EFFECT OF OZONE ENRICHMENT AND SPRAYING WITH COCONUT WATER AND MORINGA EXTRACT ON VEGETATIVE GROWTH AND YIELD OF BROCCOLI PLANT UNDER HYDROPONIC SYSTEM WITH MODIFIED NFT TECHNOLOGY

A. D. Salman* **I. J. Abdulrasool**
Lecturer **Professor**
Dept. Hortic. and Landscape Gardening ,Coll. of Agric. Eng. Sci., University Baghdad, Iraq.
abeer.dawood@coagri.uobaghdad.edu.iq eimanjabir@coagri.uobaghdad.edu.iq

ABSTRACT

This study was carried out at University of Baghdad - College of Agricultural Engineering Sciences - Research Station B during the autumn season 2019-2020, in order to evaluate the effect of Ozone and the foliar application of coconut water and moringa extract on the growth of broccoli plant grown in modified NFT film technology. A factorial experiment (2*5) was carried out within Nested Design with three replicates. The ozone treatment was distributed into the main plots which consisted of oxygen (O_2) and ozone (O_3). The foliar application of organic nutrients were distributed randomly within each replicate including five treatments, which were the control treatment (T0), Coconut water with two concentrations of 50 (T1) and 100 ml. L^{-1} (T2), and Moringa leaves extract at two concentrations 2% (T3) and 4% T4. Results revealed a significant effect of interaction between the ozone and the foliar application of coconut water 100 ml. L^{-1} (O3T2) on the leaves content of Ca, Mg, Fe, Zn, Cu, B, Chlorophyll, plant height, leaves number, leaves area, root length, roots dry weight, number and weight of secondary heads (24.09 ,33.16, 55.00, 56.01, 102.85, 72.01, 13.88, 9.39, 90.56, 96.56, 28.07, 24.52, 120.0, 77.48% respectively) compared to the control treatment (O2T0). Interaction between ozone enrichment and the foliar application of 4% Moringa leaves extract (O3T4) were recorded a significant increment in the main tablet weight, reached 687.33 gm.Plant^{-1} compared to the control treatment (O2T0). Interaction between ozone and Moringa leaves extract at 2% (O3T3) or, and coconut water 100 ml. L^{-1} (O3T2) had a significant increment in the total yield reached 51.07 and 50.94 tons.ha^{-1}, respectively, compared to the control treatment (O2T0).

Key words: soilless culture, gas enrichment, organic nutrients.
***Part of Ph. Dissertation of the 1st author .**

تأثير الاغناء بالاوزون والرش بماء جوزالهند ومستخلص المورنكا في النمو الخضري والحاصل لنبات البروكلي تحت نظام الزراعة المائية بتقنية NFT المحور

عبير داود سلمان **إيمان جابر عبدالرسول**
مدرس **أستاذ**
قسم البستنة وهندسة الحدائق – كلية علوم الهندسة الزراعية – جامعة بغداد

المستخلص

أُجري البحث في المحطة البحثية B التابعة الى كلية علوم الهندسة الزراعية – جامعة بغداد في الموسم الخريفي 2019– 2020 بهدف دراسة تاثير الاغناء بالاوزون والرش بماء جوزالهند ومستخلص المورنكا في نبات البروكلي النامي بتقنية فلم المحلول المغذي NFT المحور، نفذ كتجربة عاملية (2*5) ضمن تصميم Nested Design بثلاث مكررات وزع عامل نوعية الغاز المُجهز الى المحلول في القطع الرئيسة وشمل على الاغناء بالاوكسجين (O_2) وبالاوزون (O_3) ووزعت مستويات رش المغذيات العضوية ضمن كل مكرر بشكل عشوائي وشملت خمس معاملات هي معاملة القياس (T0) وماء جوز الهند بتركيزين 50 و 100مل.لتر$^{-1}$ (T1 وT2) على الترتيب ومستخلص اوراق المورنكا بتركيزين 2 و4 %(T3 وT4) على الترتيب، اظهرت النتائج تفوقا معنويا لمعاملة الاغناء بالاوزون والرش بماء جوز الهند 100مل.لتر$^{-1}$ (O3T2) في محتوى اوراق النباتات من Ca و Mg وFe وZn وCu وB وChlorophyll وارتفاع النبات و عدد الاوراق الكلية والمساحة الورقية وطول الجذر والوزن الجاف للمجموع الجذري وعدد ووزن الاقراص الجانبية (24.09 و33.16 و55.00و 56.01و 102.85و 72.01و 13.88و 9.39 و 90.56 و 96.56 و28.07 و 24.52 و 120.0و 77.48%على الترتيب) مقارنة بنباتات القياس (O2T0) كما سجلت معاملة الاغناء بالاوزون والرش بمستخلص اوراق المورنكا 4% (O3T4) زيادة معنوية في وزن القرص الرئيس الذي بلغ 687.33 غم.نبات$^{-1}$ مقارنة بنباتات القياس (O2T0) وكان للتداخل بين معاملة الاغناء بالاوزون والرش بكل من مستخلص اوراق المورنكا 2% (O3T3) أو بماء جوز الهند 100مل.لتر$^{-1}$ (O3T2) زيادة معنوية في الحاصل الكلي بلغ 51.07 و 50.94 طن. هكتار$^{-1}$ على الترتيب مقارنة بعاملة القياس (O2T0) .

