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Enhancing growth and production of carrot plant by spraying aqueous barley sprouts extract, trehalose, and calcium

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Abstract

This research was implemented at vegetable field of the College of Agricultural Engineering Sciences - University of Baghdad during fall seasons, 2018 and 2019. The experiment was conducted using factorial within Randomized Complete Block Design arrangement with three factors and replicates (3X3X2). The aqueous barley sprouts extract (B0, B1) (0, 100 g.L-1) represented the first factor. Trehalose (T0, T1, T2) (0, 50, 75 mmole. L-1) represented the second factor. Calcium (C0, C1, C2) (0, 1, 2 ml.L-1) represented the third factor. The research objectives are assessing the impact of the mentioned factors and their interaction on carrot growth and production. Results showed the superiority of three ways interaction treatment B1T2C1 in producing significant increases nitrogen percent in leaves (2.857, 2.9%), roots (1.273, 1.283%), and carrot production (161.6, 159 ton. ha-1) for both seasons respectively in compare with control treatment B0T0C0.

Keywords: sugars, germinated grains, sprouting, dry matter, divalent ion

Introduction

Carrot plant belongs to Apiaceae family has a noticeable importance during recent years. It classified as the most 10 produced vegetables [1]. Significantly, carrots categorized as the second most popular veggies after potato [2]. It acquired this position because of its crunchy and sweet taste. Carrots have appropriate number of carotenoids. Besides, carrots have B3, B2, B1, and C vitamins, amino acids and sugars [3]. Thus, many studies dedicated on exactly how to increase its production .

Seeds sprouts have simple, absorbable and water-soluble forms including amino acids, sugars, and fatty acids [4]. Furthermore, they have sufficient amount of gibberellins and low levels of ABA [5]. Thus, their aqua extracts can enhance plant status [6,7]. Trehalose is known as non-reduced disaccharide that forms from combining two glucose molecules. It has multipurpose functions in plant; such as carbon metabolism,plant protection from abiotic stress [8] and molecule signal [9]. Shafiq et al [10] observed that spraying trehalost (50 mmol.L-1) increased fresh weight of radish plant yield under drought conditions.

Calcium is a structural element that is a foundational component of the cell wall. Even more; it is a plasma membrane stabilizer, osmotic regulator, and second messenger for many cellular and hormonal responses [5]. Lee et al [11] noticed that spraying carrot plant of calcium nitrate 2% improved storage traits. Saaseea and Al-a'amry [12] demonstrated that spraying calcium (1000 mg.L-1) significantly improved tuber weight of potato plant. The aim of this study is to assess the impact of barley aqua sprouted grains, trehalose, and calcium on growth, production of carrot plant.

Materials and methods

This This experiment was conducted during two fall seasons (2018 and 2019) at researches station (A) College of Agricultural Engineering Sciences, University of Baghdad (Al-Jadiryah). Table 1 shows the chemical and physical characteristics of the soil for both seasons. The seeds of carrot were sowed on lines on terraces in 15/September for both seasons. The field was under drip irrigation system. Mineral fertilizer was added as recommended for carrot plants (120 kg.ha-1, 120 K2O5 kg. ha-1, 40 K2O kg. ha-1) to all plots before planting [13]. Thinning carried out after 30 days from planting seeds for both seasons. The spacing between one plant and another for both seasons was 0.05 m. The seeds were planted in a plant density 1,000,000 plants.ha-1. The entire plots harvested after 115 days of the planting day for the1st season and 85 days for the 2nd season.

The experiment was implemented as factorial arrangement (2X3X3) within randomized complete block design with three replicates. Spraying barley aqueous sprouted grains extract was represented the first factor with two levels (0, 100g.L-1 DW) which symbolized (B0, B1). The second factor is spraying with three levels of trehalose (0, 50, 75 mmol.L-1) which symbolized (T0, T1, T2). The third factor is spraying with three levels of calcium (0, 1, 2 ml.L-1) (as chelated calcium 30% Ca), which symbolized (C0, C1, C2). The first spraying was after 10 days from thinning. The second spraying was after 15 days from the first spraying. The third spraying was after 15 days from the second spraying.

Barley aqueous sprouted grains extract was prepared according to Al-Khafaji method [6,7]. Table 2 shows the chemical and physical properties and conversion ratio of barley aqueous sprouted and grains extract.

