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Effect of Moisture Stress and Magnetized Water on Growth Parameters and Yield Characteristics of Onion Plants

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Abstract : Two pot experiments were conducted during 2014/2015 and 2015/2016 seasons under open field conditions of private field at Sharkia Governorate, Egypt. The investigation aimed to study the effect of magnetized water and different levels of water supply (100, 80 and 60% of F.C. i.e. field capacity) on growth parameters and yield characters as well as photosynthetic pigments content of onion plants (cv. Giza red). Results indicated that decreasing water supply caused a significant reduction in all tested growth and yield parameters i.e. plant height, fresh and dry weights of leaves, bulb height, bulb diameter, fresh and dry weights of bulb and dry matter percentage as well as photosynthetic pigments content (chl. a, chl. b and carotenoids) in the two seasons as compared with control (normally irrigated plants). On the other hand, irrigation with magnetized water significantly increased the aforementioned parameters in the two seasons as compared with control.
Keywords: Water stress, Magnetized water, Growth, Yield, Onion plants.

Introduction

Onion (*Allium cepa* L.) is considered one of the most important vegetable crops in Egypt. The total planted area in year 2014 was 143915 feddans, which produced about 2464688 tones **FAO[1] and M. A.L. R.**[2]. The important problem face the onion producer is producing high yield that meet the quality standards and market requirements with less water usein irrigation. Onions are considered as a shallow rooted crop, which are faces great problem to irrigate and have limited water efficiency values.

Water stress is one of the limiting factors to growth and yield in many countries. **Ebtisam *et al.* [3], Sabreen *et al.*[4]** showed that different irrigation levels applied has significant effect on yield components.

Magnetized water is water that has been passed through a magnetic field, and its environmentally friendly, with low installation costs and no energy requirements.

Pejic *et al.* [5] cleared that onions yield and quality decreased with increasing soil-water stress, which is not considered obviously in many of the previous research works.

The use of magnetized water for irrigation have the positive effect to save irrigation water and the less harmful influence on the environment **Mostafazadeh *et al.*** [6]. Irrigation with magnetized water increased significantly the growth characteristics, kinetin, GA_3, nucleic acids (RNA and DNA), potassium, photosynthetic pigments (chlorophyll a & b and carotenoids), photosynthetic activity and translocation efficiency of photo-assimilates as compared with control plants as reported by **Moussa**[7].

Therefore, this study aimed to assess the effect of magnetized water on growth and yield characters of onion plants grown under different levels of water supply.

Material and Methods

This experiment was carried out under open field conditions of private field at Sharkia Governorate, during two successive seasons of 2014/2015 and 2015/2016 to study the effect of magnetized water and different levels of water supply on growth, photosynthetic pigments content in leaves and yield. Onion (*Allium cepa* L.) cv. Giza red seedlings were planted on December 8th in the two seasons at the rate of four bulbs per pot. Plastic pots (30 cm diameter) were field with 20 kg of air-dried silty clay soil. The experiment included two factors the first was water types (magnetic water, i.e. (2.5 inch, output 40 m^3 /hr.) and normal water (control)), the second was three levels of water supply (100%, 80% and 60% of F.C.).The experiment included six treatments arranged, in both seasons, in complete randomized system in ten replications for each treatment. Phosphorus and potassium fertilizers were added to soil before transplanting at the rate of 5 gram P_2O_5/pot in the form of calcium superphosphate (15% P_2O_5)2.5 gram K_2O/pot in the form of potassium sulphate (48% K_2O). Nitrogen fertilizer was used at the rate of 5.60 g N\pot in the form of ammonium nitrate (33.5%N). After 30 days from transplanting onion plants were subjected to three levels of soil moisture until harvest a) Irrigation after 60% depletion of F.C. i.e. normal water supply b) Irrigation after 80% depletion of F.C. i.e. moderate water supply c) Irrigation after 100% depletion of F.C. i.e. moisture stress. The pots were weighed daily and the needed amount of water was added to each pot with normal or magnetized water. Representative plant sample was obtained from three replicates for each treatment. After 90 days from sowing where plant height, fresh and dry weight of leaves per plant were determined and photosynthetic pigments content i.e. chlorophyll a, chlorophyll b and carotenoids (mg/ 100g of fresh weight) were extracted by aqueous solution of 85% acetone and calculated by using Von Wettstein formula **according to Von Wettstein [8]**. At harvest time, bulb length, bulb diameter, bulb fresh and dry weight and dry weight% were determined. The data of the experiments were subjected to statistical analysis as factorial experiment in complete randomized block design according to **Snedecor and Cochran [9]**.

