RESPONSE OF YIELD AND QUALITY OF BROCCOLI TO TYPE OF NUTRIENT SOLUTION UNDER HYDROPONIC SYSTEM WITH MODIFIED NFT TECHNOLOGY

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ABSTRACT

This study was carried out at the Dept. Hortic. and Land.Gard., Coll. Agric. Eng.Sci., University of Baghdad during fall season of 2019-2020, in order to evaluate the effect of nutrient solution type under hydroponic system (NFT) on growth, yield and quality of broccoli *Brassica oleracea* var.italica. Two experiments were carried out which were the standard solution experiment (Cooper) and the alternative solution experiment (ABEER) prepared from fertilizers. Results revealed that the type of solution used in the hydroponics system had non significant effect on the leaves content of N,K, Mg, Fe, Cu, B, Chlorophyll, leaves number, root length, weight of the main heads, number of side heads were not significantly affected. 13^{nt}, reflected on the productivity under the nutrient solution (45.87 and 44.78 ton ha^{-1} for the standard and alternative solutions, respectively), While the effect of the alternative solution was recorded a significant increment for each of the leaves percent of phosphorous, manganese and zinc concentration, Number of days until harvest 50% of the plants (0.65%, 23.84,59.56 mg kg^{-1}, 94.74 day respectively),compared to the standard solution, which recorded a significant increment in the calcium percent in the leaves, plant height, leaves area, shoots dry weight, roots dry weight, shoots: roots dry weight, diameter of the main heads and weight of the side heads. As for the yield quality parameters, Results revealed the type of nutrient solution non significant effect on quality of broccoli. The results could be recommend the alternative solution (ABEER) as a promising nutrient solution in hydroponics system.

Key words: soilless culture, I3C, mineral elements, Sulforaphane , Vitamins.

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إستجابة حاصل ونوعية البروكلي لنوع المحلول المغذي تحت نظام الزراعة المائية بتقنية فلم المحلول المغذي المحور

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المستخلص

أُجري البحث في حقول كلية علوم الهندسة الزراعية – جامعة بغداد في الموسم الخريفي 2019– 2020 بهدف دراسة تاثير نوع المحلول المغذي للزراعة المائية في نمو وحاصل البروكلي وجودة صفاته وذلك بتنفيذ تجربتين هما تجربة المحلول القياسي (Cooper) وتجربة المحلول البديل (ABEER) المحضر من اسمدة متوفره في الاسواق العراقية وحسب مرحلتي النمو الخضري والزهري، تمت المقارنة بين المحلولين ضمن اختبار T. أظهرت النتائج ان نوع المحلول المستعمل في منظومة الزراعة المائية لم يكن له تاثير معنوي في محتوى الاوراق من N و K وMg وFe وCu و B و Chlorophyll وعدد الاوراق للنبات وطول الجذر ووزن القرص الرئيس وعدد الاقراص الجانبية ومن ثم انعكاس ذلك على عدم تأثر الانتاجية معنوياً بنوع المحلول المغذي في المنظومة (45.87 و 44.78 طن هكتار$^{-1}$ للمحلولين القياسي والبديل على التتابع) في حين كان تأثير المحلول البديل معنويا في زيادة كل من النسبة المئوية للفسفور وتركيز المنغنيز والزنك في الاوراق وعدد الايام اللازمة لجني 50% من النباتات (0.65% و23.84 و59.56 ملغم كغم$^{-1}$ و94.74 يوم) على التتابع مقارنة بالمحلول القياسي الذي أدى الى زيادة معنوية في النسبة المئوية للكالسيوم في الاوراق و ارتفاع النبات والمساحة الورقية والوزن الجاف للمجموع الخضري والجذري ونسبة الوزن الجاف الخضري الى الجذري وقطر القرص الرئيس ووزن الاقراص الجانبية. اما في مؤشرات نوعية الحاصل أظهرت النتائج ان نوع المحلول المغذي لم يكن له تاثير معنوي في نوعية البروكلي. يمكن التوصية بالمحلول البديل (ABEER) كمحلول مغذي واعد في نظام الزراعة المائية .

الكلمات المفتاحية: الزراعة من دون تربة، العناصر المغذية، السالفورافان، الفيتامينات .

