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Effectiveness of different nutrition sources and magnetic fields on lettuce grown under hydroponic system

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ABSTRACT

The study aimed to investigate the effect of magnetic fields and different nutrient solutions on growth of lettuce plants under hydroponic system. The experiment was carried out in the Laboratory of the Soils and Water Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, during the winter season of 2018. Six treatments were used: three nutrient solutions (mineral - control, organic - compost tea and C.T, and mix of mineral and organic 50:50 v/v) were treated with and without magnetic field, a randomized complete block design in a split-plot design, with three replications. A magnetic treatment device with its magnetic field of approximately 14500 gauss was used to evaluated the growth parameters and nutrient contents. The results showed that the different nutrient solutions with magnetic fields treated had significant increases in all plant parameters. In particular, the mix-nutrient (mineral and organic 50:50 v/v) treated with magnetic fields statistically showed significant increases in all values of growth parameters (plant height, number of leaves/plant, total-chlorophyll, diameter stem and leaf area) and nutrient contents (N, P and K), with mean values of 40.33 cm, 25.00, 41.33 mg\g tissue, 1.49 cm, 13759.33 cm^2/plant and 6.03, 0.21 and 1.86%, respectively. This study suggests that the effects of magnetic field treatments act as a protective application of organic nutrition solution in the hydroponic organic system.

KEYORDS: Hydroponic system, organic nutrition, magnetic fields, lettuce, yield.

1. INTRODUCTION

In the near future, 2050 world's population will increase up to 9 billions. Therefore, the food consumption is expected to increase 70% so that an innovative solution is required to provide food needs. This can be attained only by implementing new techniques such as soilless culture. One such solution is liquid culture "hydroponic system", an agricultural technique that relies of one her seven types of soilless farming to grow some crops year-round (Shukla et al., 2016). Uses a hydroponic system of crop production implies the method of growing plants with their roots suspended directly into a solution of minerals dissolved in water "nutri-culture" without using a soil, which it allows a more efficient use of water and fertilizers, as well as a better control of climate and pest factors.

Furthermore, hydroponic system increases the crop quality and productivity, which results in higher competitiveness of the product and economic incomes (Belyavskaya, 2004; Fallovo et al., 2009; Florez, 2012).Worldwide, a high percentage of the hydroponic industry uses inorganic growing media such as nutrient solution, expanded polystyrene, urea formaldehydes and others (San Bautista et al., 2005; Böhme et al., 2008), while only about 12% uses organic growing media (Donnan, 1998) such as peat, bark, wood residues, compost, vermi or animal compost-tea and others (Islam, 2008).

The magnetic technology has been cited in the investigated living style stems since the 19th Century. Changes were determined at the living systems which were exposed to different magnetic field strength, periods of magnetic field and electromagnetic field with the lowest frequency which drew the attention of the biologists and chemists as physicists (Atak et al., 2003). Currently, magnetic technology was used to improve water quality and liquid solutions, it them involves the use of magnetic forces to magnetize the water or solutions. This technology is safe, simple, environmental friendly, cheap and harmless (Loraine, 2006). Magnetic water treatment technology does not change the chemical parameters of water and liquid solutions. However, it changes the physical parameters and according to some authors, magnetic fields can bring about changes in surface tension, density, viscosity, zeta potential, solubility, diffusion and other water properties (Campbell, 1977; Gang and Persinger, 2012). In these connections, Grewal and Maheshwari (2011) noticed that some changes occurred in some physical and chemical properties of water according to magnetic fields treatment, mainly hydrogen bonding, surface tension, polarity, pH, conductivity, and solubility of salts. Magnetic water technology has been widely-used for improving agricultural production and water quality. It increases the soil nutrient availability, solution, crop yields, germination rate, and eliminates scale formation in pipelines. Moreover, it may be used for improving water use efficiency and the added fertilizers (Ali et al., 2014). This technology is used mainly in countries like; Russia, Australia, Turkey, England, United States, Japan, China, Poland, Bulgaria and Egypt (Hozayn and Qados 2010). Recently, the use of magnetic fields (MFs) to stimulate plant growth has increased both quantitative and qualitative plant production, on the account of its lower detrimental influence on living organism and the environment (Selim and El-Nady, 2011; Jaime et al., 2014; Teixeira et al., 2014; Taimourya et al., 2017). One way of applying magnetic irrigation water treatment is by magnetizing water, thus creating magnetic water treatment. Harichand et al. (2002) observed that seed treatment with a magnetic field (1000 G; 40 h) increased plant height, seed weight per spike and subsequent yield of wheat crop. Recently Shukla et al. (2016) showed that the effect of magnetic field (0.5 Tesla) was able to give better result in increasing the growth of different crops grown in hydroponic system compared to the normal growth conditions. On the other hand, the magnetic treatment allows a beneficial effect on plant development a significant increase in the shoot fresh weight, root length and root fresh weight, mineral elements uptake (N, K and P) and chlorophylls content for both strawberry and tomato plants was obtained when they cultivated in magnetically treated culture medium (Taimourya et al., 2017).