Table 1: Soil characteristics in the two seasons before sowing.

Sand (%)	Silt (%)	Clay (%)	Textural class	FC %	PWP %	AW %	Soil pH (1:2.5)	Electric conductivity (dS_m^{-1}) (1:5)
10%	45%	45%	Silty clay	36%	17%	19%	7.00	1.64

Results and Discussion

Growth parameters

Data presented in Table 2 indicated that vegetative growth characters including plant height, fresh and dry weights of leaves were significantly decreased by increasing soil moisture stress (irrigation after 100% depletion of F.C.) in the two seasons as compared with those grown under normal water supply (irrigation after 60% depletion of F.C.). The uppermost values of plant height were 70.40 and 67.47 (cm) for magnetized water and the lowermost values were 65.87 and 63.07 (cm) for control, respectively in the two experimental seasons. Regarding water stress levels effect, it is clear that plant height decreased with water stress level being 74.40, 68.40 and 61.60 (cm) for 100, 80 and 60% of F.C., respectively in the first season. The values in the second season were 71.30, 67.00 and 57.50 (cm) for 100, 80 and 60% of F.C., respectively.

The uppermost values of leaves fresh weight were 47.47 and 44.40 (g) for magnetized water and the lowermost values were 42.27 and 38.47 (g) for control, respectively in the two experimental seasons. Concerning water stress levels effect, it is clear that leaves fresh weight decreased with water stress level being 56.30, 46.20 and 32.10 (g) for 100, 80 and 60% of F.C., respectively in the first season. The values in the second season were: 50.90, 43.50 and 29.90 (g) for 100, 80 and 60% of F.C., respectively.

The uppermost values of leaves dry weight were 5.28 and 4.62 (g) for magnetized water and the lowermost values were 4.16 and 3.63 (g) for control, respectively in the two experimental seasons. Concerning water stress levels effect, it is clear that leaves dry weight decreased with water stress level being 6.80, 4.55 and 2.81 (g) for 100, 80 and 60% of F.C., respectively in the first season. The values in the second season were: 5.71, 4.17 and 2.48 (g) for 100, 80 and 60% of F.C., respectively.

Data in the same table show that plant height, fresh and dry weights of leaves were significantly increased with using magnetized water in the two seasons as compared with control (normal water). In this connection, **Fomicheva *et al.* a & b [10,11] and Belyavskaya** [12] reported that cell metabolism and mitosis meristematic cells of pea, lentil and flax can be induced by used magnetized water. Moreover, the stimulation of all growth, and promoters in plants treated with magnetized water is responsible for the formation of new protein bands. In this respect, **Shabrangi and Majd [13]** concluded that, increasing protein biosynthesis is responsible for biomass increasing. **Reina *et al.* [14]** found that increase of magnetic force had significant effect of increase the rate of water absorption accompanied with an increase in total mass of lettuce. Moreover, **Suhail and Mahdi [15]** reported that irrigation with magnetized water increased plant height and fresh weight of onion plant.

Concerning the interaction, the highest plant height, fresh and dry weights of leaves values were obtained in plants irrigated with 100% of F.C. and using magnetized water where as the lowest values were recorded for control plants (100% of F.C. with normal water) in the two experimental seasons.

The interaction of plant height between water types and water stress levels revel uppermost values with magnetized water × 100% being 77.20 and 72.20 (cm) in the first and the second seasons, respectively. On the other hand, the lowermost values came from the interaction control × 60% being 59.20 and 53.40 (cm) in the first and the second seasons, respectively.