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INTRODUCTION

The crop nutrition is an important factor to improve productivity and the characteristics quality of horticultural products; the hydroponics are of great importance in this field that allows the management of various factors that affect plant nutrition, including the composition of the nutrient solution, the concentrations of nutrients and the degree of Solution temperature, etc. (14, 30, 31, 32, 34). Hydroponics could be contains several types of Nutrient Film Technique, which has multiple advantages, the most important of which is the optimal use of water and fertilizers, better control of the nutrient's sources, and types, and concentration, that increases the economic benefits (22). It also provides a better control of the climate factors and pests; the nutrient solution is one of the most important determinants of crop productivity and quality that affects the hydroponic systems (15, 36). In the past two decades, academics in Iraq have placed a sliding order of priority on broccoli (*Brassica oleracea* var.italica) due to its high nutritional content and versatile uses. (3, 33) Nadia et al. (23) conducted a study on the hydroponic cultivation of broccoli plants under three types of nutrient solutions with three replicates for each type during a period of 106 days. The applied solutions were T1 organic solutions consisted of soaking 3 kg of vermicompost in 90 liters of water and after 10 days, 1 kg of earthworm fertilizer was applied, and this continued for a week until the end of the experiment. While T2 was inorganic solutions were prepared by applying a mixture of 5 g urea, 7.50 g TSP, 5 g MOP, 5 g Dolomite, 5 g DAP, 0.50 g boron and 0.50 g iron to 90 liters of water, and then 80% of the initial weight of the fertilizer (22.80 g) was applied for each Two weeks, and T3 was aquaculture consisted of releasing ten tilapia fingerlings with an average length of 11.61 cm and weight of 33.71 g into the culture tanks, and the fish were fed with commercial floating feed containing 30% protein twice per day in a 3% of body weight; the result revealed the highest yield of broccoli grown under the inorganic mineral solution, which recorded 11.79 tons. ha^{-1} compared to the plant's yield grown under the Aquaponic and organic solution, which recorded 4.77 and 2.24 ton ha^{-1} respectively, while the leaves area, roots length, and weight did not significantly differ among the applied treatments. Yang and Kim (40) conducted an experiment to compare the growth and yield of tomato, basil and lettuce grown under two cultivation systems, which were the hydroponics that consisted of dissolved mineral nutrients of RO and Aquaponic, the results revealed that vegetative mass was decreased significantly under the aquaponic system in comparison with the hydroponic system, also the production of basil and lettuce were decreased by 56% and 67%, respectively. Pérez-Urrestarazu et al. (26) were applied three hydroponic systems according to NFT, Floating raft and vertical felt to produce lettuce and *carassius auratus* in two production cycles, the crop yield and water consumption were recorded the highest values under NFT system, while all systems had similar results in fish production. After all given above, This study was aimed to spread and expand the hydroponics technology projects and overcoming the obstacles, including preparing nutrient solutions from available fertilizers instead of standard solutions that require unavailable salts in the local market as well as evaluating the response of the growth, yield, and quality of broccoli to the applied solutions.

MATERIALS AND METHODS

This Two Experiments were carried out at University of Baghdad - College of Agricultural Engineering Sciences - Research Station B during the fall season of 2019-2020, which were the standard solution experiment and the alternative solution experiment, each of were included two independent systems, with total of four hydroponics systems, each of which contains a tank capacity of 1000 liters under the ground filled of the nutrient solution and a water pump connected to three plastic tubes 18 m long and 6 inches in diameter installed on a support frame and perforated with 7 cm holes with a diameter, suitable for cultivation cups, and ends with a tube with a diameter of 4 inches to return the solution to the tank in a closed loop, the drainage holes were installed by raising them to a distance of 1/3 the diameter of the cultivation tube, to retain part of the nutrient solution in the cultivation tubes when the power was cut off, and after all the NFT system completely prepared, each tank was also provided with an air pump to ventilate the nutrient solution around the clock, and a deionizer was installed at the main water source to provide deionized water Reverse Osmosis (RO) used in preparing the solutions approved in the experiment after passing a water meter to calculate the amount of water added to the two tanks on a continuous basis. The Jassmina F1 hybrid broccoli seeds produced by DELTA SEEDS (D/S) were used in the experiment, the seedlings were transplanted in the appropriate size to the system on 16/9/2019 after being planted in plastic cups for hydroponics filled with perlite in a 30 cm planting distance, between each plant and 60 cm between each tube, then the nutrient solutions were pumped out on 26/9/2019. Two types of solutions were applied under hydroponics system which were the standard nutrient solution (Cooper) Table 1 (7), and the alternative nutrient solution (ABEER) prepared from fertilizers that are available in the Iraqi markets according to the vegetative and flowering growth stages, on a scientific basis and easy to apply from the producing specialists or farmers, Table 2. The comparison was made between the standard solution and the alternative solution within the T test.