The study traits were plant height (cm), nitrogen in leaves (%) [14], potassium in leaves (%) [15], nitrogen in roots (%) [14], potassium in roots (%) [15], dry matter percent in 100g. of carrots (%), total production (ton.ha-1).

The collected data analyzed using analyses of variance and the means were compared according to L.S.D. test under 5% probability.

Table (1): Physical and chemical characteristics of the soil for the two seasons

Character	Values	
	Fall 2018	Fall 2019
pH	7.44	7.41
$EC_{1:1}$ ($ds.m^{-1}$)	2.39	2.36
Total N (mg kg^{-1})	55.0	45.6
P (mg kg^{-1})	13.7	12.1
K (mg kg^{-1})	170	166
Ca (mg kg^{-1})	187	177
Mg (mg kg^{-1})	170	130
Fe (mg kg^{-1})	2.60	2.10
Na (Meq L^{-1})	61.0	63.0
Cl^- (Meq L^{-1})	51.0	55.0
SO_4^{-2} (Meq L^{-1})	207	209
HCO_3^- (Meq L^{-1})	477	453
O.M. (%)	3.10	9.10
Gypsum (%)	320	327
Sand (%)	12.0	15.0
Silt (%)	40.0	45.1
Clay (%)	48.0	39.9
Texture	Clay Loam	

Table (2): Physical and chemical characteristics of the aqueous of quiescent (Q), sprouted (S) barley grain and conversion ratio

Table 2. Physical and chemical characteristics of the aqueous extract of quiescent (Q), sprouted (S) barley grains and conversion ratio

character	Values Q	S	CR
pH	7	6.9	—
$EC_{1:1}$ ($ds.m^{-1}$)	1.70	1.80	—
Total N ($g\ L^{-1}$)	1.52	2.01	1.32
P ($mg\ L^{-1}$)	219	232	1.05
K ($mg\ L^{-1}$)	278	266	0.95
Ca ($mg\ L^{-1}$)	29.5	39.1	1.32
Mg ($mg\ L^{-1}$)	76.3	88.7	1.16
Fe ($mg\ L^{-1}$)	2.50	6.00	2.40
Zn ($mg\ L^{-1}$)	2.00	4.01	2.00
Gibberellin ($\mu g\ L^{-1}$)	2	304	152

(Q) aqueous extract of quiescent barley grains
(S) aqueous extract of sprouted barley grains
(CR) conversion ratio: calculated by dividing Q/S for each nutrient

Results and Discussion

Vegetative growth traits

Results in table 3A exhibit that B1T2C1 treatment produced the highest nitrogen percent in leaves (2.857, 2.9%), for both seasons respectively, compared to B0T0C0 (1.84, 1.84%) for both seasons respectively. The results of Table 3B show that there were significant differences in two ways interaction between the aqueous extract of barley sprouts and trihalose. Plants with B1T2 produced the highest length (64.89, 63.33 cm), nitrogen percent in leaves (2.626, 2.613%) for both seasons respectively, and potassium percent in leaves (3.503%) for 2019 season only compared to the lowest numbers that found in B0T0.

Plants with B1C1 were displayed the highest plant height (63.67 cm) for 2018 season only, nitrogen percent in leaves (3.308%) for 2018 season only compared to B0C0. The findings of two ways interaction between calcium and trehalose (Table 3B) didn't show any significant results for the measured traits.

Table (3 A): Vegetative traits of carrot plant after treatment for three ways interaction of fall 2018 and fall 2019 seasons

Traits treatments	Plant height (cm)		N leaves (%)		K leaves (%)	
	2018	2019	2018	2019	2018	2019
B0T0C0	43.00	45.00	1.840	1.840	2.067	2.066
B0T0C1	46.00	47.00	2.087	2.100	2.300	2.200
B0T0C2	46.67	46.00	2.103	2.090	2.133	2.167
B0T1C0	49.33	52.00	2.163	2.167	2.400	2.467
B0T1C1	49.00	53.00	2.253	2.283	2.833	2.866
B0T1C2	48.33	51.67	2.173	2.183	2.533	2.733
B0T2C0	48.67	50.33	2.193	2.133	2.667	2.700
B0T2C1	51.00	54.67	2.323	2.387	2.967	2.933
B0T2C2	50.00	53.67	2.333	2.317	2.860	2.963
B1T0C0	45.67	45.67	1.993	2.007	2.367	2.267
B1T0C1	48.00	47.33	2.103	2.167	2.623	2.467
B1T0C2	47.00	46.33	2.217	2.150	2.567	2.533
B1T1C0	50.00	54.33	2.210	2.190	2.700	2.933
B1T1C1	69.67	63.67	2.513	2.600	3.500	3.533
B1T1C2	64.33	61.00	2.453	2.543	3.137	3.403
B1T2C0	53.00	54.00	2.323	2.250	2.940	3.010
B1T2C1	73.33	68.67	2.857	2.900	3.800	3.867
B1T2C2	68.34	67.33	2.697	2.690	3.367	3.633
LSD 0.05	**N.S.**	**N.S.**	**0.187**	**0.190**	**N.S.**	**N.S.**