The interaction of leaves fresh weight between water types and water stress levels revel uppermost values with magnetized water × 100% being 62.40 and 55.20 (g) in the first and the second seasons, respectively. On the other way, the lowermost values came from the interaction control × 60% being 30.00 and 28.40 (g) in the first and the second seasons, respectively.

The interaction of leaves dry weight between water types and water stress levels revel uppermost values with magnetized water × 100% being 8.09 and 6.54 (g) in the first and the second seasons, respectively. On the other way, the lowermost values came from the interaction control × 60% being 2.51 and 2.21 (g) in the first and the second seasons, respectively.

These results are in harmony with those results obtained by **Zayton [16], Abdul Qados and Hozayn [17], Hozayn and Abdul Qados [18]** they reported that plant height and fresh weight increased with increasing soil moisture level.

Table 2: Effect of magnetized water and different levels of water supply on plant height, fresh and dry weight of leaves of onion plants after 90 days from sowing (2014/2015-2015/2016 seasons).

Treatments	Plant height (cm)	Leaves fresh weight (g)	Leaves dry weight (g)
First season			
Control	65.87 B	42.27 B	4.16 B
Magnetized water	70.40 A	47.47 A	5.28 A
100% F.C	74.40 A	56.30 A	6.80 A
80% F.C	68.40 B	46.20 B	4.55 B
60% F.C	61.60 C	32.10 C	2.81 C
Control × 100% F.C	71.60 b	50.20 b	5.50 b
Control × 80% F.C	66.80 c	46.60 c	4.46 d
Control × 60% F.C	59.20 e	30.00 e	2.51 f
Magnetized water × 100% F.C	77.20 a	62.40 a	8.09 a
Magnetized water × 80% F.C	70.00 b	45.80 b	4.64 c
Magnetized water × 60% F.C	64.00 d	34.20 d	3.12 e
Second season			
Control	63.07 B	38.47 B	3.63 B
Magnetized Water	67.47 A	44.40 A	4.62 A
100% F.C	71.30 A	50.90 A	5.71 A
80% F.C	67.00 B	43.50 B	4.17 B
60% F.C	57.50 C	29.90 C	2.48 C
Control × 100% F.C	70.40 b	46.60 b	4.89 b
Control × 80% F.C	65.40 c	40.40 c	3.77 d
Control × 60% F.C	53.40 e	28.40 e	2.21 f
Magnetized water × 100% F.C	72.20 a	55.20 a	6.54 a
Magnetized water × 80% F.C	68.60 b	46.60 b	4.57 c
Magnetized water × 60% F.C	61.60 d	31.40 d	2.75 e

Photosynthetic pigments content

Data in Table 3 indicated that photosynthetic pigments content, i. e chlorophyll a, chlorophyll b and carotenoids were significantly decreased by increasing soil moisture stress (irrigation after 100% depletion of F.C.) in the two seasons as compared with those grown under normal water supply (irrigation after 60% depletion of F.C.). The uppermost values of Chll. a were 0.57 and 0.52 (mg/ 100g of F. W.) for magnetized water and the lowermost values were 0.50 and 0.44 (mg/ 100g of F. W.) for control, respectively in the two experimental seasons. Regarding water stress levels effect, it is clear that Chll. a decreased with water stress level being 0.65, 0.52 and 0.42 (mg/ 100g of F. W.) for 100, 80 and 60% of F.C., respectively in the first season. The values in the second season were: 0.60, 0.50 and 0. 35 (mg/ 100g of F. W.) for 100, 80 and 60% of F.C., respectively.

The uppermost values of Chll. b were 0.20 and 0.20 (mg/ 100g of F. W.) for magnetized water and the lowermost values were 0.18 and 0.16 (mg/ 100g of F. W.) for control, respectively in the two experimental seasons. Concerning water stress levels effect, it is clear that Chll. b decreased with water stress level being 0.21, 0.20 and 0.16 (mg/ 100g of F. W.) 100, 80 and 60% of F.C., respectively in the first season. The values in the second season were: 0.20, 0.18 and 0.16 (mg/ 100g of F. W.) for 100, 80 and 60% of F.C., respectively.