Table 1. Salts used in preparation of standard nutrient solution and elements concentration in it (Cooper solution 79)

Salt type	Chemical structure	The weight g.L^{-1}	Element type	Concentration of the element mg.L^{-1}
		Stock A		
Calcium nitrate	$Ca(NO3)_2.4H_2O$	1003	Nitrogen	119
			Calcium	170
Chelated Iron	EDDHSA	79	Iron	12
		Stock B		
Potassium dihydrogen phosphate	KH_2PO_4	263	phosphorus	60
			Potassium	75
Potassium nitrate	KNO_3	583	Potassium	225
			Nitrogen	81
Magnesium sulfate	$MgSO_4.7H_2O$	513	Magnesium	50
Manganese sulfate	$MnSO_4.H_2O$	6.1	Manganese	2
Boric acid	H_3BO_3	1.7	Boron	0.3
Copper sulfate	$CuSO_4.5H_2O$	0.39	Copper	0.1
Ammonium heptamolybdate	$(NH_4)_6Mo_7O_{24}.4H_2O$	0.37	Molybdenum	0.2
Zinc sulfate	$ZnSO_4.7H_2O$	0.44	Zinc	0.1

Table 2. Fertilizer used in preparation of alternative nutrient solution (ABEER) and elements concentration in it

Fertilizer type	The weight g.L^{-1}	Element type	Concentration of the element mg.L^{-1}
	Vegetative growth stage		
30- 10- 10 +10	0.75	Total Nitrogen	225
Neutral ammonium citrate		P_2O_5	75
		K_2O	75
		SO_3	75
Disper	0.25	Fe-EDDHSA	12.5
Complex GS		Mn -EDTA	10
		Zn-EDTA	1.5
		MgO -EDTA	5
		Cu -EDTA	1.25
		B	1.75
		Mo	0.75
Disper Mg	0.341	MgO	42
Disper Ca	1g L^{-1} sprinkled on the plant every 15 days throughout the growing season.		
	Flower growth stage		
20 -20 -20	0.75	$N-NH_4$	150
Neutral ammonium citrate		P_2O_5	150
		K_2O	150
Disper	0.25	Fe-EDDHSA	12.5
Complex GS		Mn -EDTA	10
		Zn-EDTA	1.5
		MgO -EDTA	5
		Cu -EDTA	1.25
		B	1.75
		Mo	0.75
Disper Mg	0.341	MgO	45
Disper Ca	1g L^{-1} sprinkled on the plant every 15 days throughout the growing season.		

The samples were randomly selected, and the following parameters were measured:

1. Leaves content of mineral elements and chlorophyll : The leaves content of nitrogen was determined using the Kjeldahl Micro, device and the leaves content of phosphorous were determined using the ammonium molybdate and ascorbic acid using a spectrophotometer at a wavelength of 620 nm and the leaves content of potassium using the Atomic Absorption device. the leaves content of Ca, Mg% , Fe, Mn, Zn, and Cu mg.Kg^{-1} were estimated by the Atomic Absorption device, and boron was estimated using the Carmin pigment. Also the leaves content of chlorophyll the dye was estimated according to Goodwin and then converted to mg.100 g fresh $weight^{-1}$.

