Maximizing growth and antioxidants of carrot plant (*Dacus carota* L.) by foliar application of hornwort extract, Phenylalanine and Nano-Potassium.

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Abstract

Two field trials were conducted in Babylon governorate, Tufael town which is located in the Al-Kifl district in a mixed sandy soil for the growing seasons 2021-2022 and 2022-2023 to assess the impact of hornwort extract, phenylalanine amino acid, and Nano-potassium and it's interactions on growth and antioxidants accumulation of carrots plant. The treatments were implemented within Randomized Complete Block Design (R.C.B.D) with three factors and three replications. The trial comprised three factors, the first is spraying hornwort extract with three concentrations of 0, 4 and 8 ml. L^{-1}, and the second factor included the spraying amino acid Phenylalanine with three concentrations 0, 75 and 150 mg.L^{-1} and the third factor included the spraying Nano-potassium fertilizer with three concentrations 0, 1 and 2 g.L^{-1} . The averages were compared according to the least significant difference (L.S.D) test at a probability level of 0.05. The results showed that the triple-interaction (A3B3C3) between hornwort extract (8ml.L^{-1}), phenylalanine (150mg.L^{-1}) and Nano-potassium (2g.L^{-1}) was superior to all treatments in achieving the highest values in leaf area (112.30, 116.10 cm^2), leaves fresh weight (61.25, 66.56 g), total chlorophyll content of leaves (290.09, 305.20 mg.100 f. w), beta-carotene (10.05, 10.19 mg.100 f. w) and ascorbic acid (7.80, 8.20 mg.100 ml f. w) for two seasons respectively. The favorable formulation that carrots strongly respond to is thevA3B3C3 treatment.

Keywords: hornwort, Phenylalanine (phe), Nano-potassium (K), carrots (*Daucus carota* L)

Indroduction

Carrots (*Dacaus carorta* L.) is an essential crop vegetable related to Apeaceae family. It is a biennial crop developing root and leaves until the end of its growing season (21). People used to include carrots consumption in their diet because it is a rich source of anti-oxidant (33). Awareness of healthy food has increased in recent days due to the rise in many health issues of cancer, high blood pressure, diabetes and heart disease as a result of following a wrong diet for several years (18). Therefore, this motivates people to involve a rich vegetable of antioxidants in their daily diet as therapeutic nutrition. Orange carrot like other many colorful vegetables is rich of antioxidants like beta carotene and vitamin C that plays an important role in body health maintenance (29 and 12), therefore carrot crop is ranked 10^{th} in terms of nutritional value (3). Thus, planting of carrots has become within researchers' attention to meet people's demand globally. Foliar spray of hornwort extract has been frequently used in recent years to promote carrot quality because it is rich of NPK and Ca elements, vitamin C, plant hormones and amino acids (5 and 4). Spraying hornwort ($20ml.L^{-1}$) increased growth and NPK of cucumber leaves (5), as increased N enhances biosynthesis of ascorbic acid (30) and increasing P element lead to promote carotenoids in the plant because it enhances biosynthesis of all carotenoids (28). Phenylalanine is an essential main amino acid that plays a key role in stimulating growth and development because it contributes in the biosynthesis plant hormones specially gibberellin (32). As spraying plants with amino acid increased ascorbic acid and carotenoids (9). Nano fertilizers are different from traditional fertilizers due to their small size and increased surface area which leads to increase absorption surface and thus ability to improve nutrients efficiency via certain mechanisms like slow release nutrients for the target plant organ which resulting in promoting photosynthesis and consequently increased nutrient accumulation in the plant (27, 31). Potassium fertilizer is the most demanded root crop because it activates 60 enzymes of bio-process (19). The aim of this study is to study the impact of hornwort extract, amino acid phenylalanine and Nano-potassium and their interaction on the growth and antioxidant accumulation of carrots plant.

Material and Methods

The research investigation was conducted for the winter seasons 2021-2022 and 2022-2023 in Babylon governorate, Tufael town which is about 15 km of Hilla city at longitude 44. 39 degrees East and latitude 32.30 North in a mixed sandy soil to evaluate the role of foliar application of hornwort extract, Phenylalanine and Nano-potassium in maximizing growth and antioxidant of the carrot plant. Field soil analysis was done before planting as chemical and physical properties for both seasons were shown in (table 1).