The uppermost values of carotenoids were 0.54 and 0.50 (mg/ 100g of F. W.) for magnetized water and the lowermost values were 0.48 and 0.41 (mg/ 100g of F. W.) for control, respectively in the two experimental seasons. Concerning water stress levels effect, it is clear that carotenoids decreased with water stress level being 0.59, 0.51 and 0.42 (mg/ 100g of F. W.) for 100, 80 and 60% of F.C., respectively in the first season. The values in the second season were: 0.57, 0.46 and 0.33 (mg/ 100g of F. W.) for 100, 80 and 60% of F.C., respectively.

Abdalla and El-Khoshiban[19] reported that photosynthetic pigments content decreased by increasing water stress was in response to the ultra structural deformation of plastids including the protein membranes forming the thylakoids which in turn cause untying of photo system 2 which captures photons, so its efficiency declined, that caused declines in ATP and NADPH production, electron transfer and eventually Co2 fixation processes.

Data in the same table indicated that photosynthetic pigments content, i. e chlorophyll a, chlorophyll b and carotenoids were significantly increased with using magnetized water as compared with control (normal water). This came true in both seasons. The positive effect of magnetized water was explained by **Hilal and Helal** [20] **and Suhail and Mahdi**[15] who reported that irrigation with magnetized water due to increase in the absorption of Ca^{++} , Mg^{++}, So_4^{--} and increase in wash salts and low alkaline soil and low Na^{+} absorption, leading to lower concentration of positive and negative ions remaining in soil. Magnetized water improves stimulates the roots to penetrate the soil and the permeability of the cell membrane as reported by **Fluid Energy Australia Report** [21].

Concerning the interaction, photosynthetic pigments content, i. e chlorophyll a, chlorophyll b and carotenoids increased in plants irrigated with 100% of F.C. using magnetized water comparing with control plants (100% of F.C. with normal water) in the two experimental seasons.

The interaction of Chll. a between water types and water stress levels revel uppermost values with magnetized water × 100% being 0.70 and 0.62 (mg/ 100g of F. W.) in the first and the second seasons, respectively. On the other hand, the lowermost values came from the interaction control × 60% being 0.40 and 0.40 (mg/ 100g of F. W.) in the first and the second seasons, respectively.

The interaction of Chll. b between water types and water stress levels revel uppermost values with magnetized water × 100% being 0.22 and 0.21 (mg/ 100g of F. W.) in the first and the second seasons, respectively. On the other way, the lowermost values came from the interaction control × 60% being 0.15 and 0.12 (mg/ 100g of F. W.) in the first and the second seasons, respectively.

The interaction of carotenoids between water types and water stress levels revel uppermost values with magnetized water × 100% being 0.64 and 0.60 (mg/ 100g of F. W.) in the first and the second seasons, respectively. On the other way, the lowermost values came from the interaction control × 60% being 0.40 and 0.26 (mg/ 100g of F. W.) in the first and the second seasons, respectively.

Moussa[7] found that irrigation magnetized water increased significantly the growth characteristics, photosynthetic activity and translocation efficiency of photo-assimilates and photosynthetic pigments (chlorophyll a, b and carotenoids), as compared with control plants.

Yield characters

Data presented in Table 4 indicated that yield characters including bulb height, bulb diameter, bulb fresh and dry weight and dry matter% were significantly decreased by increasing soil moisture stress (irrigation after 100% depletion of F.C.) in the two seasons as compared with those grown under normal water supply (irrigation after 60% depletion of F.C.).