Vegetable crops are grown and consumed worldwide as source of fibers and nutraceutical compounds in human diets (Pane et al., 2013). Lettuce (*Lactuca sativa* L.), an annual plant of the Asteraceae family (*Formally Compositae*), is a self pollinating plant cultivated for its edible rosette leaves and propagation is by seed (Wang et al., 2015). It has become an important commercial vegetable crop for local market and is a popular salad crop in the world, especially in urban areas of South Africa and Egypt (Hill, 1990; Niederwieser, 2001; Maboko, 2007). Recently the consumers tend to prefer organic production foods compared to others, because they are perceived more nutritious and tasty. Moreover, leafy vegetable particularly lettuce is gaining popularity in the market because it is full of vitamins and minerals with lots of fibers (Moreira et al., 2014).

Therefore, the objective of this study was to investigate the effects of mineral and organic nutrition treatments and magnetic field on the growth and yield of lettuce under the hydroponic system.

2. MATERIALS AND METHODS

2.1. Location and experimental conditions; To investigate the effects of magnetic field and liquid organic-nutrition treatments on the organic production of lettuce grown in the hydroponic system, a experiment was carried out in the Laboratory of the Soils and Water Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, during the winter season of 2018, under laboratory conditions with natural light and an average temperature of 24±2ºC.

2.2. Treatments and experimental design; The experiment was carried out in a randomized complete block design in a split-plot design, with six treatments and with three replications. Magnetic field with or without was first factor that occupied the main plots, and with three nutrient solutions in the subplots. The treatments were: control - T1 = mineral nutrient solution (Cooper, 1979), T2 = organic nutrient solution (mix-C.T), T3 = mix. 50:50 (50 mineral nutrient solution: 50 organic nutrient solution in v/v) without magnetic field and the same treatments (T1, T2 and T3) under the magnetic field effect called (T4, T5 and T6).

2.3. Experimental hydroponic unit; The hydroponic culture unit had a U-shape flat system (0.5 m width and 2 m length of the ribs). It was very similar to a commercial system and consisted of three pipes of PVC diameter 6 inch which were half, lengthwise filled with different studied growing media. The PVC pipes were holed every 25 cm net pots cultivated with lettuce plants using a density of 10 plants per an experimental unit were put in plant holes. This experimental unit had 1.5% slope and it has a water plastic tank (50-l capacity) for storage solutions. Different studied nutrient solutions were pumped via a submersible pump (40 watt, flow maximum of 1800 l/h and head maximum of 2.2 m), which had a timer set at 10 min/1 h which was the sufficient time to pump the amount of nutrient solution in tank that had one aeration pump with air stones.

2.4. Preparation of magnetic field; The magnetic field device in the hydroponic culture unit was provided with a magnetic field intensity of approximately 1.45 Tesla (nearly about 14500 Gauss) that was used for the magnetic treatments of different nutrient solutions under study to pass through the magnetic device before applying the plants. The magnetic treatment device which was placed after the submersible pump have a magnetizer (size 1 inch, output 12 m^3/h) produced by Delta Water Company Alexandria, Egypt (Figure 1). The magnetization of nutrient solutions was applied through the all period of experiment.

Fig. (1): The magnetizer device from Delta Water Company (Alexandria, Egypt).