The field land of two trials was plowed twice perpendicularly, then it was flattened and leveled well and divided into three blocks with 27 plots each. Plot size was $1X1m^2$ with 50cm between plots and 1m between blocks (16). Both experiments were conducted on 21/09/2021 and 21/09/2022 for both growing

seasons. Carrots seed of the Nantes cultivar were produced by MONARCH SEED Company. Seeds were slowed by hand in rows with a distance of 20 cm between rows. Weeds were removed manually especially during first stages of plant growth several times and irrigation (conventional system) was carried out whenever needed. Plants were thinned 1 month after planting to the space of approximately 10 cm apart within each row (26, 10, and 13).

The experiment included three factors. The first factor is spraying hornwort extract with three concentrations 0, 4, and 8 ml. L^{-1} which symbolized (A1, A2, and A3). Hornwort extract (Table 2) was prepared by collecting hornwort plants from the rivers. Then, they were washed with distilled water in the laboratory several times to get rid of the mud and suspended stuff. Then, 250 g of hornwort was taken and chopped into small pieces and placed in an electric mixer with addition 250 ml of distilled water and mixed well for 10 minutes. After that, a piece of soft cloth was used to separate the extract from the plant residue to obtain an a pure extract of 50% of hornwort extract (6). The second factor was spraying amino acid Phenylalanine with 3 concentrations of 0, 75 and 150 $mg.L^{-1}$ which symbolized (B1, B2, B3) and third factor was spraying Nano-potassium fertilizer with 3 concentrations 0, 1 and 2 $g.L^{-1}$ which symbolized (C1, C2, and C3). Comparison treatments (A1, B1, and C1) included spraying with distilled water only. The period of spray between factors was seven days. Carrots plant were sprayed three times, the first spray was applied 10 days after thinning stage , the second spray was 21 days after the first spray and the third spray was 14 days after the second spray.

Samples of 10 plants were taken from each plot to record vegetative parameters (leaf area, leaves fresh weight and total chlorophyll of leaves (15) and calculate root content of beta-carotene (25) and ascorbic acid (1). Collected data were analyzed using analyses of variance and averages were compared according to L.S.D at a probability level of 0.05 (8).

Table 1. Physical and chemical properties of pre-sowing soil.

Character	Values	
	2021-2022	2022-2023
pH	7.98	7.6
EC ($ds.m^{-1}$)	3.1	2.7
N ($mg.\ kg^{-1}$)	79.1	82.1
P ($mg.\ kg^{-1}$)	10.6	8.6
K ($mg.\ kg^{-1}$)	110	188
Ca ($Meq\ L^{-1}$)	140	130
Mg ($Meq\ L^{-1}$)	250	450
Na ($Meq\ L^{-1}$)	22.6	29.8
Cl^{-} ($Meq\ L^{-1}$)	3700	1480
So_4 ($Meq\ L^{-1}$)	35	4.36
HCO3 ($Meq\ L^{-1}$)	1.2	0.8
O.M (%)	1.37	1.1

Gypsum (%)	4	3
Sand g.kg^{-1}	768	654
Silt g.kg^{-1}	100	187
Clay g.kg^{-1}	132	159
Texture	Mixed sandy	Mixed sandy

Table 2. Chemical composition of hornwort extract.

	Character	Value
%	N	11.84
	P	4.32
	K	15.62
	Ca	0.727
Ppm	IAA	124.6
	GA3	30.2
	Cytokinins	181.0
	Vitamin C	445.1
	Glutamic acid	41.129
	Serine	1720.63
	Glysine	211.26
	Threonine	3706.46
	Valine	449.43
	Tryptophan	60.55
	Phenylalanine	261.89

Al-Amin and Aboohana (4 and 5)

Result and Discussion

Vegetative growth parameters

From (Tables 3, 4, 5), it is clear that there is a significant influence of individual factors in leaf area, leaves fresh weight and total chlorophyll of leaves. Plants sprayed with hornwort extract (8.ml.L^{-1}) produced the highest values of leaf area (100.37, 103.47cm), fresh weight of leaves (56.38, 58.85g) and total chlorophyll of leaves (255.32, 268.91 mg.100g^{-1} F. W) for two seasons respectively compared to lowest value in control treatment (A1). Foliar spray of phenylalanine (150mg.L^{-1}) achieved the highest means of leaf area, leaves fresh and total chlorophyll of leaves for two seasons compared to lowest means that were found in comparison treatment (B1) for two reasons. Spraying Nano-K (2g.L^{-1}) was superior in leaf area (99.95, 102.63 cm), leaves fresh weight (56.03, 58.33 g) and total chlorophyll of leaves (253.98, 267.56 mg.100g^{-1} F. W) while the lowest means were found in control treatment (C1).