The results of the statistical analysis of the individual factors showed the significant superiority of B1 in plant height (57.7, 56.48 cm), nitrogen percent in leaves (2.368, 2.386%) and potassium percent in leaves (3, 3.072%) for both seasons respectively in compare with the lowest numbers that found in B0 treatment. Plants that received foliar trehalose application (75 mmol/l-1) showed higher vegetative traits for both seasons, while the lowest traits were found in T0. Spraying calcium (1 ml.l-1) was produced the highest vegetative traits compared to the lowest numbers in C0 (Table 3C).

Table (3 B): Vegetative traits of carrot plant after treatment for two ways interaction of fall 2018 and fall 2019 seasons

Treatments	Plant height (cm)		N leaves (%)		K leaves (%)	
	2018	2019	2018	2019	2018	2019
TXB						
B0T0	45.22	46.00	2.010	2.011	2.167	2.144
B0T1	48.89	52.22	2.214	2.219	2.589	2.689
B0T2	49.90	52.89	2.283	2.279	2.831	2.866
B1T0	46.89	46.44	2.087	2.108	2.519	2.422
B1T1	61.33	59.67	2.392	2.437	3.112	3.290
B1T2	64.89	63.33	2.626	2.613	3.369	3.503
LSD 0.05	**5.14**	**4.65**	**0.108**	**0.101**	**N.S.**	**0.248**
CXB						
B0C0	47.00	49.11	2.083	2.054	2.378	2.411
B0C1	48.67	51.56	2.221	2.257	2.700	2.667
B0C2	48.33	50.44	2.203	2.197	2.509	2.621
B1C0	49.56	51.33	2.176	2.141	2.669	2.737
B1C1	63.67	59.89	2.491	2.556	3.308	3.289
B1C2	59.89	58.22	2.438	2.461	3.023	3.190
LSD 0.05	**5.14**	**N.S.**	**N.S.**	**0.101**	**0.205**	**N.S.**
CXT						
T0C0	44.33	45.33	1.917	1.923	2.217	2.167
T0C1	47.00	47.17	2.095	2.133	2.462	2.333
T0C2	46.83	46.17	2.133	2.120	2.350	2.350
T1C0	49.67	53.17	2.130	2.178	2.550	2.700
T1C1	59.33	58.33	2.383	2.442	3.167	3.200
T1C2	56.33	56.33	2.313	2.363	2.835	3.068
T2C0	50.83	52.17	2.258	2.192	2.803	2.855
T2C1	62.17	61.67	2.590	2.643	3.383	3.400
T2C2	59.17	60.50	2.515	2.503	3.113	3.298
LSD 0.05	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**

Table (3 C): Vegetative traits of carrot plant after treatment for individual factors of fall 2018 and fall 2019 seasons

treatments	Plant height (cm)		N leaves (%)		K leaves (%)	
	2018	2019	2018	2019	2018	2019
B						
B0	48.00	50.37	2.169	2.169	2.529	2.566
B1	57.70	56.48	2.368	2.386	3.000	3.072
LSD 0.05	**2.97**	**2.92**	**0.062**	**0.063**	**0.118**	**0.143**
T						
T0	46.06	47.17	2.048	2.059	2.343	2.283
T1	55.11	55.94	2.303	2.328	2.851	2.989
T2	57.39	58.11	2.454	2.446	3.100	3.184
LSD 0.05	**3.63**	**3.58**	**0.076**	**0.077**	**0.145**	**0.175**
C						
C0	48.28	50.22	2.129	2.098	2.523	2.574
C1	56.17	55.94	2.356	2.406	3.004	2.978
C2	54.11	58.11	2.321	2.329	2.766	2.906
LSD 0.05	**3.63**	**3.58**	**0.076**	**0.077**	**0.145**	**0.175**

Production traits

The most significant increases in nitrogen percent in roots (1.273, 1.283%), and carrot production (161.6, 159 ton.ha-1) for both seasons respectively found in B1T2C1 treatment, moreover the mentioned treatment shows superiority in carrot dry matter percent (12.36)) for 2019 season only compared to the lowest numbers that found in B0T0C0 (Table 4A).