2.5. Preparation of nutrition solutions; Two sources of nutrition solutions, the first used nutrition solution its mineral nutrient solution is illustrated in Table 1 according to Cooper (1979), was which obtained from Central Laboratory for Agricultural Climate, Agricultural Research Center, Giza, Egypt. The average ranges of electrical conductivity (EC) and pH of the nutrient solution were adjusted at the optimum values for the lettuce growth which were between, 1.0-1.5 dS/cm and 5.8-6.2, respectively, through the period of experiment. The second used nutrient solution was organic (mix-compost tea, mix-C.T). The nutrient solution of mix-CT was extracted in the liquid phase with a forced air blowing system. It was prepared, by soaking 5 kg of mix-compost (50:50 v/v ratio, plant waste: animal waste) in a tap water tank (50 l) to have a 1:5 (w/v) ratio to get the concentrated extract. That that is going to be used as an organic nutrient solution, supplemented with 0.5% humic acid and 1% molasses to stimulate microbial growth. The entire contents were continuously aerated at room temperature with air pump automatic ventilation (3 min in a 15, 30 or 45 min cycle) with an automatic electronic timer, at the end of the process. After one week (7-day fermentation cycle), mix-CT was filtered. The mix-CT was added after the dilution on the basis of EC and pH values which are the same values of the nutrient solution (Cooper, 1979) during the different plant growth stages. On the other hand, the commercial El Nile mix-compost was brought from the Egyptian company for recycling solid waste "ECARU". The chemical composition of mix-CT and mix-compost were present in Table 1.

Table 1. Chemical composition of nutrient solution Cooper (1979), mix-CT and mix-compost used in the experiment

Element	Nutrient solution, Cooper (1979)	Mix-CT solution	Mix-compost (50:50)
	mg/L		
N	200.00	111.19	10800.00
P	60.00	20.85	8000.00
K	300.00	172.66	10200.00
Ca	170.00	104.41	1730.00
Mg	50.00	51.36	1020.00
Fe	12.00	11.09	1500.00
Mn	2.00	1.21	150.00
Cu	0.10	0.17	180.00
Zn	0.10	0.16	80.00
B	0.30	0.20	20.00
Mo	0.20	--	--

2.6. Crop conduction of the lettuce: Lettuce seedlings it was brought ready from plantation of the Horticulture Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, were transplanted to the hydroponic system on 21 October, when had four leaves and the treatments started. To each hydroponic unit had 15 lettuce seedlings.

2.7. Variables evaluated: The plants were harvested on 6 December 2018, at 46 days after transplanting. At harvest, three plants were randomly removed from each hydroponic culture unit. Growth parameters such as plant height (cm); number of leaves/plant; total chlorophyll (mg\g tissue), using chlorophyll meter SPAD-501; diameter stem (cm) and leaf area (cm^2) was determined in these plants, according to Lima et al. (2007). In addition, yield components such as plant fresh weight (g), plant dry weight (g), dry matter (g/kg Fw.) and length of leaves (cm) were also determined. As for lettuce head content of macronutrient (N, P and K) were also determined in the dry matter of leaves, according to Cottenie et al. (1982). The samples were dried at 70°C and the dried samples were digested with concentrations of H_2SO_4 and H_2O_2 according to the method described by Allen (1974). Total-N content was determined by Kjeldahl method, total-P content was determined using spectrophotometer method and total-K content was determined using the flam photometer method, according to the procedure described by FAO (2008).

2.8. Statistical analysis; All data were subjected to analysis of variance by F-test, using software COSTAT program. Also, Duncan's multiple range test was used to compare treatment means at the 0.05 level probability.