Also, result of the same tables showed that there was a significant impact of bi-interaction in leaf area, leaves fresh weight and total chlorophyll of leaves. Plant that

treated with hornwort extract (8ml.L^{-1}) and phenylalanine (150mg.L^{-1}) produced the highest leaf area (106.28, 109.62 cm), leaves fresh weight (59.30, 62.61g) and total chlorophyll of leaves (270.12, 286.16 mg.100g^{-1} F. W) for both seasons respectively compared to the comparison treatment (A1B1) that displayed the least means. Bi-interaction between hornwort extract (8ml.L^{-1}) and nano-potassium (2g.L^{-1}) display the highest leaf area (107.90, 110.13cm), leaves fresh weight (59.58, 63.22g) and total chlorophyll of leaves (272.74, 288.51 mg.100g^{-1} F. W). Plants were sprayed with B3C3 treatment achieved the highest averages of leaf area (105.93, 109.17 cm), leaves fresh weight (58.95, 62.15 g) and total chlorophyll of leaves (269.09, 285.15 mg.100g^{-1} F. W).

Regarding the tri-interaction. The most impact was evident in (A3B3C3) treatment that achieved the highest means of leaf area (112.30, 116.10 cm), leaves fresh weight (61.25, 66.56 g) and total chlorophyll of leaves (290.09, 305..20 mg.100g^{-1} F. W) for two seasons respectively compared to lowest means 74.70, 77.40 (cm), 42.20, 40.10 (g) and 180.36, 186.05 (mg.100g fresh weight) that were found in control treatment (A1B1C1) respectively.

Antioxidant parameters in root of carrots**.**

The results of (Tables 6, 7) indicated that there is a significant effect in ascorbic acid and beta-carotene when treating plants with hornwort extract (8ml.L^{-1}) as the results reached (6.84, 7.25 mg.100ml) and (8.61, 8.91 mg.100g^{-1} F.W) for both seasons respectively compared to the lowest values in control treatment (A1). Plants that were sprayed with 150mg.L^{-1} treatment displayed a significant increase in ascorbic acid (6.74, 7.16 mg.100 ml) and beta-carotene (8.48, 8.76 mg.100g^{-1} F.W) for both seasons compared to the comparison treatment (B1) that displayed the lowest values. Plants were treated with nano-potassium (2g.L^{-1}) displayed a significant increase in ascorbic acid (6.80, 7.20 mg.100 ml) and beta-carotene (8.56, 8.85 mg.100g^{-1} F.W) while lowest values were found in comparison treatment (C1).

The results of same tables, showed a significant impact for bi-interact between hornwort extract and Phenylalanine. Plants sprayed with (A3B3) treatment showed the highest values of ascorbic acid (7.28, 7.70 mg.100 ml) and beta-carotene (9.21, 9.47 mg.100g^{-1} F.W) while lowest averages were found in comparison treatment (A1B1) for both seasons. Plant that sprayed with (A3C3) treatment demonstrated the highest ascorbic acid (7.34, 7.73 mg.100 ml) and beta-carotene (9.30, 9.57 mg.100g^{-1} F.W) while the lowest averages were found in the control treatment (A1C1) for both seasons. Interaction between (B3C3) achieved the highest ascorbic acid (7.25, 7.67 mg.100 ml) and beta-carotene (9.13, 9.43 mg.100g^{-1} F.W) for both seasons compared to the control treatment (B1C1) that produced the lowest values.

Regarding the tri-interaction, results showed that the most significant impact in ascorbic acid (7.80, 8.20 mg.100 ml) and beta-carotene (10.05, 10.19 mg.100g^{-1} F.W) was observed in (A3B3C3) treatment for both seasons compared to the lowest values of ascorbic acid 5.05, 5.40 (mg.100 ml) and beta-carotene 6.84, 7.00 (mg.100 F.W) that were observed in comparison treatment.

Table 3. Effects of hornwort, Phenylalanine (phe) and nano-potassium (K) on leaf area (cm) of carrots plant for both seasons.