الكلمات المفتاحية: الزراعة من دون تربة، الاغناء بالغاز، المغذيات العضوية.
***مستل من اطروحة دكتوراه للباحث الاول**

Received:14/1/2021, Accepted:11/4/2021

INTRODUCTION

One of the greatest challenges in this century is providing fresh water for human use, which is largely related to the global population growth and the subsequent increment in demand of food. 70% of fresh water use is currently wasted by agricultural practices, which makes it necessary to develop technologies that increase the agricultural production while reducing their requirements (22), including hydroponics with NFT technology, which is considered at recent years as a promising strategy to grow various crops. It is possible to cultivate fast-growing crops and give an early production, such as vegetables over the year, in very limited areas with reduced efforts and costs (32), less in soil pollution and shallow water, and give the advantage of more efficient use of water, fertilizers, and increase the production. The closed system is typically used in applied horticulture and moreover in commercial greenhouses producing salad crops (19). One of the most important parameters of concern in any hydroponic system is dissolved oxygen (DO) (21). The atmosphere contains 20% oxygen, which is very low in solubility. The water consumed for several reasons, including the chemical, physical and biological properties of water and most important the distribution system through pipes and tanks (35). There are several methods of providing dissolved oxygen in water, including the application of hydrogen peroxide, air pumps with stones, oxygen gas injection, or ozone enrichment, as well as appropriate stirring of water through the tanks, which are common practices to increase its concentration. Suyantohadi et al. (33) found that a lettuce plant grown in a deep-water farm and under the high concentration of dissolved oxygen (23 mlg. L^{-1}) increased by 2.1 of the regularly grown lettuce under the outdoor air conditions; also Peykanpour et al. (28) noted that the fertigation of Halkland solution along with concentrations of ozone on cucumber that cultivated under hydroponic conditions, produced a significant increment in total yield, fruits number, fresh and dry weight of the plant compared to the control treatment. The application of expansive inorganic fertilizers by farmers is related to the soil degradation and environmental pollution; therefore, there is a constant need to develop an alternative natural source that is safe for plants and environment that could be applied as a potential fertilizer (29). Organic nutrients provide unlimited opportunities for fertilization development due to their availability and chemical diversity (30). The coconut water has a major role in the agricultural applications; the application of coconut water is widely used in plant tissue cultivation due to its high content of sugars, fats, vitamins, mineral nutrients, amino acids, Nitrogen, organic acids, enzymes, and phytohormones, including cytokinins (27); it also has a major role in breaking the apical dominance of the plant and the growth stimulation of lateral shoots (10). Al-Hachami et al. (14) showed that the foliar application of coconut water on two varieties of strawberries has significantly affected the vegetative characteristics, including plant height, leaves number, leaves area, leaves content of chlorophyll, and plant dry weight. Moringa leaves extract is a main source of calcium, potassium, vitamins such as A, B, C, and nutrients, Zn, Mg, Fe, Cu, proteins, carotene, amino acids, sulfur and various phenols (38), as well as its content of Zeatin (1). Maishanu et al. (23) mentioned that the foliar application of Moringa leaves extract gave a significant effect in the shoots number, number and length of leaves and branches, stem diameter, and plant yield compared to the foliar application of urea fertilizer and control treatment. The results also showed that the extract contained many growth hormones, especially Zeatin, which increases the yield by 10-45%, it also includes micronutrients in appropriate quantities that increase the growth and yield of various crops. The consuming of non-traditional vegetable crops has widely increased in the previous period of time, as it enriches our food systems with balanced nutrients. Therefore, this research was aimed to evaluate the effect of ozone enrichment and the foliar application of organic nutrients on the broccoli cultivated under hydroponics conditions.