The uppermost values of bulb height were 41.40 and 41.07 (mm) for magnetized water and the lowermost values were 40.87 and 38.60 (mm) for control, respectively in the two experimental seasons. Concerning water stress levels effect, it is clear that bulb height decreased with water stress level being 43.00, 40.60 and 39.80 (mm) for 100, 80 and 60% of F.C., respectively in the first season. The values in the second season were 41.70, 39.00 and 38.80 (mm) for 100, 80 and 60% of F.C., respectively. The interaction between water types and water stress levels revel uppermost values with magnetized water × 100% being 43.60 and 42.60 (mm) in the first and the second seasons, respectively. On the other way, the lowermost values came from the interaction control × 60% being 38.80 and 36.20 (mm) in the first and the second seasons, respectively.

The uppermost values of bulb diameter were 50.53 and 47.33 (mm) for magnetized water and the lowermost values were 45.27 and 44.87 (mm) for control, respectively in the two experimental seasons. Concerning water stress levels effect, it is clear that bulb diameter decreased with water stress level being 52.80, 47.50 and 43.40 (mm) for 100, 80 and 60% of F.C., respectively in the first season. The values in the second season were: 51.30, 46.00 and 41.00 (mm) for 100, 80 and 60% of F.C., respectively. The interaction between water types and water stress levels revel uppermost values with magnetized water × 100% being 57.60

and 53.20 (mm) in the first and the second seasons, respectively. On the other way, the lowermost values came from the interaction control × 60% being 41.20 and 39.60 (mm) in the first and the second seasons, respectively.

The uppermost values of bulb dry matter were 40.94 and 39.80 (%) for magnetized water and the lowermost values were 38.82 and 37.67 (%) for control, respectively in the two experimental seasons. Concerning water stress levels effect, it is clear that bulb dry matter percentage decreased with water stress level being 42.46, 39.34 and 36.77 (%) for 100, 80 and 60% of F.C., respectively in the first season. The values in the second season were: 41.18, 38.60 and 35.43 (%) for 100, 80 and 60% of F.C., respectively. The interaction between water types and water stress levels revel uppermost values with magnetized water × 100% being 43.50 and 42.07 (%) in the first and the second seasons, respectively. On the other way, the lowermost values came from the interaction control × 60% being 35.71 and 33.14 (%) in the first and the second seasons, respectively.

Data in the same Table showed that bulb height, bulb diameter, bulb fresh and dry weight and dry matter% were significantly increased with using magnetized water as compared with control (normal water). This came true in both seasons. According to **Hozayn and Abdul Qados [18],** magnetized water increased significantly chickpea yield and its components. Obtained results are laid to improvement growth parameters and photosynthetic pigments and growth promoters (IAA).

Table 3: Effect of magnetized water and different levels of water supply on leaf pigments and carotenoids of onion plants after 90 days from sowing (2014/2015-2015/2016 seasons).

Treatments	Chlorophyll A (mg/ 100g of F. W.)	Chlorophyll B (mg/ 100g of F. W.)	Carotenoids (mg/ 100g of F. W.)
First season			
Control	0.50 B	0.18 B	0.48 B
Magnetized Water	0.57 A	0.20 A	0.54 A
100% F.C	0.65 A	0.21 A	0.59 A
80% F.C	0.52 B	0.20 B	0.51 B
60% F.C	0.42 C	0.16 C	0.42 C
Control × 100% F.C	0.60 b	0.20 b	0.55 b
Control × 80% F.C	0.49 c	0.19 c	0.48 c
Control × 60% F.C	0.40 d	0.15 d	0.40 d
Magnetized water × 100% F.C	0.70 a	0.22 a	0.64 a
Magnetized water × 80% F.C	0.55 b	0.20 b	0.54 b
Magnetized water × 60% F.C	0.45 c	0.17 c	0.44 c
Second season			
Control	0.44 B	0.16 B	0.41 B
Magnetized Water	0.52 A	0.20 A	0.50 A
100% F.C	0.60 A	0.20 A	0.57 A
80% F.C	0.50 B	0.18 B	0.46 B
60% F.C	0.35 C	0.16 C	0.33 C
Control × 100% F.C	0.57 b	0.19 b	0.54 b
Control × 80% F.C	0.46 c	0.17 c	0.43 c
Control × 60% F.C	0.40 d	0.12 d	0.26 d
Magnetized water × 100% F.C	0.62 a	0.21 a	0.60 a
Magnetized water × 80% F.C	0.53 b	0.19 b	0.49 b
Magnetized water × 60% F.C	0.42 c	0.19 b	0.40 c