3. RESULTS

3.1. Growth parameters

Table 2. Influence of magnetic field (MF) and nutrition treatments on growth parameters of hydroponic lettuce plant

Cod	Treatment		Plant height (cm)	No. leaves / plant	Total-Chlor. (mg\ g tissue)	Diameter stem (cm)	Leaf area (cm^2/plant)
	Magnetic field	Nutrition					
T1	Without	Min-Nutri.	36.47b	19.67bc	37.63ab	1.04cd	4169.67d
T2		Org-Nutri.	27.87d	14.00d	34.43b	0.91d	2138.00f
T3		Mix. 50:50	39.47a	22.67b	38.80a	1.15c	10770.00c
Mean			34.60b	18.78b	36.96b	1.03b	5692.56a
T4	With	Min-Nutri.	38.90ab	21.33c	39.20a	1.22b	40468.00a
T5		Org-Nutri.	32.47c	18.33c	38.10ab	1.01d	3280.33e
T6		Mix. 50:50	40.33a	25.00a	41.33a	1.49a	13759.33b
Mean			37.23a	21.56a	39.54a	1.24a	19169.22a

Min-Nutri. = Mineral Nutrition (nutrient solution), Org-Nutri. = Organic Nutrition (mix-CT), Mix. 50:50 = 50 Min-Nutri.:50 Org-Nutri. (V/ V).
The different letters indicate significant differences (analysis of variance, Duncan's test, ($P < 0.05$).

The shoot growth parameters (plant height, number of leaves/plant, total-chlorophyll, diameter stem and leaf area) of lettuce plants statistically showed significant increases in all nutrient solutions treated without or with magnetic field (Table 2). Moreover, lettuce plants grown in the mix-nutrient (mineral: organic, 50:50) treated with magnetic field (T6) gave the highest values in all growth parameters. Mineral nutrient solution without magnetic field treatment (T3) came in the second order followed by the mineral nutrient solution with magnetic field treatment (T4) except, the total-chlorophyll and diameter stem parameters. However, the lowest growth parameters were obtained by using the organic nutrient solution without the magnetic field treatment (T2). The highest values of plant height, number of leaves/plant, total-chlorophyll, diameter stem and leaf area occurred using T6 treatment (40.33 cm, 25.00, 41.33 mg\g tissue, 1.49 cm and 13759.33 cm^2/plant, respectively).

The average increases in plant height, number of leaves/plant, total-chlorophyll, diameter stem and leaf area using T6 treatment reached to 30.89, 44.00, 16.69, 38.93 and 84.46%, respectively compared to performing organic nutrient solution without magnetic treatment (T2). On the other hand, for the nutrient solutions treatments without using the magnetic field, T3 treatment, gave the higher growth parameters values with increases reached to 29.39, 38.24, 11.26, 20.87 and 80.15% for plant height, number of leaves/plant, total-chlorophyll, diameter stem and leaf area, respectively, compared to T2 treatment (organic nutrient solution without the magnetic field).

Therefore, the used of magnetic field of culture medium (mineral and organic nutrient solutions) under hydroponic system enhances the growth of lettuce plants. For all parameters, plants grown under the magnetic field treatment, showed better growth than lettuce plants without using this treatment. Applying mix-nutrient (mineral: organic, 50:50) with the magnetic field treatment (T6) statistically gave significant best results in most measurements.

3.2. Nutrient contents of plants

Nitrogen content and uptake of lettuce plants showed significant increases by using magnetic field with all nutrient solutions treatments (Table 3). The highest values of N content and uptake of lettuce plants (60.32 g/kg dry weight and 164.26 mg/plant, respectively) were obtained with using T6 treatment, with an increment of 15.92 % in the nitrogen content compared to T3 treatment (Table 3). Furthermore, the nitrogen uptake highly increased 32.83% with using T6 compared to the T3 treatment. However, the increase in the phosphorus (P) content and uptake of lettuce plants in all treatments with or without using magnetic field was not significant (Table 3). The highest values of P content and uptake (2.13 g/kg dry weight and 0.06 mg/plant, respectively) were obtained for T6 treatment, with an increment of 33.33 for in the P content, and 50.00% for the P-uptake compared to the T3. Regarding the potassium (K) content of the lettuce plants significant increases occurred in all treatments (Table 3). However, the increase in the K-uptake was not significant. The highest values of K content and uptake (18.62 g/kg dry weight and 0.51 mg/plant, respectively) were obtained for T6 treatment, with an increment of 24.73% in the K content, and 41.18%.