MATERIALS AND METHODS

This experiment was carried out at the University of Baghdad - College of

Agricultural Engineering Sciences - Research Station B during the autumn season 2019-2020 inside a greenhouse partially covered by saran with a dimension of 9 * 45 m. Two hydroponic systems were installed including a 1000 liter tank underground containing a standard nutrient solution Copper (1979) (12) and a water pump to raise the solution into three 18 m long and 6-inch plastic tubes fixed on iron stands and perforated with 7 cm holes suitable for a planting pots and ending with 4-inch tube to collect the flowed solution back to the tank in a closed loop. Also the drainage system holes were installed by a distance of 1/3 in diameter of the planting tube, in order to keep the nutrient solution in the culture tubes as a precaution for electrical power cut off. Each tank was equipped with an air pump to ventilate the nutrient solution; also, the deionizing device was installed at the main water source to provide deionized water Reverse Osmosis (RO), that applied in preparing the solution confirmed in the experiment after moving over a water meter to continuously calculate the amount of water gathered into the tanks. The hybrid broccoli seeds Jassmina F1 were used which is produced by DELTA SEEDS (D/S) in the experiment and after growing to an appropriate size, the seedlings were transferred into the hydroponic system on 16th Sptemper 2019 after being planted in plastic cups for hydroponics filled with perlite at a planting distances of 30 cm between plants, and 60 cm between tubes, 10 plants per experimental unit, then the nutrients pumping process was started on 26 Sptemper 2019 A factorial experiment (2*5) was carried out according to Nested Design with three replications. Ozone treatment was in main plots which consisted of oxygen enrichment (O_2) and Ozone enrichment (O_3) by an ozone generating device at a concentration of 3 gm as an additional source of oxygen which works to pump the oxygen to the tank at a rate of four times per half an hour during the 12 hours of the day during the growth season. The foliar application of organic nutrients were distributed randomly within the replicates and included five treatments, which were the control treatment (T0), the foliar application of coconut water (liquid endosperm) at a concentration of 50 ml. L^{-1} (13) (T1) and 100 ml. L^{-1} (T2), the foliar application of Moringa leaves extract in a concentration of 2% (2) (T3) and 4% (T4). The foliar applications were applied after 2 weeks of cultivation and one month between each application, five plants were selected randomly from each experimental unit and the following charaeters were measured:

1. Leaves content of mineral elements and chlorophyll: The fourth leaf (from the growing apex) of the selected plants was taken, washed and dried by Oven, then 3 ml of concentrated sulfuric acid and 2 ml of concentrated perchloric acid were added to the solution. After the digestion process was completed, the leaves content of Ca, Mg% , Fe, Mn, Zn, and Cu mg.Kg^{-1} were estimated by the Atomic Absorption device (11), and boron was estimated using the Carmin pigment (16). Also the leaves content of chlorophyll the dye was estimated according to Goodwin (20) and then converted to mlg. 100 gm wet 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 (dcm. plant^{-1}) was calculated according to the dry weight method by Watson and Watson (36). 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 (gm. Plant^{-1}) was calculated using a sensitive scale.

3. Yield traits: The weight of the main flower heads (gm. 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 (gm.Plant^{-1})was calculated cumulatively until the end of the season, then the total yield (tons. 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.

RESULTS AND DISCUSSION

1 - Chemical Indicators

The results in Table 1 reveal a significant effect of ozone treatment (O3) in the leaves content of Ca, Mg, Fe, Mn, Zn, Cu, B and Chlorophyll, reached 1.823, 0.488%, 163.2, 21.40, 55.83, 6.102 and 17.65. mg. kg^{-1} and

392.4 mg.100 gm wet weight^{-1} respectively, compared to the oxygen treated plants, which gave 1.785, 0.453%, 136.2, 19.81, 48.76, 3,850, 16.87 mg. Kg^{-1} and 389.3 mg. 100 gm wet weight^{-1} respectively, The foliar application of organic nutrient were significantly affected the chemical parameters; the application of coconut water 100 ml.L^{-1} (T2) gave a significant increment in the leaves content of Ca, Mg, Fe, Mn, Zn, Cu, B and Chlorophyll, which reached 1.926 and 0.511%, 170.5, 23.01, 62.16, 5.520 and 20.38 mg. Kg^{-1} and 408.4 mg. 100 g wet weight^{-1}, respectively, while the control treatment (T0) produced the lowest values reached 1.578 and 0.413. 130.0%, 18.25, 43.50, 4.250 and 12.50 mg. Kg^{-1} and 363.1 mg. 100 g wet weight^{-1} respectively. The interaction treatment between gas enrichment and the foliar application of organic nutrients had a significant effect on the studied traits reached 1.947, 0.534%, 186.0, 67.40, 7.100 and 20.47 mg. Kg^{-1} and 411.8 mg. 100 g wet weight^{-1} respectively. While the treatment (O2T0) had the lowest concentration reached 1.569, 0.401%, 120.0, 43.20, 3.500, and 11.90 mg. Kg^{-1} and 361.6 mg. 100 g wet weight^{-1}, respectively, The interaction treatments did not gave a significant values among the leaves content of manganese.