Treatments		Season 2021-2022				Season 2022-2023			
		Nano-K (g.L^{-1})			Hornwort and Phe	Nano-K (g.L^{-1})			Hornwort and Phe
Hornwort ml.L^{-1}	Phe mg.L^{-1}	0.0	1.0	2.0		0.0	1.0	2.0	
0.0	0.0	74.70	77.90	79.55	77.38	77.40	80.60	83.30	80.43
	75	77.40	84.40	90.54	84.11	78.25	89.20	94.00	87.15
	150	79.00	89.48	94.80	87.76	82.00	92.13	98.30	90.81
4.0	0.0	78.40	86.56	92.75	85.90	81.00	90.90	95.50	89.13
	75	84.90	104.80	107.49	99.06	90.00	106.50	109.08	101.86
	150	90.20	105.90	110.70	102.27	93.04	107.60	113.11	104.58
8.0	0.0	80.30	93.15	99.60	91.02	85.05	97.10	100.15	94.10
	75	91.20	108.40	111.80	103.80	94.90	111.09	114.15	106.71
	150	95.30	111.25	112.30	106.28	99.06	113.70	116.10	109.62
L.S.D 0.05		1.922			1.110	0.221			0.128
Nano-K (g.L^{-1}) Mean		83.49	95.76	99.95		86.74	98.75	102.63	
L.S.D 0.05		0.641				0.074			
					Hornwort ml.L^{-1} mean				Hornwort ml.L^{-1} mean
Hornwort and Nano-K	0.0	77.03	83.93	88.30	83.09	79.21	87.31	91.86	86.13
	4.0	84.50	99.09	103.65	95.74	88.01	101.66	105.89	98.52
	8.0	88.93	104.27	107.90	100.37	93.00	107.29	110.13	103.47
L.S.D 0.05		1.110			0.641	0.128			0.074
					Phe ml.L^{-1} mean				Phe ml.L^{-1} mean
Phe and Nano-K	0.0	77.80	85.87	90.63	84.77	81.15	89.53	92.98	87.88
	75	84.50	99.20	103.28	95.66	87.71	102.26	105.74	98.57
	150	88.17	102.21	105.93	98.77	91.36	104.47	109.17	101.67
L.S.D 0.05		1.110			0.641	0.128			0.074

Table 4. Effects of hornwort, Phenylalanine (phe) and nano-potassium (K) on leaves fresh weight (g) of carrots plant for both seasons.

Treatments		Season 2021-2022				Season 2022-2023			
		Nano-K ($g.L^{-1}$)			Hornwort and Phe	Nano-K ($g.L^{-1}$)			Hornwort and Phe
Hornwort $ml.L^{-1}$	Phe $mg.L^{-1}$	0.0	1.0	2.0		0.0	1.0	2.0	
0.0	0.0	42.20	44.00	45.10	43.76	40.10	42.20	44.70	42.33
	75	43.20	48.00	52.10	47.76	41.50	50.20	53.10	48.26
	150	44.50	51.00	55.00	50.16	44.05	52.05	55.10	50.40
4.0	0.0	44.35	49.05	53.00	48.80	43.06	51.00	53.80	49.28
	75	48.60	58.90	59.80	55.76	50.30	60.80	63.80	58.30
	150	51.75	59.15	60.60	57.16	52.50	63.00	64.80	60.10
8.0	0.0	46.00	53.55	56.50	52.01	47.20	54.09	57.00	52.76
	75	52.50	60.00	61.00	57.83	53.50	63.95	66.12	61.19
	150	55.90	60.75	61.25	59.30	56.14	65.13	66.56	62.61
L.S.D 0.05		0.022			0.012	0.185			0.107
Nano-K ($g.L^{-1}$) Mean		47.66	53.82	56.03		47.59	55.82	58.33	
L.S.D 0.05		0.007				0.061			
					Hornwort $ml.L^{-1}$ mean				Hornwort $ml.L^{-1}$ mean
Hornwort and Nano-K	0.0	43.30	47.66	50.73	47.23	41.88	48.15	50.96	47.00
	4.0	48.23	55.70	57.80	53.91	48.62	58.26	60.80	55.89
	8.0	51.46	58.10	59.58	56.38	52.28	61.05	63.22	58.85
L.S.D 0.05		0.012			0.007	0.107			0.061
					Phe $ml.L^{-1}$ mean				Phe $ml.L^{-1}$ mean
Phe and Nano-K	0.0	44.18	48.86	51.53	48.19	43.45	49.09	51.83	48.12
	75	48.10	55.63	57.63	53.78	48.43	58.31	61.00	55.91
	150	50.71	56.96	58.95	55.54	50.89	60.06	62.15	57.70
L.S.D 0.05		0.012			0.007	0.107			0.061

Table 5. Effects of hornwort, Phenylalanine (phe) and nano-potassium (K) on total chlorophyll (mg.100g^{-1} fresh weight) of carrot plant for both seasons.