Table 3. Influence of magnetic field (MF) and nutrition treatments on the N, P and K contents of hydroponic lettuce plant

Cod	Treatment		N		P		K	
	Magnetic field	Nutrition	content (g/kg dry W.)	uptake (mg plant^{-1})	content (g/kg dry W.)	uptake (mg plant^{-1})	content (g/kg dry W.)	uptake (mg plant^{-1})
T1	Without	Min-Nutri.	32.81d	62.01d	1.11a	0.02a	10.62e	0.21a
T2		Org-Nutri.	25.51e	45.38e	0.83a	0.01a	12.53d	0.22a
T3		Mix. 50:50	50.70b	110.34b	1.45a	0.03a	14.02c	0.31a
Mean			36.30b	72.58b	1.13b	0.02b	12.33b	0.24b
T4	With	Min-Nutri.	37.31cd	78.42c	1.43a	0.03a	21.02a	0.44a
T5		Org-Nutri.	40.23c	75.03c	0.92a	0.02a	13.30cd	0.26a
T6		Mix. 50:50	60.32a	164.26a	2.13a	0.06a	18.62b	0.52a
Mean			43.91a	105.90a	1.51a	0.03a	17.61a	0.42a

Min-Nutri. = Mineral Nutrition (nutrient solution), Org-Nutri. = Organic Nutrition (mix-CT), Mix. 50:50 = 50 Min-Nutri.:50 Org-Nutri. (V/ V).
The different letters indicate significant differences (analysis of variance, Duncan's test, ($P < 0.05$).

in the K-uptake compared to using T3 treatment.

Fresh and dry weights of lettuce plants in the hydroponic system growth using all nutrient solutions and magnetic field treatments it shows in (Table 4). The maximum fresh and dry weights (163.19 and 27.38 g/plant, respectively) were recorded for T6. The average fresh and dry plant weights of lettuce plants for without using the magnetic field were 78.99 and 19.49 g/plant, respectively, and with using the magnetic field were 107.70 and 22.50g/plant, respectively. However, the lowest fresh and dry plant weights (43.69 and 17.81 g/plant, respectively) were found for T2 treatment.

The influence of magnetic field and nutrient solutions treatments on dry matter (g/kg Fw.) and length of leaves (cm) of lettuce plants under the hydroponic system is illustrated in Figure 3. The highest plant dry matter (410.13 g/kg Fw.) was with using T3 treatment, with an increment of 52.19% compared to that of T2 treatment. In addition, the highest length of leaves (36.67 cm) was with T6, with an increment of 37.28 % compared to that of T2 treatment.

4. DISCUSSION

In this study, the results obtained in this lab experiment showed the positive effects of mix-nutrient solution (50:50), treatment with magnetic field (T6) on shoot growth parameters (plant height, number of leaves/plant, total-chlorophyll, diameter stem and leaf area) and nutrient contents and accumulation of lettuce plants compared to untreated solution treatment T3. This suggests that the influence of T6 can lead to better lettuce growth and even to induce precocity in plant development. Early shoot growth parameters, have been found to be promoted by the mix-nutrient solution with magnetic field (Table 2). Use of a magnetic field of 0.15 mT on maize plants led to an increase in the shoot fresh

Table 4. Influence of magnetic field (MF) and nutriton treatments on fresh, dry plant weight, dry matter and length of leaves of hydroponic lettuce plant

Cod	Treatments		Fresh plant weight	Dry plant weight	Dry matter	length of leaves
	Magnetic	Nutrition	(g)	(g)	(g Kg^{-1} Fw.)	(cm)
T1	No-magnetic	Min-Nutri.	78.25±6.78bc	18.93±1.12bc	242.87±23.73b	29.00±1.00c
T2		Org-Nutri.	43.69±4.65c	17.81±0.34c	196.03±22.02bc	23.00±1.00e
T3		Mix. 50:50	115.02±5.93b	21.74±2.17b	410.23±37.92d	35.00±1.00abb
Mean			78.99	19.49	280.63	29.00
T4	With-magnetic	Min-Nutri.	107.15±6.26b	20.95±1.95bc	367.97±46.04a	33.33±1.53b
T5		Org-Nutri.	52.75±8.16c	19.17±1.02bc	188.80±11.48a	25.67±0.58d
T6		Mix. 50:50	163.19±46.73a	27.38±2.43a	176.97±49.40a	36.67±1.53a
Mean			107.70	22.50	246.99	31.89

Min-Nutri. = Mineral Nutrition (nutrient solution), Org-Nutri. = Organic Nutrition (mix-CT), Mix. 50:50 = 50 Min-Nutri.:50 Org-Nutri. (V/ V).