Table 1. Effect of ozone enrichment and spraying with coconut water and moringa extract and their interaction on chemical indicators of broccoli leaves under hydroponic system with modified NFT technology for the autumn season 2019-2020

Treatment	%		mg.Kg^{-1}					mg.100g fresh wt.$^{-1}$
	Ca	Mg	Fe	Mn	Zn	Cu	B	Chlorophyll
O_2	1.785	0.453	136.2	19.81	48.76	3.850	16.87	389.3
O_3	1.823	0.488	163.2	21.40	55.83	6.102	17.65	392.4
L.S.D $_{0.05}$	0.005	0.010	3.51	0.59	1.35	0.220	0.20	1.20
T_0	1.578	0.413	130.0	18.25	43.50	4.250	12.50	363.1
T_1	1.745	0.470	147.5	20.58	51.13	5.100	17.52	397.0
T_2	1.926	0.511	170.5	23.01	62.16	5.520	20.38	408.4
T_3	1.909	0.502	160.5	21.70	57.30	5.290	19.05	402.6
T_4	1.862	0.456	140.0	19.49	47.40	4.710	16.86	383.2
L.S.D $_{0.05}$	0.007	0.007	4.86	0.78	2.83	0.309	0.30	3.12
O_2 T_0	1.569	0.401	120.0	17.40	43.20	3.500	11.90	361.6
O_2 T_1	1.726	0.456	135.0	20.00	47.90	3.900	17.35	394.1
O_2 T_2	1.905	0.489	155.0	22.13	56.93	3.950	20.30	404.9
O_2 T_3	1.875	0.477	141.0	21.10	50.00	4.200	18.60	405.3
O_2 T_4	1.851	0.442	130.0	18.43	45.80	3.700	16.23	380.6
O_3 T_0	1.587	0.426	140.0	19.10	43.80	5.000	13.10	364.5
O_3 T_1	1.765	0.484	160.0	21.16	54.36	6.300	17.70	399.9
O_3 T_2	1.947	0.534	186.0	23.90	67.40	7.100	20.47	411.8
O_3 T_3	1.943	0.527	180.0	22.30	64.60	6.380	19.50	399.9
O_3 T_4	1.873	0.470	150.0	20.56	49.00	5.730	17.50	385.8
L.S.D $_{0.05}$	0.009	0.012	6.60	N.S	3.69	0.419	0.40	4.03

The increment in the leaves content of Ca, Mg and Fe under the application of ozone can be due to the increase in the concentration of O_2 that occurred by the decomposition of O3, which reflected on the plant's ability of nutrients absorption (15). Ozone is an extremely unstable gas, with a fast decomposition ability, also its solubility is more to 13 times than the oxygen dissolution ability (37); In addition, the Fe used in the preparation of the standard solution is Fe-EDDHSA chelated iron that remains stable and available for absorption in a wide range of pH 4-9 (7), While the increment in the leaves content of manganese, zinc, copper and boron under this treatment can be due to the role of the ozone that is fed through the air instead of oxygen and thus the nitrogen or nitric acids can be produced from nitrogen oxides, and these chemical compounds could by significantly affect the pH of the solution, which increases the availability of the nutrients and positively affects their absorption and the length of the growing season (9), this results was in agreement with Nicoletto et al. (25) that the application of this type of ozone has a role in the production of nitrogen acids that have a great influence on the pH of water. The increment in the leaves content of chlorophyll in broccoli plant that were growing in the standard solution under the ozone enrichment could be due to preparing the plant with appropriate concentrations of nutrients; the magnesium is the key nutrient and the central part of chlorophyll structure, as it consisted of 15-30% of the total magnesium in plants. Magnesium is also important for proteins that are involved in the thylakoids of the chlorophyll molecule, as well as increasing the leaves content of Fe and Mg, which is important in the structure of chlorophyll, which is included in the chloroplasts synthesis (26). The increment in the leaves content of nutrients and chlorophyll under the foliar application of organic nutrients would be due to their content of many nutrients required for plant's growth and, which varies according to the nutrient type and the extract nature (27, 38).