2. Vegetative and root growth: Plant height (cm), and leaves number (leaf. $plant^{-1}$) were measured at the end of the season. The leaves area (dsm^2. $plant^{-1}$) was calculated according to the dry weight method by Watson and Watson. Dry weight of shoots (g.$plant^{-1}$) Root length (cm) was measured at the end of the season, then the roots of the selected plants were dried in Oven, then the dry weight (g.$plant^{-1}$) was calculated using a sensitive scale, then the ratio of the shoots to roots dry weight.

3. Yield indicators : Calculated the number of days from planting until 50% of the plants were harvested in the experimental unit (day), then measure the circumference of the head and record the diameter from the circumference of the circle (cm), The weight of the main flower heads (g.$Plant^{-1}$) was calculated at harvest and the number of secondary heads on the main stem (head. $plant^{-1}$) at the end of the growth season. The secondary heads weight (g.$Plant^{-1}$)was calculated cumulatively until the end of the season, then the plant yield (g.$Plant^{-1}$) and total yield (ton.ha^{-1}) was calculated according to the experimental unit yield from the cumulative yield of the main and secondary heads yield until the end of the season.

4. Yield quality parameters : The percent of N, P, K, Ca, and Mg was calculated, and the concentration of Fe, Zn, Mn, Cu, and B nutrients. Main heads content of chlorophyll as the same methods used to estimate the leaves chlorophyll content of chlorophyll. The protein percent was calculated according to the method of Dalali and Al-Hakim, and the nitrate was estimated (mg 100 g^{-1} dry weight) according to Cataldo et al. method. The total carbohydrates percent was calculated according to Joslyn method. And the main heads content of TSS according to Ibrahim (16). Also, β-carotene was extracted and calculated (mg $100g^{-1}$ fresh weight) according to Nagata and Yamashita method. The concentration of folic acid (µg$100g^{-1}$) was also estimated according to the method of Ruengsitagoon and Hattanat (28). The main head juice filtrate was calibrated with the dye (2.6, Dichlorophenol Indophenols) to calculate the concentration of Ascorbic acid (VC) (mg 100 g^{-1} fresh weight) and Davies method was applied to extract the total carotenoids (mg 100 g^{-1} fresh weight) in the main heads using a high-performance liquid chromatography (HPLC) device. Indol-3-Carbonel (mg kg^{-1} dry weight) was calculated according to Li et al. (14) and Sulforaphane (mg kg^{-1} dry weight) as reported by Li et al. (15).

RESULTS AND DISCUSSION

Effect of the nutrient solution type on the chemical characteristics of leaves, vegetative, and root growth and yield parameters of broccoli plants grown under hydroponic conditions: The results in Table 3 according to the t-test for comparison between the standard and alternative solutions indicat that the type of solution used in the hydroponics system had no significant effect in most of the measured chemical parameters (7 out of 11 measured parameters). While the effect of the alternative solution was recorded a significant increment in each of the leaves percent of phosphorous (0.65%), the manganese concentration (23.84 mg kg^{-1}), and leaves content of zinc (59.56 mg kg^{-1}) compared to the standard solution, which recorded a significant increment in the calcium percent in the leaves for the alternative solution, which reached 1.804 and 1.650%, respectively. As for the vegetative and root growth parameters, the leaves number and root length were not significantly affected by the type of solution. However, the standard solution had a significant increment in both plant height and leaves area, which increased the dry weight of the shoot and root system, and this was significantly increased the ratio of vegetative / root weight. The alternative solution had a significant effect in the days number required until harvest 50% of the plants, as it took the plants growing in the alternative solution 94.74 day, compared to 104.47 day in the plants grown under the standard solution, As for the single plant's yield, the weight of the main heads and the number of side heads were not significantly affected, which reflected on the productivity under the nutrient solution (45.87 and 44.78 ton ha^{-1}) for the standard and alternative solutions, respectively). However, the diameter of the main heads and the weight of the side heads were increased significantly in the standard solution compared to the alternative solution.

Table 3. Effect of the nutrient solution type on the chemical characteristics of leaves, vegetative, and root growth and yield parameters of broccoli plants grown under hydroponic conditions for autumn season 2019-2020.