Treatments		Season 2021-2022				Season 2022-2023			
		Nano-K (g.L^{-1})			Hornwort and Phe	Nano-K (g.L^{-1})			Hornwort and Phe
Hornwort ml.L^{-1}	Phe mg.L^{-1}	0.0	1.0	2.0		0.0	1.0	2.0	
0.0	0.0	180.36	190.05	210.06	193.49	186.05	197.09	210.11	197.75
	75	186.04	225.00	230.10	213.71	194.16	227.15	242.27	221.19
	150	195.02	228.05	237.06	220.04	213.20	238.40	252.12	234.57
4.0	0.0	191.22	229.06	235.07	218.45	200.32	235.06	247.25	227.54
	75	227.09	254.03	275.19	252.11	230.17	275.50	292.60	266.09
	150	229.05	268.08	280.12	259.08	240.45	287.31	298.13	275.30
8.0	0.0	215.13	236.08	240.06	230.42	212.15	250.32	258.16	240.21
	75	231.07	277.13	288.07	265.42	245.32	293.61	302.18	280.37
	150	238.13	282.14	290.09	270.12	254.14	299.15	305.20	286.16
L.S.D 0.05		1.909			1.102	2.829			1.633
Nano-K (g.L^{-1}) Mean		210.34	243.29	253.98		219.55	255.95	267.56	
L.S.D 0.05		0.636				0.943			
					Hornwort ml.L^{-1} mean				Hornwort ml.L^{-1} mean
Hornwort and Nano-K	0.0	187.14	214.37	225.74	209.08	197.80	220.88	234.83	217.84
	4.0	215.79	250.39	263.46	243.21	223.65	265.96	279.33	256.31
	8.0	228.11	265.12	272.74	255.32	237.20	281.03	288.51	268.91
L.S.D 0.05		1.102			0.636	1.633			0.943
					Phe ml.L^{-1} mean				Phe ml.L^{-1} mean
Phe and Nano-K	0.0	195.57	218.40	228.40	214.12	199.51	227.49	238.51	221.83
	75	214.73	252.05	264.46	243.75	223.22	265.42	279.02	255.88
	150	220.73	259.42	269.09	249.75	235.93	274.95	285.15	265.34
L.S.D 0.05		1.102			0.636	1.633			0.943

Table 6. Effects of hornwort, Phenylalanine (phe) and nano-potassium (K) on total Ascorbic acid (mg.100 ml) of carrots plant for both seasons.

Treatments		Season 2021-2022				Season 2022-2023			
		Nano-K ($g.L^{-1}$)			Hornwort and Phe	Nano-K ($g.L^{-1}$)			Hornwort and Phe
Hornwort $ml.L^{-1}$	Phe $mg.L^{-1}$	0.0	1.0	2.0		0.0	1.0	2.0	
0.0	0.0	5.05	5.27	5.50	5.27	5.40	5.63	5.85	5.62
	75	5.23	5.84	6.14	5.73	5.60	6.22	6.50	6.10
	150	5.47	6.04	6.36	5.95	5.82	6.42	6.76	6.33
4.0	0.0	5.30	5.95	6.20	5.81	5.67	6.32	6.58	6.19
	75	5.89	6.93	7.43	6.75	6.25	7.70	7.83	7.26
	150	6.09	7.30	7.60	6.99	6.55	7.75	8.07	7.45
8.0	0.0	5.54	6.27	6.48	6.09	5.92	6.68	6.88	6.49
	75	6.19	7.51	7.75	7.15	6.60	7.95	8.13	7.56
	150	6.40	7.66	7.80	7.28	6.80	8.10	8.20	7.70
L.S.D 0.05		0.075			0.043	0.059			0.034
Nano-K ($g.L^{-1}$) Mean		5.68	6.53	6.80		6.06	6.97	7.20	
L.S.D 0.05		0.025				0.019			
					Hornwort $ml.L^{-1}$ mean				Hornwort $ml.L^{-1}$ mean
Hornwort and Nano-K	0.0	5.25	5.71	6.00	5.65	5.60	6.09	6.37	6.02
	4.0	5.76	6.72	7.07	6.52	6.15	7.25	7.49	6.96
	8.0	6.04	7.14	7.34	6.84	6.44	7.57	7.73	7.25
L.S.D 0.05		0.043			0.025	0.034			0.019
					Phe $ml.L^{-1}$ mean				Phe $ml.L^{-1}$ mean
Phe and Nano-K	0.0	5.29	5.83	6.06	5.72	5.66	6.21	6.43	6.10
	75	5.77	6.76	7.10	6.54	6.15	7.29	7.48	6.97
	150	5.98	7.00	7.25	6.74	6.39	7.42	7.67	7.16
L.S.D 0.05		0.043			0.025	0.034			0.019

Table 7. Effects of hornwort, Phenylalanine (phe) and nano-potassium (K) on total Beta-carotene (mg.100 g^{-1} fresh weight) of carrots plant for both seasons.

