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Growth and root yield of carrot as affected by magnetic water and sowing times

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Abstract

This study examines effects of two sowing times (28/10 and 14/11 of 2014) and different levels of magnetic treatment of irrigation (0, 2500, 5000gauss) on productivity and yield of carrot plants. A pot experiment was conducted at the Agriculture Research Center, Ministry of Agriculture in Kurdistan region-Iraq. This study was carried out during 28-10-2014 and 14-5-2015 the two factor experiment was laid out in complete randomized design with four replicates, each replicate contain three plants. Data were collected from all plants at harvest time and statistically analyzed. Comparisons between means were made by using least significant differences test (LSD) at 5% probability. Magnetized water at the level of 2500gause caused the most significant effects on plant length (55.58cm), root length (30.19cm), (root diameter (35.14mm) and root dry weight (128.19gm). However, the sowing time 14/11 was more effective on plant length (54.64cm) and vegetative growth fresh weight (17.64gm). While the longest root obtained when the seeds sown in 28/10. On the other hand the interaction of 2500gauss and 4/11/2014 sowing time gave the maximum plant length, shoot fresh weight and root diameter (59.67cm, 20.63 gm and 43.75mm respectively), but the longest root and highest root fresh weight were found in the interaction of the same level of magnetic water with 28/10/2014 sowing time. The highest amount of the chlorophyll in the leaves (52.815%) was measured from the interaction of 2500gauss magnetic water and 14/11/2014 sowing time, and the best carotene content in the roots (3.427mg/ml) was obtained from 5000gauss magnetic water in the same sowing time.

Introduction

Carrot (*Daucus carota L.*) belonging to family Umbelliferae, and is a very common winter season vegetable [13]. Carrot is rich in beta-carotene and an excellent source of iron, calcium, phosphorus, vitamin B, sugar and folic acid [7]. It is also has some medicinal values in the production of vitamin A [21].

Sowing time is important because carrots can be grown well in the tropics where high elevation give cool night temperature and in temperate regions of the world. Carrot can be grow well at relevant temperature of 15°C to 20°C and can withstands low temperature up to 5°C and high up to 24°C,this therefore favors cool season conditions. Temperature above or below this range may reduce seed germination [13]. Extremely high and low temperatures have a negative effect on carrot growth, yield and quality because at both extremes the growth ceases, yield is decreased and the quality (both internal and external) is affected. When temperatures rise too high above the optimum, growth and yield are drastically reduced, and the quality is also eventually affected negatively. Carrot roots tend to be shorter and thicker at very high temperatures and when temperatures are too low the roots become longer and thinner. Because of these temperature requirements the time of sowing carrot seeds is critical.

The internal quality of carrots is also affected negatively by high temperatures as the production of terpenoids, responsible for the bitter taste is increased, thereby masking the sweet taste of carrot roots [15].

Hence the need for more efficient utilization and management of scarce irrigation water for high quality crop production [7]. Though, plants get major nutrients from the soil depending on water supplement, they are not adequate to meet the increasing demand for higher production. In carrot growing areas of country, many soils are unable to supply the required nutrients. Hence, the importance of organic source of energy in promoting soil health and better plant nutrition has gained much attention on a global level. The organic sources help in improving physico-chemical characteristics, fertility of soil and increases crop yield [17].

Water is a liquid crystal with a pliable lattice matrix that is capable of adapting in many structural forms. It flows from higher potential to lower potential. Water works as a bridge between the world of energy and matter and it is may be reformed by exposure to electromagnetic force when it is turbulent [12]. Agricultural sciences take an interest not only in the common and valued crop forming factors, but also in those less expensive, safe environmentally and generally underestimated. The technology of magnetic water has been developed and subsequently used widely in the field of agriculture in many countries such as Australia, USA, China and Japan. Further results indicated that the number of protein bands got increased in plants treated with magnetized water when compared to untreated control plants. Moreover, the magnetized water treatment increased yield and yield component traits of studied crops [9]. Irrigation with magnetized water could be employed as one of the most valuable modern technologies that can assist in saving irrigation water and improving yield and quality of sugar beet, the usage of magnetic water in the agriculture production will enable intense and more quantities and qualitative production [11], and moreover magnetized water for irrigation is recommended to save irrigation water [18]. Wherefore, bio-magnetic stimulation is applied widely in agricultural fields [3]. For all this, the magnetic field application should be recommended for applying in agriculture fields in our country.

Hence the need for more optimum utilization of irrigated water for high quality root production of carrot, therefore the objective of the present study was to evaluate how carrot yield and quality in our region is affected by sowing time and utilization of magnetic water technology which is considered as a promising technique to improve and highest crop productivity.

Material and methods

The study was carried out in the experimental opened field of the agriculture research center, Ministry of Agriculture in Kurdistan region. This study was performed during 28/10 till 14/5/2015. Air temperature and relative humidity were recorded and shown in table 1. Some of the sowing media properties are recorded in table (2).