Two ways interaction between T2 and B1 had a significant impact on nitrogen percent in roots (1.134, 1.142%), and carrot production (149.6, 147.1 ton.ha-1), moreover the mentioned treatment shows superiority in carrot dry matter percent (12.36)) for 2019 season only.(Table 4B). The results in the same table also showed the superiority of B1C1 treatment by producing the highest carrot production (140.5, 141.7 ton.ha-1) for both seasons. Statistical analysis of the individual factors (Table 4C) reveals the significant results of B1 treated plants by producing the highest carrot production (131.1, 132 ton.ha-1), N roots (0.996, 1.015%) and dry matter (11.72, 11.8%) for both seasons respectively, K roots (0.973%) for 2019 season only. in compare with the lowest numbers that found in B0 treated plants. T2 treated plants showed superiority in carrot production (136.7, 135.2 ton.ha-1), N roots (1.078, 1.07%) and dry matter (11.83, 11.67%) for both seasons respectively, K roots (0.977%) for 2019 season only, while the lowest traits were found in T0. Spraying calcium (1 ml.l-1) was produced the highest carrot production (130, 130.1 ton.ha-1), N roots (0.993, 1.002%) and dry matter (11.64, 11.46%) for both seasons respectively, compared to the lowest numbers in C0.

Table (4A): Yield and quality traits of carrot plant after treatment for three ways interaction of fall 2018 and fall 2019 seasons

Treatments	N roots (%)		K roots (%)		Dry matter (roots%)		Production ($ton.ha^{-1}$)	
	2018	2019	2018	2019	2018	2019	2018	2019
B0T0C0	0.703	0.705	0.832	0.834	10.00	10.00	101.0	101.4
B0T0C1	0.840	0.841	0.900	0.917	10.43	10.23	105.0	104.3
B0T0C2	0.802	0.850	0.833	0.867	10.36	10.16	99.33	103.0
B0T1C0	0.800	0.818	0.983	0.933	10.33	10.13	117.3	115.6
B0T1C1	1.010	1.037	0.917	0.967	11.43	11.10	118.3	119.3
B0T1C2	0.952	0.969	0.950	0.900	10.96	10.80	113.3	115.0
B0T2C0	0.927	0.860	0.960	0.901	10.53	10.53	115.0	115.6
B0T2C1	1.096	1.123	0.951	0.983	11.83	11.40	135.0	131.6
B0T2C2	1.043	1.011	0.887	0.987	11.50	10.96	121.6	122.7
B1T0C0	0.776	0.811	0.933	0.950	10.16	10.33	101.3	107.6
B1T0C1	0.854	0.874	0.950	0.883	11.16	11.36	110.0	116.7
B1T0C2	0.823	0.862	0.883	0.917	11.00	11.30	102.6	106.6
B1T1C0	0.840	0.846	0.984	1.017	11.36	11.73	118.3	119.3
B1T1C1	1.129	1.181	0.990	1.003	12.40	12.22	150.0	149.6
B1T1C2	1.143	1.134	0.960	0.955	12.30	12.20	148.6	147.3
B1T2C0	0.933	0.959	1.005	1.038	12.10	12.30	132.3	128.3
B1T2C1	1.273	1.283	0.963	0.973	12.66	12.46	161.6	159.0
B1T2C2	1.196	1.184	0.983	0.983	12.36	12.36	155.0	154.0
LSD 0.05	**0.079**	**0.079**	**N.S.**	**N.S.**	**N.S.**	**0.52**	**9.7**	**9.9**

Table (4 B): Yield and quality traits of carrot plant after treatment for two ways interaction of fall 2018 and fall 2019 seasons