Treatments		Season 2021-2022				Season 2022-2023			
		Nano-K ($g.L^{-1}$)			Hornwort and Phe	Nano-K ($g.L^{-1}$)			Hornwort and Phe
Hornwort $ml.L^{-1}$	Phe $mg.L^{-1}$	0.0	1.0	2.0		0.0	1.0	2.0	
0.0	0.0	6.84	7.00	7.15	6.99	7.00	7.17	7.34	7.17
	75	6.97	7.45	7.65	7.35	7.18	7.58	7.80	7.52
	150	7.10	7.60	7.90	7.53	7.32	7.75	8.20	7.75
4.0	0.0	7.06	7.55	7.79	7.46	7.20	7.65	8.00	7.61
	75	7.50	8.56	9.20	8.42	7.65	9.10	9.70	8.81
	150	7.63	9.00	9.45	8.69	7.76	9.50	9.90	9.05
8.0	0.0	7.20	7.84	8.06	7.70	7.38	8.26	8.50	8.04
	75	7.70	9.25	9.80	8.91	7.90	9.76	10.03	9.23
	150	8.00	9.60	10.05	9.21	8.25	9.97	10.19	9.47
L.S.D 0.05		0.027			0.015	0.037			0.021
Nano-K ($g.L^{-1}$) Mean		7.33	8.20	8.56		7.51	8.52	8.85	
L.S.D 0.05		0.009				0.012			
					Hornwort $ml.L^{-1}$ mean				Hornwort $ml.L^{-1}$ mean
Hornwort and Nano-K	0.0	6.97	7.35	7.56	7.29	7.16	7.50	7.78	7.48
	4.0	7.39	8.37	8.81	8.19	7.53	8.75	9.20	8.49
	8.0	7.63	8.89	9.30	8.61	7.84	9.33	9.57	8.91
L.S.D 0.05		0.015			0.009	0.021			0.012
					Phe $ml.L^{-1}$ mean				Phe $ml.L^{-1}$ mean
Phe and Nano-K	0.0	7.03	7.46	7.66	7.38	7.19	7.69	7.94	7.61
	75	7.39	8.42	8.88	8.23	7.57	8.81	9.17	8.52
	150	7.57	8.73	9.13	8.48	7.77	9.07	9.43	8.76
L.S.D 0.05		0.015			0.009	0.021			0.012

Foliar spray of hornwort extract on efficiently increased growth parameters. This a significant increase may be due to extract content of hornwort macro elements such as nitrogen, phosphorus, and potassium (Table 2). Nitrogen is essential elements for plant growth, as it is considered one of the main components of chlorophyll that determine and activate photosynthesis (14 and 22), nitrogen also maintains leaf surface and increases its durability and consequently enhance rate and duration of photosynthesis and eventually increase plant growth (2, 34). Phosphorus is important to build nucleic, amino acids and coenzyme that involved in respiration and photosynthesis process which lead to accumulation of organic compounds such as proteins, carbohydrates, vitamins and other organic product and eventually promoting biomass and dray matter (2). Potassium plays a key role as an activator and regulator of proteins biosynthesis, sugars transport, metabolism of nitrogen and carbon (20 and 24) and thus enhance plant cell growth (17). The amino acid Phenylalanine plays an essential role in enhancing plant growth because its role as suitable alternative for essential nitrogen to build enzymes and proteins that enhance plant growth (7).

Table (6, 7) indicated that foliar application of hornwort, phenylalanine and nano-K had a significant effect in antioxidants such as ascorbic acid and beta-carotene. This could be related to sufficient amount of P and N elements in the root as resulted from foliar spray of hornwort extract (Table2). As increasing P in the root leads to elevate beta-carotene concentration in the roots because P involved in all intermediate of beta-carotene biosynthesis (11) and increased N enhance biosynthesis of ascorbic acid (30). Also, spraying plants with amino acid has a main role in stimulating plant to absorb NPK due to increase osmotic pressure in plant cells and thus increase absorption of water and nutrients from soil (9). Elevation of N and P in root reinforce concentration of ascorbic acid (30) and beta-carotene in the roots (11). Furthermore, foliar spray of nano-K had increase antioxidants like carotene in the root and this may be due to role of potassium in activating photosynthesis which forms (Isoprenoids) through a series of reactions. Isoprenoids are Isoprere which some of it unite to form carotene (23).