Concerning the interaction, the highest bulb height, bulb diameter, bulb fresh and dry weight and dry matter% were showed in plants irrigated with 100% of F.C. using magnetized water comparing with control plants (100% of F.C. with normal water) in the two experimental seasons.

Obtained results are in harmony with those results reported by **El-Haris and Adbel Razek [22], Olalla *et al.* [23], Kumar *et al.* [24], Zayton [16], Abdul Qados and Hozayn [17], Hozayn and Abdul Qados [18], Metwally [25] and Pejic *et al.* [5]** they revealed that growth characteristics, yield and yield components generally improved with the increased in total water applied during growing period. **Suhail and Mahdi [15]** confirmed that irrigation with magnetized water increased yield and yield components.

Table 4: Effect of magnetized water and different levels of water supply on bulb height, bulb diameter, bulb fresh weight, bulb dry weight and bulb dry matter percentage of onion plants at harvest time (2014/2015-2015/2016 seasons).

Treatments	Bulb height (mm)	Bulb diameter (mm)	Bulb fresh weight (g)	Bulb Dry weight (g)	Bulb dry matter (%)
First season					
Control	40.87 B	45.27 B	49.80 B	19.33 B	38.82 B
Magnetized Water	41.40 A	50.53 A	61.87 A	25.33 A	40.94 A
100% F.C	43.00 A	52.80 A	72.30 A	30.70 A	42.46 A
80% F.C	40.60 B	47.50 B	52.50 B	20.60 B	39.24 B
60% F.C	39.80 C	43.40 C	42.70 C	15.70 C	36.77 C
Control × 100% F.C	42.40 b	48.00 b	60.00 b	24.60 b	41.00 b
Control × 80% F.C	41.40 c	46.60 b	50.20 d	19.40 d	38.65 d
Control × 60% F.C	38.80 d	41.20 d	39.20 e	14.00 e	35.71 f
Magnetized water × 100% F.C	43.60 a	57.60 a	84.60 a	36.80 a	43.50 a
Magnetized water × 80% F.C	39.80 d	48.40 b	54.80 c	21.80 c	39.78 c
Magnetized water × 60% F.C	40.80 c	45.60 c	46.20 d	17.40 d	37.66 e
Second season					
Control	38.60 B	44.87 B	46.53 B	17.53 B	37.67 B
Magnetized Water	41.07 A	47.33 A	55.27 A	22.00 A	39.80 A
100% F.C	41.70 A	51.30 A	62.90 A	25.90 A	41.18 A
80% F.C	39.00 B	46.00 B	50.00 B	19.30 B	38.60 B
60% F.C	38.80 C	41.00 C	39.80 C	14.10 C	35.43 C
Control × 100% F.C	40.80 b	49.40 b	56.40 b	22.60 b	40.07 b
Control × 80% F.C	38.80 c	45.60 b	48.80 d	18.60 d	38.11 d
Control × 60% F.C	36.20 d	39.60 d	34.40 e	11.40 e	33.14 f
Magnetized water × 100% F.C	42.60 a	53.20 a	69.40 a	29.20 a	42.07 a
Magnetized water × 80% F.C	39.20 c	46.40 b	51.20 c	20.00 c	39.06 c
Magnetized water × 60% F.C	41.40 b	42.40 c	45.20 d	16.80 d	37.17 e

Conclusion

Yield and vegetative growth parameters including plant height, fresh and dry weights of leaves, photosynthetic pigments content (i. e chlorophyll a, chlorophyll b carotenoids) were significantly decreased by increasing soil moisture stress (irrigation after 100% depletion of F.C.), while the same parameters were significantly increased by magnetized water application.

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