2 – Growth and Yield Indicators

Results in Table 2 show a significant effect of Ozone (O3) on the leaves number, leaves area, root length, roots dry weight, the main flower weight, the side heads number, and the total yield, which reached 87.10 leaves, 123.0 cm, 29.42 gm. $Plant^{-1}$, 640.93 gm, 5.12 heads. $plant^{-1}$, and 48.20 tons. Ha^{-1} respectively, compared to the O_2 treated plants which were recorded 85.70 leaves. $Plant^{-1}$, 295.23 dm^2 $Plant^{-1}$, 117.9 cm and 29.10 gm. $plant^{-1}$, 557.70 gm and 4.58 heads. $Plant^{-1}$ and 43. .52 tons. Ha^{-1}, respectively, while plant height, and side heads weight did not differ significantly under the application of Ozone and Oxygen. The foliar application of organic nutrients has significantly affected the vegetative, roots and the yield traits of the broccoli plant grown under hydroponic conditions; the treatment of coconut water 100 ml. L^{-1} (T2) has significantly increased the leaves number, leaves area, root length, roots dry weight, number and weight of side heads, and yield which reached 96.50 leaves $plant^{-1}$, 362.02 dcm^2 $plant^{-1}$, 129.0 cm, 31.10 gm $plant^{-1}$ and 6.30 heads. $plant^{-1}$, 266.75 gm $plant^{-1}$, 48.65 tons. Ha^{-1}, respectively, compared to T0 treatment which gave the lowest values reached 56.00 leaves. $Plant^{-1}$ and 197.96 dcm^2. $Plant^{-1}$, 106.7 cm and 25.50 gm $Plant^{-1}$ and 3.30 heads. $Plant^{-1}$ and 161.50 gm, and 37.50 tons. Ha^{-1}, respectively, while the foliar application of 4% Moringa leaves extract (T4) has significantly increased plant height and main heads weight, reached 75.99 cm and 648.91 gm. $Plant^{-1}$, respectively, compared to (T0) treatment, which recorded 71.31 cm and 513.66 gm $plant^{-1}$, respectively. The interaction between Ozone and the foliar application of organic nutrients of O3T2 gave a significant highest values of plant height, leaves number, leaves area, roots length, roots dry weight, number and weight of side heads, reached 77.33 cm and 101.00 leaves. $plant^{-1}$ and 383.31 dcm^2 plant-^{1}, 130.0 cm and 31.13 gm. $plant^1$ and 6.60 heads. $plant^1$ and 268.00 gm Compared to O2T0, which gave the lowest values reached 70.69 cm, 53.00 leaves, $Plant^1$, 195.00 dcm^2 . plant, 101.5 cm, 25.00 gm. $Plant^1$, 3.00 heads. $Plant^1$, 151.00 gm. $Plant^1$ respectively, While the treatment of ozone enrichment and the foliar application of Moringa leaves extract at the concentration of 4% (O3T4) showed a significant increment in the weight of the main tablet reached 687.33

gm. Plant^{-1} compared to the control treatment (O2T0) which recorded 473.00 gm. Plant^{-1}, while the treatment O3T3 gave a significant increment in total yield reached 51.07 tons which did not significantly differed from the treatment O3T2 (50.94 tons. Ha^{-1}) in comparison with the control treatment (O2T0) which recorded 34.66 tons.Ha^{-1}.

Table 2. Effect of ozone enrichment and spraying with coconut water and moringa extract and their interaction on Growth and Yield indicators of broccoli leaves under hydroponic system with modified NFT technology for the autumn season 2019-2020