The different letters indicate significant differences (analysis of variance, Duncan's test, ($P < 0.05$).

weight by 72% compared to the control (Aladjadjiyan, 2002). Recently, Bilalis et al. (2013) found higher nutrient contents of cotton plants treated with a magnetic field resulted in higher rates of photosynthetic machinery. Nutrients like N, P and K improve the root and shoot growth parameters which in turn increase the intake of water which helps the stomata regulation. Similar results have been recorded by Nasher (2008) who concluded that the magnetized water increased growth and was considered an important factor for inducing plant growth parameters. Also, a magnetic treatment of a culture medium shows a significant increase in growth parameters like number of leaves, shoot length, shoot fresh weight, root length and root fresh weight of strawberry plants (Taimourya et al., 2017). In the current study where hydroponic nutrients were used to grow lettuce plants and we found that when complete system is placed in the magnetic field, it gives better result for plant growth compared to the normal plant growth condition (Shukla et al., 2016). Furthermore, the use of these mineral or organic nutrient solutions, the effectiveness of magnetic fields supports the conditions of root growth, produces better the growth parameters and finally improves the biological functions of the plant (Niederwieser, 2001; Belyavskaya, 2004, San Bautista et al., 2005; Fallovo et al., 2009; Jaime et al., 2014). Plant nutrient content and uptake analysis (Table 3) showed the positive effects of magnetic field pronounced in T6 treatment improving the nutrient (nitrogen, phosphorus and potassium) contents and uptakes by lettuce plants compared to the same treatment without using the magnetic field.

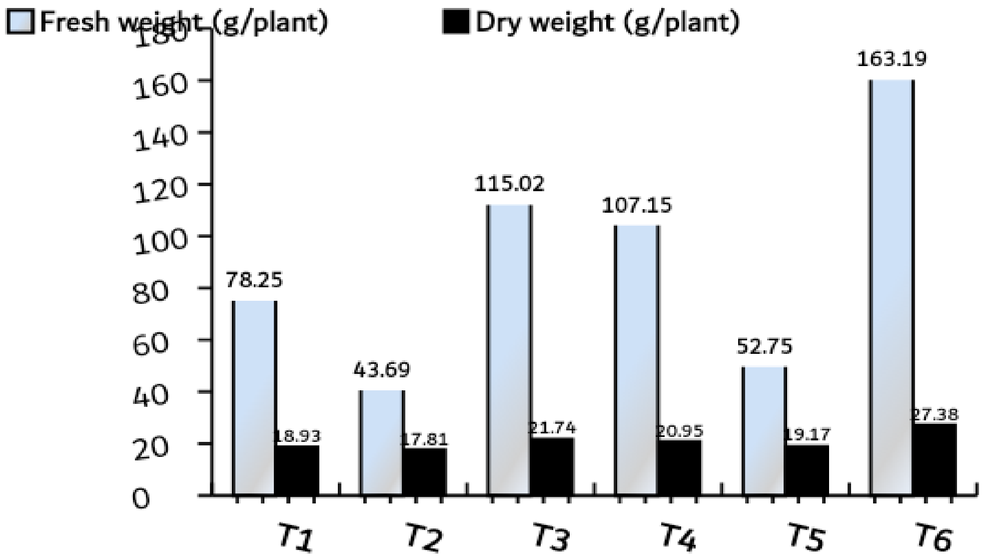

Fig 2. Influence of magnetic field (MF) and nutrition treatments on fresh and dry plant weight (g/plant) of hydroponic lettuce plants