Study Indications	Average values of the standard nutrient solution	Average values of the alternative nutrient solution	Common standard error	Calculated t value
Leaves content of mineral elements and chlorophyll				
N %	4.052	4.021	0.1550	0.20
P %	0.5394	0.6554	0.0288	-4.03
K %	3.048	3.018	0.0346	0.88
Ca %	1.804	1.650	0.0465	3.31
Mg %	0.4706	0.4563	0.0156	0.92
Fe ($mg.Kg^{-1}$)	149.70	154.60	8.0580	-0.61
Mn ($mg.Kg^{-1}$)	20.61	23.84	1.1460	-2.82
Zn ($mg.Kg^{-1}$)	52.30	59.56	2.9690	-2.44
Cu ($mg.Kg^{-1}$)	4.976	4.898	0.4550	0.17
B ($mg.Kg^{-1}$)	17.27	17.15	1.2410	0.09
Chlorophyll (mg $100g^{-1}$ fresh weight)	390.80	396.30	7.7260	-0.71
Vegetative and root growth				
Plant height (cm)	74.24	69.25	1.126	4.42
No. of Leaves (leaf. $plant^{-1}$)	86.40	74.20	5.957	2.05
Leaf area (dsm^2. $plant^{-1}$)	304.8	234.9	22.91	3.05
Dry weight of the shoots ($g.Plant^{-1}$)	155.1	127.5	9.168	3.01
Root length (cm)	120.5	115.2	4.014	1.30
Dry weight of the roots ($g.Plant^{-1}$)	29.26	26.28	0.801	3.72
Shoots: Roots dry weight	5.273	4.827	0.201	2.22
Yield Indicators				
No. of days until harvest 50% of the plants (day)	104.47	94.74	0.922	10.55
Diameter of the main head (cm)	18.58	17.31	0.554	2.29
Weight of the main head ($g.Plant^{-1}$)	599.3	619.0	24.81	-0.79
No. of the side heads (head. $plant^{-1}$)	4.850	4.740	0.460	0.24
Weight of the side heads ($g.Plant^{-1}$)	226.3	187.2	18.11	2.16
Plant yield ($g.Plant^{-1}$)	825.7	806.1	36.08	0.54
Total yield ($ton.ha^{-1}$)	45.87	44.78	2.004	0.54