Treatment	Plant height cm	No. of Leaves Leaf. plant^{-1}	Leaf area dsm^2. plant^{-1}	Root length cm	Dry weight of the root g.plant^{-1}	Weight of main head g.plant^{-1}	No. of secondary head head. plant^{-1}	Weight of secondary head g.plant^{-1}	Total yield t.ha^{-1}
O_2	73.86	85.70	295.23	117.9	29.10	557.70	4.58	225.80	43.52
O_3	74.61	87.10	314.38	123.0	29.42	640.93	5.12	226.90	48.20
L.S.D $_{0.05}$	N.S	0.53	7.11	0.85	0.12	12.88	0.02	N.S	0.26
T_0	71.31	56.00	197.96	106.7	25.50	513.66	3.30	161.50	37.50
T_1	73.66	92.00	291.51	126.2	29.75	596.08	4.95	255.75	47.31
T_2	75.32	96.50	362.02	129.0	31.10	609.00	6.30	266.75	48.65
T_3	74.91	96.25	361.02	127.0	29.99	628.91	5.45	246.00	48.60
T_4	75.99	91.25	311.54	113.2	29.97	648.91	4.25	201.75	47.25
L.S.D $_{0.05}$	1.53	1.41	7.11	2.11	0.12	9.02	0.09	4.62	0.39
O_2 T_0	70.69	53.00	195.00	101.5	25.00	473.00	3.00	151.00	34.66
O_2 T_1	74.99	98.00	283.20	123.5	30.26	562.50	4.60	252.00	45.24
O_2 T_2	73.32	92.00	340.73	128.0	31.08	569.00	6.00	265.50	46.36
O_2 T_3	75.33	94.50	349.07	126.0	29.65	573.50	5.30	257.00	46.13
O_2 T_4	74.99	91.00	308.19	110.5	29.55	610.50	4.00	203.50	45.22
O_3 T_0	71.93	59.00	200.93	112.0	26.00	554.33	3.60	172.00	40.35
O_3 T_1	72.33	86.00	299.83	129.0	29.24	629.66	5.30	259.50	49.39
O_3 T_2	77.33	101.00	383.31	130.0	31.13	649.00	6.60	268.00	50.94
O_3 T_3	74.49	98.00	372.98	128.0	30.34	684.33	5.60	235.00	51.07
O_3 T_4	77.00	91.50	314.89	116.0	30.39	687.33	4.50	200.00	49.29
L.S.D $_{0.05}$	2.06	1.82	10.35	2.73	0.18	15.13	0.12	6.13	0.52

The increment in vegetative and root growth traits could be due to the role of ozone treatment in providing optimal concentrations of oxygen for cellular respiration and providing the plant with the energy required for photosynthesis and compounds concentration and transportation which reflected on the plant growth increment (8), also it could be due to the role of ozone in increasing the plants absorption and nutrients accumulation in the leaves (Table 1) which is positively reflected on the vegetative growth traits and the roots dry weight (31). Even that the roots growth, length, and their apparent qualities are genetically controlled, they arʾaffected by the external factors, including oxygen and nutritions, which could be provided by the nutritional solution that are balanced in terms of their content of nutrients (4) as well as the decomposition of ozone into more quantities of oxygen that are necessary for roots growth and activity. The increment in the vegetative and root growth traits under the foliar application of organic nutrients could be due to their role in providing the plant with nutrients, as they are rich in mineral nutrients, organic and amino acids, vitamins and hormones which were important for In the growth, chlorophyll structure and prolong life (3); the amino acids are important were for the synthesis of many enzymes of the photosynthesis and supply nitrogen directly to the plant, and leads to a decrease the osmotic potential of the cell, which reduces its water potential, which reflected on increasing the cell's ability to absorb the water and dissolved nutrients in the growth medium and increase plant's vegetative growth (34), also the vitamins provided by the water solution are work to move from the leaves to the roots, leading to their elongation and enlargement, which increases their size and maturity (5); moreover, they have a role in the biochemical reactions that convert the nutrients into energy

which provide the appropriate requirements to increase the growth of roots which the reflected on their dry weight. The improvement of yield traits in comparison to the control treatment under the application of ozone can be due to their role in providing additional amounts of energy that increase the absorption of the nutrients available in the hydroponics solution and increase its concentration inside the plant, including boron (Table 1), which is the most important nutrient the photosynthesis outputs transmission from leaves to storage tissues in plants; the boron interacts with sugars which results a complex component that transports easier through cell membranes and also contributes to cells division, elongation, and the formation of cell walls (18) as well as its role in transporting to growth center , which gives an opportunity to develop new branch growth and increase of secondary heads weight (6) ; thus, the increase in the weight of the main heads and the number of secondary heads when under the application of ozone was positively reflected on the plant yield, this result was in agreement with Peykanpour et al. (28) that showed the significant effect of ozone on the total yield. The increment of plant's yield under the foliar application of organic nutrients can be due to their content of nutrients that stimulate the process of growth and production and the preservation of consumer health and protects the environment (24) . It contains vitamin C (Ascorbic acid), which is an antioxidant that protects the chloroplasts and the pigments from ROS, especially H_2O_2, which are produced and formed during the process of photosynthesis and elongate the leaves life, which increases the effectiveness of this process and increases the yields, which are transferred to the growing tissues and contributes to their development (17) and improve the characteristics of vegetative and root growth, which is positively reflected on the yield parameters which were the weight of the main heads and the number and weight of the secondary heads, which increases the total plant yield, these results are in agreement with Maishanu et al. (23) in terms of an increase in the yield of cowpea under the foliar application of Moringa leaf extract. It is clear from this study the possibility of enrichment with ozone in the standard solution as an additional source of oxygen and the foliar application of plant extracts to improve the vegetative and root growth and increase the yield of the hydroponically grown broccoli with the modified NFT technology.