Table (1): Mean air temperatures and relative humidity throughout the experiment period.

Years	*Months*	*Mean air temperature (^oC)*	*Mean relative humidity (%)*
2014	*October*	*21.90*	*50.21*
	November	*12.60*	*63.53*
	December	*10.36*	*77.64*
2015	*January*	*8.12*	*71.90*
	February	*10.61*	*67.84*
	March	*11.81*	*63.84*
	April	*19.44*	*49.43*
	May	*24.73*	*25.64*

Table(2): Some properties of the experiment sowing media .

Properties	*The soil*	*The local compost*
N (Kjeldahl method)	*0.18%*	*1.52%*
P (Spectrophotometer method)	*5.1ppm*	*0.42%*
K (Flamephotometor method)	*90ppm*	*0.55%*
pH	*7.5*	*8.3*
Electric conductivity(dS m⁻¹)	*0.3*	*2.03*
clay	*20%*	_________
silt	*40%*	_________
sand	*40%*	_________
soil texture (Hydrometric Methode)	*loam*	_________

A. Plant material

The seed of the hybrid cultivar of carrot (*Daucus carota L.*) cv. Dordogen F1 were used. Five seeds were sown in each pot (33cm in diameter and 34cm in length), and then the plants were thinned to three seedlings after 44 days from sowing (for both times).

B. Magnetic flux densities

The pots were irrigated with three levels of magnetized water; 0, 2500 and 5000 Gauss. Each pot was irrigated with two liters of water according their treatments in every time. The tap water was treated magnetically using local devices with a power of 2500 and 5000Gauss, which were measured by tesla meter (model 05009-A2). The velocity of water was 0.086 $l.sec^{-1}$.

C. Time of seed sowing

The seeds were sown in the pots directly in two times; October 28^{th} and November 14^{th} of 2014.

D. Experimental design and statistical analysis

Factorial completely randomize design with six treatments were used, each treatment was replicated four times each replication include one pot with three plants. Comparisons between means were made by using least significant differences test (LSD) at 5% probability, SAS system was used for all statistical analysis [22].

E. Experimental parameters

- Growth characters

The parameters were measured from all plants including; number of leaves per plant, plant length (from the tallest leaf to end of the root) , shoot fresh weight , root length, root diameter, root fresh weight [2].

- Chemical analyses

The following contents were determined:

1- Chlorophyll content in the leaves (%)

The chlorophyll content in the leaves was determined by chlorophyll – meter SPAD – 502 [8 and 16].

2-Carotenoid content in the roots (µg /ml)

The carotene content in the roots was determined by spectrophotometer on 480nm by acetone assay, the solutions were prepared according to [6] method.

Results and Discussion

A. Growth characters

1- Effect of magnetic water:

Table (3) shows that the levels of magnetized water affected significantly on plant length, root length, root diameter and root dry weight. The highest values of plant length, root length, root diameter and root fresh weight (55.58cm, 30.19cm, 35.14mm and 128.19gm respectively) were recorded from 2500 gauss level of magnetic water. These may resulted as using organic matter in the sowing media and irrigated with various levels of magnetic water. In the magnetic water the positive and negative charges are strengthened resulting in their attraction and repulsion and make crystal chains, which help in water absorption by the cells [12]. Moreover dissolving and deeper penetration of fertilizers in soil irrigated with magnetized water is better [4].

Table (3): Effect of magnetic water on the growth and yield characteristics.

Magnetic water (Gauss)	*Number of leaves/ plant*	*Plant length (cm)*	*Shoot fresh Wt. (gm)*	*root length (cm)*	*Root diameter (mm)*	*Root fresh Wt. (gm)*
0	*11.04*	*51.38*	*14.00*	*25.37*	*30.20*	*92.29*
2500	*10.42*	*55.58*	*16.71*	*30.19*	*35.14*	*128.19*
5000	*11.15*	*47.58*	*13.13*	*24.90*	*31.74*	*103.00*
L.S.D.<0.05	*N.S.*	*3.89*	*N.S.*	*2.01*	*3.22*	*21.82*

2- Effect of sowing time:

The two sowing times had significant effect on plant length and vegetative growth dry weight and root length. The highest plant length and shoot fresh weight (54.63cm and 17.64gm respectively) were observed in 14/11/2014. However, the longest root (28.36cm) was measured in 28/10/2014 (table 4). The variation in previous results of sowing times may be due to the temperature effects, temperature is not a growth factor supplying energy or constituents but primarily controls the rates of chemical reactions, plant development including morphogenesis and plant quality, these processes make temperature a major growth factor worldwide, determining climatic zones, controlling plant distribution, growth cycles and growth rates resulting in yields [23]. In addition low temperature and heat stress would cause negative impact [14].