Treatments	N roots (%)		K roots (%)		Dry matter (roots%)		Production ($ton.ha^{-1}$)	
	2018	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
TXB								
B0T0	0.782	0.799	0.872	0.872	10.26	10.13	101.7	102.8
B0T1	0.920	0.941	0.950	0.933	10.91	10.67	116.3	116.6
B0T2	1.022	0.998	0.932	0.957	11.29	10.96	123.9	123.3
B1T0	0.818	0.849	0.922	0.917	10.77	11.00	104.6	110.3
B1T1	1.037	1.054	0.978	1.005	12.02	12.04	139.0	138.7
B1T2	1.134	1.142	0.984	0.998	12.37	12.37	149.6	147.1
LSD 0.05	**0.049**	**0.045**	**N.S.**	**N.S.**	**N.S.**	**0.30**	**5.6**	**5.7**
CXB								
B0C0	0.810	0.794	0.926	0.889	10.29	10.22	111.1	110.8
B0C1	0.982	1.000	0.922	0.956	11.23	10.91	119.4	118.4
B0C2	0.932	0.943	0.907	0.918	10.94	10.64	111.4	113.5
B1C0	0.850	0.872	0.974	1.002	11.21	11.45	117.3	118.4
B1C1	1.085	1.113	0.968	0.953	12.04	12.01	140.5	141.7
B1C2	1.054	1.060	0.942	0.965	11.92	11.95	135.4	136.0
LSD 0.05	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**5.6**	**5.7**
CXT								
T0C0	0.740	0.758	0.883	0.892	10.08	10.16	101.1	104.5
T0C1	0.847	0.858	0.925	0.900	10.80	10.80	107.5	110.5
T0C2	0.813	0.856	0.884	0.893	10.68	10.73	101.0	104.8
T1C0	0.820	0.832	0.983	0.975	10.85	10.93	117.3	117.5
T1C1	1.069	1.109	0.953	0.985	11.86	11.65	134.1	134.5
T1C2	1.047	1.051	0.955	0.947	11.68	11.50	131.0	131.1
T2C0	0.930	0.910	0.982	0.969	11.31	11.41	123.6	122.0
T2C1	1.185	1.203	0.957	0.978	12.25	11.93	148.3	145.3
T2C2	1.120	1.097	0.935	0.985	11.93	11.66	138.3	138.3
LSD 0.05	**0.060**	**0.056**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**6.9**	**7.0**

Table (4 C): Yield and quality traits of carrot plant after treatment for individual factors of fall 2018 and fall 2019 seasons

Treatments	N roots (%)		K roots (%)		Dry matter (roots %)		Production (ton.ha^{-1})	
	2018	2019	2018	2019	2018	2019	2018	2019
B								
B0	0.908	0.913	0.918	0.921	10.82	10.59	114.7	114.3
B1	0.996	1.015	0.961	0.973	11.72	11.80	131.1	132.0
LSD 0.05	**0.028**	**0.026**	**N.S.**	**0.043**	**0.22**	**0.17**	**3.2**	**3.3**
T								
T0	0.800	0.824	0.897	0.894	10.52	10.56	103.2	106.6
T1	0.979	0.997	0.964	0.969	11.46	11.36	127.6	127.7
T2	1.078	1.070	0.958	0.977	11.83	11.67	136.7	135.2
LSD 0.05	**0.035**	**0.032**	**N.S.**	**0.053**	**0.27**	**0.21**	4.0	4.0
B								
C0	0.830	0.833	0.945	0.944	10.75	10.83	114.2	114.7
C1	1.033	1.056	0.950	0.954	11.64	11.46	130.0	130.1
C2	0.993	1.002	0.924	0.941	11.43	11.30	123.4	125.0
LSD 0.05	**0.035**	**0.032**	**N.S.**	**N.S.**	**0.27**	**0.21**	4.0	4.0

Foliar Application of sprouted barley aqueous extract, trehalose, and calcium was efficiently utilized by increasing the vegetative growth, minerals content and production traits. This could be due to the effect of each factor in triggering different activation of different cellular process. Sprouted barley aqua extract has gibberellins and bioavailable forms of nutrients (Table 2), which has a role in cells division and elongation. In addition to that; trehalose spray has a contribution in nitrate assimilation in leaves [15]. Meristematic cells need calcium to form the spindle, enlarge the cells and form cell walls [5], As a result that's all led to increasing vegetative, and production traits.

Two seasons of field and laboratory studies confirm that aqueous extract of barley sprouts, trehalose, and modest level of calcium had a role in improving vegetative, , and production traits in carrot plant.

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