The stimulatory effect of the magnetic field on the content and uptake of nutrients reported in this study may be due to the increase in total-chlorophyll pigments (Table 2). Also, these results may be due to the absorption of mineral nutrients N, P and K of mix-nutrient solutions and their mobility to the roots greatly improved when the magnetic treatment was used (Hilal and Hilal, 2000). Subsequently, use of mix-nutrient solution with magnetic field had a positive effect on the growth and N, P and K contents of lettuce. Bilalis et al. (2013) found that the plant uptake of N, P and K from growth media increased using the magnetic field treatment. In fact, when the nutrient solution is exposed to the magnetic field, the roots of plant are activated, allowing a better absorption of nutrients (Taimourya et al., 2017). Generally, applying the mix-nutrient solution 50:50 with the magnetic field (T6 treatment) significantly increased the nutrient contents and uptakes of lettuce plants. This could be a result of using the mix-nutrient solutions as mixture of organic and inorganic fertilizers that has many advantages, as well as the positive effect of magnetic field in increasing the absorption and assimilation of nutrients. Various studies have demonstrated higher absorption of nutrients in plants when exposed to magnetic field or irrigated with magnetic water treatments. There are few publications research on the effect of magnetic fields under the hydroponic system on nutrients content and uptake by plants. Only recently, Shukla et al. (2016) found that the magnetic field is able to increase the growth of plants and nutrients content under the hydroponic system and proved that the magnetic field is able to give a better result compared to the conventional method of farming. Similar results have been recorded by Taimourya et al., (2017) who reported that the magnetic treatment allows a beneficial effect on the mineral element uptake (K and P) and chlorophylls content when the plants are grown in magnetically treated culture medium.

Regarding to the fresh, dry plant weights (g/plant) and length of leaves (cm), the results showed that all plant growth parameters significantly increased when the lettuce plants were treated with magnetic fields compared to the same treatment without using magnetic fields (Figures 2 and 3). In general, the seedling of lettuce grown in mix-nutrient solution with magnetic field, (T6) had a positive effect on the growth and nutrient contents of lettuce and increased fresh, dry plant weights. However, the increase in the dry matter weight of lettuce plants grown in a nutrient solution with magnetic field was not significant. The positive effect of mix-nutrient solution with magnetic field on fresh, dry plant weight and length of lettuce leaves may be attributed to the role of nutrient solution and magnetic treatment in increasing the absorption and assimilation of nutrients.

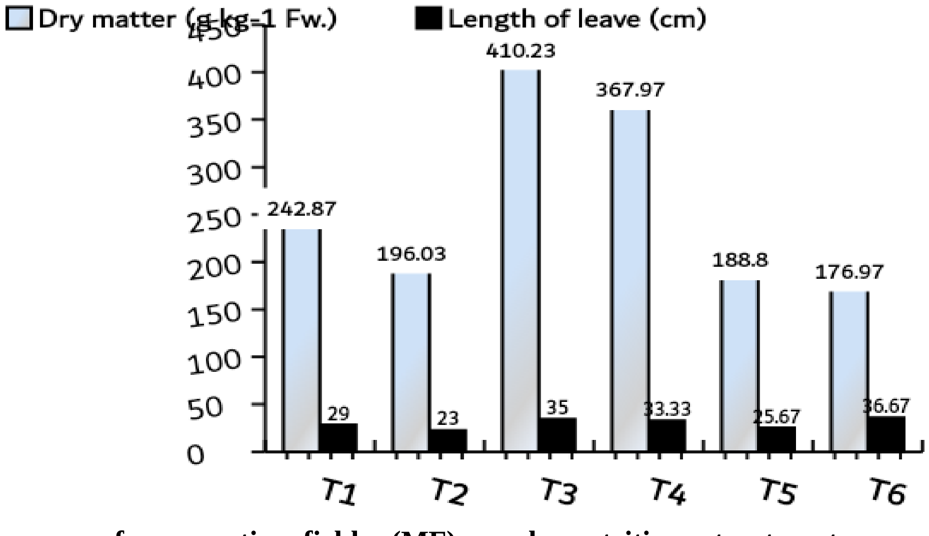

Fig 3. Influence of magnetic field (MF) and nutrition treatments on dry matter (g kg^{-1} Fw.) and length of leaves (cm) of hydroponic lettuce plants