Table (4): Effect of sowing time on growth and yield characteristics.

sowing time	*Number of leaves/ plant*	*Plant length (cm)*	*Shoot fresh Wt. (gm)*	*root length (cm)*	*Root diameter (mm)*	*Root fresh Wt. (gm)*
28/10/2014	*11.51*	*48.40*	*11.58*	*28.36*	*32.40*	*110.58*
14/11/2014	*10.22*	*54.63*	*17.64*	*25.28*	*32.32*	*105.07*
L.S.D.<0.05	*N.S.*	*3.17*	*3.37*	*1.65*	*N.S.*	*N.S.*

3- Interaction effects of magnetic water and sowing time:

Interaction between studied magnetic levels and sowing times affected significantly on the field parameters except number of leaves. The highest values of plant length, shoot fresh weight and root diameter (59.67cm, 20.63 gm and 43.75mm respectively) were obtained from the interaction of 2500gauss and 14-11/2014 sowing time. While, the best results of root length and root fresh weight (32.29cm and 134.17gm respectively) were founded in the interaction of the same level of magnetic water with 28/10/2014 sowing time (table 5). The usage of magnetic water in the agricultural production will enable intense and more quantities and qualitative production [11].

Table (5): Interaction effects of magnetic water and sowing time on growth and yield.

Magnetic water (Gauss)	*Sowing time*	*Number of leaves/ plant*	*Plant length (cm)*	*Vegetative growth fresh Wt. (gm)*	*root length (cm)*	*Root diameter (mm)*	*Roots fresh Wt. (gm)*
0	*28/10/2014*	*11.33*	*47.17*	*10.25*	*26.67*	*29.40*	*89.34*
	14/11/2014	*10.75*	*55.59*	*17.75*	*24.08*	*30.99*	*95.25*
2500	*28/10/2014*	*11.38*	*51.50*	*12.79*	*32.29*	*35.54*	*134.17*
	14/11/2014	*9.46*	*59.67*	*20.63*	*28.08*	*43.75*	*122.21*
5000	*28/10/2014*	*11.83*	*46.54*	*11.71*	*26.13*	*32.26*	*108.25*
	14/11/2014	*10.46*	*48.63*	*14.54*	*23.67*	*31.22*	*97.75*
L.S.D.<0.05		*N.S.*	*5.50*	*5.83*	*2.85*	*4.55*	*30.85*

B- Chemical analysis:

1- Effect of magnetic water:

The studied levels of magnetized water had no significant effects on chlorophyll and carotene contents in the leaves and the roots respectively (table 6).

Table (6): Effect of magnetic water on chlorophyll and carotene contents.

Magnetic water (Gauss)	*Chlorophyll content in the leaves (%)*	*Carotene content in the roots (µg/ml)*
0	*34.235*	*2.608*
2500	*40.171*	*2.648*
5000	*29.309*	*3.100*
L.S.D.<0.05	*N.S.*	*N.S.*

2- Effect of sowing media:

Table (7) shows no significant effects of the two sowing times on chlorophyll and carotene contents.

Table (7): Effect of sowing time on chlorophyll and carotene contents.

Sowing time	*Chlorophyll content in the leaves (%)*	*Carotene content in the roots (µg/ml)*
28/10/2014	*31.362*	*2.738*
14/11/2014	*37.782*	*2.810*
L.S.D.<0.05	*N.S.*	*N.S.*

3- Interaction effects of magnetic water and sowing time:

The interaction of magnetic water levels and sowing times affected significantly on chlorophyll and carotene contents. The highest chlorophyll content in the leaves (52.815%) was measured in the interaction of 2500gauss magnetic water and 14/11/2014 sowing time, and the best carotene content in the roots (3.427µg /ml) was obtained from 5000gauss magnetic water in the same sowing time (table 8). These results may be due to that the facilitated penetration of water solutions according to using of magnetic field is confirmed by a more efficient extraction of chemicals from plant material [20].

Table (8): Interaction effects of magnetic water and sowing time on chlorophyll and carotene contents.

Magnetic water (Gauss)	Sowing time	Chlorophyll content in the leaves (%)	Carotene content in the roots (µg/ml)
0	28/10/2014	35.168	2.825
	14/11/2014	33.303	2.390
2500	28/10/2014	27.528	2.683
	14/11/2014	52.815	2.613
5000	28/10/2014	31.390	2.704
	14/11/2014	27.228	3.427
L.S.D.<0.05		18.816	0.816

Conclusions and Recommendations:

We concluded that the application of magnetized water at the level of 2500 Gauss gave good impression for carrot production. Moreover, the interaction of magnetized water with the two studied sowing times gave the best results over the control.

Based on the above results, the magnetic field application should be recommended for applying in agriculture fields in our region, and more studies is required for other magnetic forces with carrot and other vegetables or fruits in various sowing times.

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