REFERANCES

1. Abohassan,R.A. and A.O.Abusuwar. 2018. Effects of *Moringa oleifera* leaf extracts on growth and productivity of three leguminous crops. Legume Research. 41(1):114-119

2. Abou El-Nour, H. H. and N. A. Ewais.2017. Effect of *Moringa oleifera* Leaf extract (MLE) on pepper seed germination, seedlings improvement, growth, fruit yield and its quality. Middle East Journal of Agriculture Research.06(02):448-463

3. Al-Asadi, M. H. S., and A. H. J. Al-Khaikani. 2019. Plant Hormones and their Physiological Effects. Al-Qasim Alkhadraa University. College of Agriculture, House of National Books and Archives, Baghdad. Deposit No. 2272. International Number: 9789922917108, pp: 332

4. Al-Amiri, A. A.N. 2018. The Effect Cultivar Medium and Nutrient Solution on Growth and Yield of Cucumber (*Cucumis sativus* L.) Under the Hydroponic cultivation system. Master Thesis . College of Agriculture . University of Kufa. pp: 60

5. Al-Chalabi, S. K. and N. K. Al-Khayyat. 2013. Ornamental plants in Iraq, Ministry of Higher Education and Practical Research. Baghdad University. College of Agriculture. pp: 416

6. Al-Halfi, I. H. H. and N. H. Zeboon. 2016. The response of the yield of bread wheat and its components to the spraying with boron and vitamin C. Iraqi Journal of Agricultural Sciences 47 (5): 1171-1180

7. Ali, N. S. 2012. Fertilizer technologies and Uses. Ministry of Higher Education and Scientific Research. Baghdad University, College of Agriculture. Iraq. pp: 207

8. Ali, N. S., 2012a. The Guide in Plant Nutrition. Translated by Allen V Parker and David J. Philbeam. Part one and two. Ministry of Higher Education and Scientific Research, University of Baghdad, College of Agriculture. Scientific Books House for printing, publishing and distribution. Iraq. pp: 854

9. Ali, N. S., H. S. Rahi, and A. A. Shaker. 2014. Soil Fertility. Scientific Books House for Printing, Publishing and Distribution. Iraq. pp: 307

10. Al-Khafaji, M. A. 2014. Plant Growth Organizations, the Horticultural Applications and Uses. University House for Printing, Publishing and Translation. Iraq. pp: 348

11. Al-Sahhaf, F. H.. 1989a. Applied plant nutrition. Baghdad University. Ministry of Higher Education and Scientific Research. House of Alhikma for publishing, translation and distribution. Mosul Higher Education Press. Iraq.pp:260

12. Al-Sahhaf, F. H. 1989. Hydroponics Agricultural Systems. Ministry of Higher Education and Scientific Research. University of Baghdad - House of Wisdom - Iraq, pp: 320

13. Attia, H. J., S. M. K. Saadeddin And B. A. Ibrahim. 2010. The effect of plant growth regulators on the vegetative Parameters of black seed. Iraqi Journal of Agricultural Sciences 41 (2): 80-88

14. AL-Hachami, S. H.J. ; S.A.Khalil and Y. F.Sallom.2019. Effect of spraying coconut liquid and marine algae extract on vegetative and production properties of two types of strawberry *Fragaria ananassa* Duch. Plant Archives .19(2): 1856-1863

15. Bhatla,S.C. and M.A. Lal . 2018. Plant Physiology, Development and Metabolism. Springer. pp:1237. https:/ /doi.org/ 10.1007 /978-981-13-2023-1

16. Black,C.A.1965. Methods of soil analysis,Part2 .Amer. Soc. Agric. Lnc

17. Cheruth, A.J.2009. Changes in non enzymatic antioxidants and ajmalicin production in catharanthus roseus with different soil salinity regimes Bot. Res. Intr. 2(1): 1-6

18. Debnath, M. R.; M.Jahiruddin; M. M. Rahman and M. A.Haque.2011. Determining oplimum rate of boron application for higher yield of wheat in old Brahmaputra Flood Plain Soil. J.Bangladesh Agric.9(2): 505-510

19. Goddek,S.; A.Joyce; B.Kotzen and G.M.Burnell.2019.Aquaponics Food Production Systems. Combined Aquaculture and Hydroponic Production Technologies for the Future. Chapter4. Springer Open. pp:619. https://doi.org/10.1007/978-3-030-15943-6