Various studies have demonstrated higher fresh and dry weights when the plants were irrigated with nutrient solution treated with the magnetic field. Hozayn and Qados (2010) showed that the fresh weight was significantly increased when flax plants were irrigated with a nutrient solution treated with a magnetic field. These results are in with line with those of El Sayed (2014) who observed that pretreatment of seeds nutrient solution and a magnetic field increased leaf, stem and root fresh and dry weights of tomato. Furthermore, the application of these organic nutrient solutions mixed with mineral ones in presence of a magnetic field effect showed the best conditions of root growth, increases the plant growth parameters and are reflected on all parts of plant and its components. Finally improving the yield and biological functions of the plants (Hilal and Hilal, 2000; Harichand et al., 2002; Maboko, 2007; Islam, 2008; Grewal and Maheshwari, 2011; Florez, 2012; Ali et al., 2014; Shukla et al., 2016).

5. CONCLUSION

The application of magnetic field affects on an organic nutrient solution mixed with a mineral nutrient solution treatment under the hydroponic system can improve plant growth parameters and the accumulation of the nutrients. Moreover, this technique is organic production and environment friendly, an attribute highly desirable in modern hydroponic system. Lettuce plants when exposed to magnetic fields were found to grow faster and all growth parameters are enhanced, resulting the bigger and heavier plants than without exposed to magnetic fields. Result also shows using an organic nutrient solution mixed with a mineral one with magnetic fields, less time for the plant growth occurred compared to without magnetic fields treatments.

Generally, in the soilless culture production, using magnetic technology could be a promising technique for hydroponic systems which improves the efficiency of the added organic nutrient solution. In sum, magnetic technologies under hydroponic system appear as a promising growth parameter stimulation approach even under soil conditions.

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الملخص العربي

فعالية مصادر التغذية المختلفة والحقول المغناطيسية علي نمو الخس تحت نظام الزراعة المائية

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تهدف الدراسة إلى التحقيق من تأثير الحقل المغناطيسي ومصادر تغذية مختلفة على نمو نباتات الخس تحت نظام الزراعة المائية. أجريت تجربة زراعة مائية و شملت ثلاث أنواع من التغذية النباتية هي؛ تغذية معدنية، تغذية عضوية وخليط من التغذية المعدنية والعضوية بنسبة ٥٠:٥٠ مع وبدون تأثير الحقل المغناطيسي وذلك في معمل الزراعة المائية بقسم الأراضي والمياه، كلية الزراعة، جامعة الأزهر، أسيوط، مصر، خلال فصل الشتاء لعام ٢٠١٨ م .

تم استخدام جهاز حقل مغناطيسي ذو قوة فيض مغناطيسي ١٤٥٠٠ جاوس تقريباً للمعالجة المغناطيسية لمحاليل التغذية المستخدمة. وتشير هذه الدراسة إلى أن تأثير محاليل التغذية المختلفة مع معاملة المعالج المغناطيسي أدت الي زيادات كبيرة في جميع قياسات النمو للنبات مقارنة بالمعاملات الأخرى. وقد أعطت معاملة خليط التغذية (المعدنية:العضوية، ٥٠:٥٠) تحت تأثير الحقول المغناطيسية (٦T) افضل النتائج حيث أدت الي زيادات كبيرة معنويا في جميع قياسات النمو ومحتوى النبات من عناصر N، P و K ؛ وكانت نتائج هذه المعاملة لقياسات النمو هي؛ طول النبات، عدد الأوراق لكل نبات، الكلوروفيل الكلي، قطر الساق ومساحة الورقة هي ٤٠,٣٣ سم ، ٢٥,٠٠ ، ٤١,٣٣ ملجم/ جرام ، ١,٤٩ سم ، ١٣٧٥٩,٣٣ سم^2/النبات وكذلك محتوي العناصر كانت ٦٠,٣٢ ، ٢,١٣ و ١٨,٦٢ جرام/كجم مادة جافة، على التوالي.وتشير هذه الدراسة إلى أن تأثيرمعاملات الحقل المغناطيسي بمثابة تطبيق وقائي لمحاليل التغذية العضوية تحت نظام الزراعة المائية العضوية لنبات الخس وتوصي بتطبيق المعاملة رقم (٦T) .