***Sample size N= 10 for each solution and t-value under 0.05 probability level and 18 degrees of freedom = 2.101**

These results would be due to the non-significant differences in the main parameters of the yield represented in the weight of the main heads and the number of side heads, which was reflected on the productivity of the nutrition solution type for plants grown in both standard and alternative solutions. However, the mixture of fertilizer applied in preparing the alternative solution and the concentrations of the dissolved nutrients and according to the stages of plant growth, which depend mainly on the balance between the nutrients that the plant required in a certain amount, have reached the optimum limit for the plant's need of nutrients. Also the advantage of preparing the fertilizers of available components in the local market and at a low cost compared to the salts used in preparing the standard solution, part of which is not available in the local market, in addition to the high cost compared to the alternative solution. The increment in leaves content of calcium for the plants growing under the standard solution can be due to their concentration in the plant tissues depends on their concentration in the solution. Since the standard solution consisted of nitrate NO^{-3} as a source of nitrogen; during the absorption, the radicals will release the bicarbonate ions HCO^{-3} and hydroxyl OH - into the nutrient solution, which increases the pH of the solution, which increases the availability of calcium (24). When the factors that stimulate the calcium absorption are available, including ventilation, the required energy for growth, and the appropriate environmental conditions, it will be reflected their content in the vegetative growth. Also, calcium will flow throw the xylem to the produced mature leaves, (9) compared to their foliar application spraying on the plant grown under the alternative solution and its weak flow through the phloem tissues, which may affect their absorption and concentration in the leaves, as the applied calcium moves to the lower or upper surface of the leaves and to the rest of the plant tissues (17), this nutrient, which is one of the major nutrients, has several important physiological functions for plant growth and development, as it has a basic role in the cell division process through its influence in the formation of spindle threads and the formation of middle lamella which is reflected on the plant cells stability (29, 41). It also has a role in regulating the production of some plant hormones such as auxins (37), which increased the plant's height. Calcium is also considered as a secondary messenger of retrograde signals, and this function contributes in nutrients absorption (35), including nitrogen and potassium in the roots, which is affects the plant's growth and increases the leaves area, accumulates compounds, and increases the dry weight of the vegetative growth. These results agreed with Abahri (1) on the hydroponic grown bean plant under the application of Cooper's solution which increases the plant height, leaves area, and dry weight of vegetative growth of the three varieties approved in the research compared to other solutions. The appropriate concentration of calcium creates an appropriate growth and development conditions for the roots (4, 5, 6). while a low concentration leads to a poor development (13), and this was evident in the increase in dry weight of them and an increase in the ratio of the vegetative to root system of plants growing in the standard solution, This researcher also confirmed that the effect of nutrients on plant growth and development extends to the various vital interactions that occur in plant tissues that can affect the characteristics of the plant. The availability of calcium is one of the determinants of production that plays an important role in maintaining tissues and their stability in addition to the yield characteristics, as it reflected positively on the diameter of the main heads and the weight of the side heads as a result of the increment in leaves area and shoots height Dry weight. This is reflected on the head's growth, development, and size, in addition to the compound's accumulation in the side heads, which has increased their weight. These results were consisted with Ayyub et al. (8) that indicated the role of calcium in increasing the diameter and weight of tomato and reducing the effect of physiological diseases on fruits.The increment of phosphorous, manganese and zinc content in the leaves of the alternative solution plants can be due to the content of the solution of ammonium NH^{+4} as a source of nitrogen; the role of which is the roots will release H^{+} ions, which leads to decrease the pH of the nutrient solution, which increases the readiness of these nutrients (10). Also, the application of chelated formula EDTA for manganese and zinc in through the alternative solution, that is characterized by a low molecular weight, which contributes to increase the plant's absorption, as it characterized by a high percent of chelating nutrients and the maximum acidity ratio is 1.5: 6.5 (2), which was clearly reflected on the plant's content. Also, the foliar application of calcium on the plants was to avoid the deposition of mineral phosphorous in the form of calcium phosphate $Ca(H_2PO_4)_2$ (25), which increased its readiness, absorption, and accumulation in the vegetative growth. This high content of phosphorous has clearly affected the yield characteristic and reduced the time required for harvesting, as it directly stimulated the plant's flowering, especially that the broccoli is relying on inflorescences yield (27). It also can be due to the low content of nitrates in the alternative solution, which may be reflected on its concentration in the plant, which leads to an increase in gibberellins biosynthesis (20), which contributes to stimulate flowering, which indicates that low nitrate concentration stimulates flowering (11, 21).

Effect of the nutrient solution type on yield quality indicators of broccoli plants grown in hydroponics: Results in Table (4) according to the t-test indicat that the concentration of most of the mineral nutrients in the heads (10 measured major and minor nutrients) were not significantly affected by the nutrient solution type, namely nitrogen, phosphorous, iron, zinc, copper, and boron. However, the percent of potassium and calcium in the heads were increased significantly in plants grown in the standard solution and reached 2.553 and 0.9928 % respectively compared to the alternative solution, which recorded 2.297 and 0.829 % respectively, while the opposite results were recorded for the magnesium and manganese, which increased significantly in the alternative solution plants (0.3842% and 15.96 mg kg^{-1}, respectively) compared to the standard solution plants (0.364% and 9.99 mg kg^{-1}, respectively). Also, the non-significant increment of chlorophyll content were recorded in the heads for plants grown in the alternative solution over the standard solution, as it recorded 122.3 and 110.4 mg 100 g fresh $weight^{-1}$ for each of the alternative and standard solutions, respectively. Neither the standard solution nor the alternative solution had a significant effect on the total soluble solids TSS, and all the compounds and vitamins measured in the heads, which constitute the nutritional value of the yield, and reflects the quality of the crop.

Table 4. Effect of the nutrient solution type on yield quality indicators of broccoli plants grown in hydroponics for autumn season 2019-2020.

