	NS
A × B × C	*	*	*	*

Table 11: Nitrite (NO_2) contents in head lettuce as affected by the interaction among magnetic water irrigation, foliar spraying with lithovit and levels of nitrogen fertilizer during 2015/2016 and 2016/2017 seasons.

Treatments			**NO_3 (ppm)**		**NO_2 (ppm)**	
Water treatments	**Spraying with lithovit**	**N-levels**	2015/ 2016	2016/ 2017	2015/ 2016	2016/ 2017
Magnetic water	Lithovit (0.5 g/L)	100 % N	109.6	108.7	1.483	1.460
		75 % N	101.7	100.8	1.127	1.100
		50 % N	93.2	93.9	0.787	0.737
	Without	100 % N	115.5	112.6	1.677	1.627
		75 % N	105.5	102.1	1.327	1.277
		50 % N	97.1	94.9	0.970	0.933
Normal water	Lithovit (0.5 g/L)	100 % N	112.8	110.9	1.587	1.473
		75 % N	103.5	101.2	1.243	1.207
		50 % N	95.2	92.1	0.880	0.843
	Without	100 % N	119.2	114.3	1.750	1.650
		75 % N	107.3	104.2	1.603	1.530
		50 % N	98.7	96.6	1.063	1.003
LSD (at 5 %)			2.1	2.9	0.111	0.121

The interaction among water irrigation treatments, foliar spraying with lithovit (as nano material) and nitrogen fertilizer levels had significant effects on the same parameters of head lettuce in both seasons. The highest values of leaf area, total yield/fed, dry matter percentage in inner and outer leaves, total soluble solids (TSS), total sugars, total carbohydrates and crude protein percentages, chlorophyll a, b and total chlorophylls contents of head lettuce were resulted from irrigation head lettuce plants with magnetic water and foliar spraying with nano materials (lithovit at the rate of 0.5 g/liter water) and addition mineral fertilizing at 100 % of the recommended doses (41 kg N/fed) in both seasons as shown from data presented in Tables 5, 7, 9 and 11. While, the highest values of nitrate (NO_3) and nitrite (NO_2) contents in head lettuce were produced from irrigation head lettuce plants with normal water and without foliar spraying with lithovit and mineral fertilizing with 100 % of the recommended doses (41 kg N/fed) in both seasons.

Conclusion

Although this study conclude that irrigation head lettuce plants irrigated with magnetic water and foliar sprayed with nano materials (lithovit at the rate of 0.5 g/liter water) in addition mineral fertilizing with 100 % of the recommended doses (41 kg N/fed). Produced the highest values of yield and quality parameters of head lettuce, its recommended under the environmental conditions.

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