Conclusion

Two seasons of field experiments authenticate that foliar application of hornwort extract, Phenylalanine and Nano-Potassium had a prominent role in promoting all studied parameters.

Conflict of interest

The authors declare no conflict of interest.

References

1. **Abbas, M. F and M. J. Abbas.1992.** Practical Care and Storage of Fruit and Vegetables. Dar Al-Hikma Press. University of Basras. Iraq. 142 p.
2. **Abo Dahi, Y. M and M. A. Al-Younes. 1988**. Handbook of plant nutrition. Baghdad University. Ministry of Higher Education and Scientific Research. Iraq.

3. **Acharya, U.R; M. Mishra; J. Patro and Panda, M.K. 2008.** Effect of Vitamins C and E on spermatogenesis in Mice Exposed to Cadmium. Reproductive Toxicology, 25: 84-88. https://doi.org/10.1016/j.reprotox.2007.10.004
4. **Al-Amin, A. F and M. A. Aboohanah. 2018.** Effect of hornwort extract and magnetically treated water on some growth chemical and production of cucumber *cucumis sativus* L. in desert area. Kerbala Journal of Agricultural Science, 5(3):90-105. https://doi.org/10.59658/jkas.v5i3.517.
5. **Al-Amin, A. F and M. A. Aboohanah. 2017**. The Effect of hornwort extract and magnetically treated water on growth and production of cucumber *Cucumis sativus* L. in desert area. Al Euphrates Journal of Agricultural Sciences, 9(4): 630-646.
6. **Al-Hadithi, E. K; D. A.A. Al-Asafi and Hamad, R. M. 2003.** Useful agricultural uses of hornwort plant *Ceratophlam demeresum* L. estimation of its ability to retain water and use it as germination medium. Anbar Journal of Agricultural Sciences, 1(1): 23-38.
7. **Al-Mohammad, M. H. S; T. F. K. Sachet and Al-dulaimi, Z. S . 2021.** Effect of phenylalanine, jasmonic acid biofertilizer on growth, yield and anthocyanin pigments of roselle calyces. Earth and Environmental Science 910:1-5. Doi:10.1088/1755-1315/910/1/012077.
8. **Al-Rawi, K. M and A. M. Khalaf Allah. 2000**. Design and Analysis of Agricultural Experiments. Foundation of Dar Al-Kutub for printing and publishing. Al-Mosul University. Iraq. pp. 488.
9. **Azza, S. M and R. S. Yousef .2015.** Response of Basil Plant (*Ocimum sanctum* L.) to Foliar Spray with Amino Acids or Seaweed extract. Journal of Horticultural Science & Ornamental Plants, 7 (3): 94-106. DOI 10.5829/idosi.jhsop.2015.7.3.1161
10. **Bouras, M; B. Abo Turabi and Al-Baseet, I. 2006**. Vegetable crops production. Theoretical part. Faculty of agriculture. Damascus University. Al-Dawoody press. Syria.135p.
11. **Cvetkovic, D. J and G. S. Nikolic. 2017**. Carotenoids. In Tech publisher, pp: 222. DOI 10.5772/65523.
12. **Dias, J.S. 2012**. Nutritional Quality and health benefits of vegetables: A review. Food and Nutrition Sciences, 3: 1354-1374. DOI:10.4236/fns.2012.310179
13. **FAO. 2013**. Planting of KS variety carrots to withstand heavy and prolonged rainfall. Philippines Italy.
14. **Fathi, A. 2022.** Role of nitrogen (N) in plant growth, photosynthesis pigments, and N use efficiency: A review. Agrisost, 28: 1-8. http://doi.org/10.5281/zenodo.7143588.