Study Indications	Average values of the standard nutrient solution	Average values of the alternative nutrient solution	Common standard error	Calculated t value
N %	4.732	4.781	0.0689	-0.71
P %	0.6910	0.6559	0.0283	1.24
K %	2.553	2.297	0.0567	4.51
Ca %	0.9928	0.8289	0.0316	5.19
Mg %	0.3639	0.3842	0.00951	-2.13
Fe ($mg.Kg^{-1}$)	77.19	82.96	3.813	-1.51
Zn ($mg.Kg^{-1}$)	72.10	80.75	4.265	-2.03
Mn ($mg.Kg^{-1}$)	9.99	15.96	0.419	-14.22
Cu ($mg.Kg^{-1}$)	4.570	4.430	0.374	0.37
B ($mg.Kg^{-1}$)	22.49	24.07	0.781	-2.02
Chlorophyll (mg $100g^{-1}$ fresh weight)	110.4	122.3	6.139	-1.93
Protein %	29.57	29.88	0.431	-0.71
Nitrate (mg 100 g^{-1} dry weight)	47.93	46.60	4.613	0.29
Total carbohydrates %	6.435	6.338	0.145	0.67
TSS %	8.476	8.247	0.249	0.92
β-carotene (mg 100 g^{-1} fresh weight)	5.636	5.402	0.255	0.92
V.B9 (μg$100g^{-1}$)	80.24	78.37	4.356	0.43
V.C(mg 100 g^{-1} fresh weight)	99.2	102.80	4.255	-0.86
Total carotenoids (mg 100 g^{-1} fresh weight)	9.782	8.835	0.497	1.91
Concentration of I3C (mg Kg^{-1} dry weight)	61.49	67.33	5.268	-1.11
Sulforaphane (mg Kg^{-1} dry weight)	28.40	27.42	5.62	1.7

***Sample size N= 10 for each solution and t-value under 0.05 probability level and 18 degrees of freedom = 2.101**

Back to Table 3, results reveal that the leaves content of potassium did not differ between the plants grown in both solutions, while the potassium percent in the heads differed for the plants growing in the standard solution than in the alternative (Table 4). Which may be attributed to the cells division and elongation of the main heads, which require the flow of photosynthesis products from the source tissues (leaves) to the accumulation areas and the activation of the various necessary enzymes in the storage areas, that the potassium is considered as one of the most important nutrients responsible for these tasks (38), which was positively reflected on the increment in the diameter of the main heads in standard solution plants, as well as its role in regulating the hormones responsible for the production of flowers. These results were consisted with Çolpan et al. (12) that recorded that the increment of potassium in Steiner nutrient solution prepared using highly soluble commercial fertilizers available in the local markets in the United States of America has increased the diameter of the fruits of watermelons grown under protected cultivation conditions, this increment in the percent of potassium in the heads can be due to the increment of calcium in the heads for its role in regulating the rate of transpiration, which increases the transmission of water and nutrients, including calcium, which ensures the nutritional balance process (39), or it may be due to the increasing the leaves content of nutrients in the plants of the standard solution compared to the alternative solution. As for the magnesium and manganese increment in the heads in the alternative solution plants compared to the standard solution plants, the reason can be due to the use of Disper fertilizers that contains these nutrients in a chelated form, which increased the guarantee of their absorption and transmission. The reason for the non-significant differences in the heads content of compounds related to human nutrition and health of plants grown in the alternative solution compared to plants grown in the standard solution is that the components of the alternative solution from chemical formulas, quality and origins made it suitable to achieve the plants requirements from vegetative growth and transferring its surplus to the downstream to raise the efficiency of performance and maintain the level of product quality, and make it suitable for current and future consumer requirements as well as reducing cost, risk and ease of preparation compared to the standard solution. This study concluded the possibility of preparing an alternative solution and overcoming one of the most important obstacles to the spread of hydroponics technology, which is the unavailability of standard solutions in the local markets and the difficulty of obtaining and preparing their costly salts, As well as obtaining a productivity with quality specifications similar to the productivity of the plant in the standard solution, so we recommend the alternative solution (ABEER) as a promising nutrient solution prepared from fertilizers available in the local markets, easy to prepare and low cost, and according to the stages of plant growth in the NFT film axis technology as an alternative to the use of high-priced and unsafe standard solutions in the cultivation of various types of leafy and flowering vegetables and the spread the culture of hydroponics after solving the problem of nutrient solutions.

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