20. Goodwin,T.W. 1976. Chemistry and Biochemistray of Plant Pigment. 2nd ed. Academic.Press. London.New York.San Francisco.pp :373

21. Hazeltine, B.;C. Bull. 2003.Field Guide to Appropriate Technology. Science Direct. pp:874. ISBN 978-0-12-335185-2. https://doi.org/10.1016/B978-0-12-335185-2.X5042-6

22. Kulkarni, S. ; P. S. Abraham ;N. Mohanty; N. N. Kadam and M. Thakur. 2018. Sustainable Raft Based Hydroponic System for Growing Spinach and Coriander. Springer International Publishing AG2018. pp:117-125. DOI 10.1007/978-3-319-53556-2_13

23. Maishanu, H. M. ; M. M. Mainasara ; S. Yahaya and A. Yunusa.2017. The use of moringa leaves extract as a plant growth hormone on cowpea (*Vigna Anguiculata*) .Traektoriâ Nauki Path of Science.3(12):3001-3006

24. Nasralla,A.Y.; I.H.Al-Hilfy ; H.M.Al-Aboodi; O.A.Mahammed and M.Mhmood.2014. Effect of spraying some plant extraction and anti- oxidant on growth and yield of sunflower .The Iraqi J. of Agri. Sci.45(7): 651-659 (special issue).

25. Nicoletto, C. ; C. Maucieri and P. Sambo. 2017. Effects on water management and quality characteristics of ozone application in chicory forcing process: APilot System. Agronomy .7 (29):1-14. DOI: 10. 3390/ agronomy 7020029.

26. Ördög,V. 2011. Plant Physiology. Created by XML mind XSL-FO Converter . pp:115

27. Payamnoor,V.; R.J.Hajati and Khodadai.2018. The effect of coconut extract on callus growth and ultrasound waves on production of botulin and betulinic acid in in-vitro culture conditions of *Betula pendula* Roth species. Folia Forestalia Polonica,S eries A-Forestry.60(4):261-268

28. Peykanpour,E. ;A.M. Ghehsareh ; J. Fallahzade and M. Najarian.2016. Interactive effects of salinity and ozonated water on yield components of cucumber. Plant Soil Environ. 62(8): 361-366

29. Phiri, C.2010. Influence of *Moringa oleifera* leaf extracts on germination and early seedling development of major cereals. Agric. Biol. J.N. Amer.1(5):774-777

30. Sasidharan, S.; Y .Chen; D. Saravanan; K.M.Sundram and L.Y. Latha. 2011. Extraction, isolation and characterization of bioactive compounds from plants' extracts. Afr J Tradit Complement Altern Med.8(1):1-10

31. Sharma, R. R. 2002. Growing Strawberry. International Book Distributing Co. Indian.pp:164

32. Soares,C. S.; A. C. S.Lim; J. A.Silva; M.S.A.Vilar;A.L.P.Silva; J.A.L. Junior and J.F.B.Neto .2020.Production of lettuce in NFT hydroponic system at different planting seasons and irrigation regimes. Australian Journal of Crop Science. 14(07):1047-1047. Doi:10.21475/ajcs.20.14.07.pp:1828. ISSN:1835-2707.

33. Suyantohadi, A.; T. Kyoren; M. Hariadi; M.H.Purnomo and T. Morimoto. 2010. Effect of high consentrated dissolved oxygen on the plant growth in a deep hydroponic culture under a low temperature. Elsevire, IFAC Proceeding 43(26):251-255

34. Taiz, L. and E. Zeiger .2010. Plant Physiology. 5th. ed. Sinauer Associates, Inc. publisher Sunderland, Massachus- AHS. U.S.A.pp:778.

35. Vivo, B. ; H.E. Belkin and A. Lima. 2018. Environmental Geochemistry .Science Direct.pp:644. https://doi.org/10.1016/C2015-0-05618-0. ISBN 978-0-444-63763-5.

36. Watson, D.J. and M.A.Watson. 1953. Comparative physiological studies on the growth of yield crops. III-Effect of infection with beet yellow. Ann.Appl.Biol.40.1:1-37

37. Wei, C. ; F. Zhang ;Y. Hu ;C. Feng and H. Wu. 2016. Ozonation in water treatment: the generation, asic properties of ozone and its practical application .Rev Chem Eng. DOI 10.1515/revce-2016-0008.

38.Yadav,R.; R.K.Khare and A. Singhal. 2017. Qualitative phytochemical screening of some selected medicinal plants of Shivpuri district (M.P.). Int. J. Life. Sci. Scienti. Res.3(1):844-847.