15. **Goodwin, T.W. 1976.** Chemistry and Biochemistry of Plant Pigment. 2 nd. Academic Press. London.UK. p.373.
16. **Hailu, S ; T. Seyoum and Dechassa, N. 2008**. Effect of combined application of organic-P and inorganic-N fertilizers on yield of carrot. African Journal of Biotechnology, 7 (1):027-034. http://www.academicjournals.org/AJB
17. **Hepler, P. K; L. Vidali and Cheung, A. Y. 2001.** Polarized cell growth in higher plants. Annu. Rev. Cell. Dev. Biol, 17: 159-187. https://doi.org/10.1146/annurev.cellbio.17.1.159
18. **Jasinska, A. J; M. Yasuda; C. F. Burant; N. Gregor; S. Khatri; M. Sweet and Falk, E. B. 2012.** Impulsivity and inhibitory control deficits are associated with unhealthy eating in young adults. Appetite, 59(3):738-747. doi:10.1016/j.appet.2012.08.001.
19. **Kumar, P; T. Kumar; S. Singh; N. Tuteja; R. Prasad and Singh, J. 2020.** Potassium: A key modulator for cell homeostasis. Journal of Biotechnology, 324: 198-210. https://doi.org/10.1016/j.jbiotec.2020.10.018.
20. **Marschner, P. 2012.** Marschner's mineral nutrition of higher plants. School of Agriculture, Food and Wine. The University of Adelaide Australia. Third edition.
21. **Martin, N; V. Geert-jan and Arne, V.B.2004.** Parameter for carrot quality and the development of inner quality concept. Louis Bolk Institute.
22. **Moeinirad, A; E. Zeinali; S. Galeshi; A. Soltani and Eganepour, F. 2021.** Investigation of fluorescence chlorophyll sensitivity, chlorophyll index, rate of Chlorophyll (a, b), nitrogen concentration and nitrogen nutrition index under nitrogen and phosphorus nutrition in wheat. J. Crop Prod, 14(1): 1-18. https//doi.org/10.22069/EJCP.2021.12259.1947.
23. **Mohamed, A. K. 1985**. Plant Physiology. second part. Directorate of Book Dar for Printing and Publishing. Mosul University.
24. **Oosterhuis, D; D. Loka; E. Kawakami and Pettigrew, W. 2014.** The physiology of potassium in crop production. Adv. Agron, 126: 203-233. https://doi.org/10.1016/B978-0-12-800132-5.00003-1.
25. **Rodriguez-Amaya, D. B. 2001.** A Guide to Carotenoid Analysis in foods. ILSI Press. Washington D. C., USA. pp. 64.
26. **Salman, J. A. A. 1985.** Effect of sowing distance and potassium fertilizer on growth and yield of carrot (*Daucus carota* Var. sativa D.C). Master Thesis. Faculty of Agriculture and Forestry. Mosul University. Iraq.
27. **Siddiqi, K. S and A. Husen.2017.** Plant response to engineered metal oxide nanoparticles. Nano scale Research Letter, 12:1-18. DOI 10.1186/s11671-017-1861-y.
28. **Simon, P.; M. Lorizzo; D. Grzebelus and Baranski, R.2019**.

The Carrot Genome. Springer Nature Switzerland AG1st ed. pp: 372.

29. **Singh, M.N; R. Srivastava and Yadav, I. 2021.** Study of different varieties of carrot and its benefits for human health: A review. Journal of Pharmacognosy and Phytochemistry, 10(1): 1293-1299. https://doi.org/10.22271/phyto.2021.v10.ilr.13529.
30. **Smirnoff, N and G. L. Wheeler. 2000.** Ascorbic acid in plants: biosynthesis and function. Critical Review in Plant Sciences, 19 (4):267-290. https://doi.org/10.1080/10409230008984166
31. **Sohair, E. E. D; A. A. Abdalla; A. M. Amany and Houda, R. A. 2018.** Effect of nitrogen, phosphorus and potassium nano fertilizers with different application times, methods and rates on some growth parameters of Egyptian cotton (*Gossypium barbadense* L.). Bioscience Research, 15(2):549-564. http://www.isisn.org/
32. **Tanaka, Y; N. Sasaki and Ohmiya A. 2008**. Biosynthesis of plant pigments: anthocyanins, betalains and carotenoids. The Plant Journal, 54(4):733-49. https://doi.org/10.1111/j.1365-313x.2008.03447.x
33. **Zeb, A and S. Mahmood. 2004.** Carotenoid contents from various sources and their potential health applications. Pakistan J. Nutr, 3(3): 199-204 https://doi.org/10.3923/pjn.2004.199.204.
34. **Zebarth, B. J and R.W. Sheard. 1992.** Influence of rate and timing of nitrogen fertilization on yield and quality of hard red winter wheat in Ontario. Can J. Plant Sci, 72(1): 13-19.https://doi.org/10.4141/cjps92-002.