Effect of Growing Media, Humic Acid and Boron on Storage Life of Strawberry Fruits (*Fragaria ananassa* Duch.) cv. Albion

Hezha A. Omer Ahmed [*], Sidiq A. Sidiq kasnazany [**] Fakhraddin M. hama salih [**]

* Director of Agriculture research of, Sulaimani, Sulaimani, Iraq
** Department of Horticulture, College of Agricultural Sciences, University of Sulaimani, Sulaimani, Iraq
Corresponding Author Email: hhezhaa89@gmail.com

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A study was conducted during the (2019-2020) growing season in the plastic house and cold room of the Horticulture Department, College of Agricultural Engineering Science, University of Sulaimani, Sulaimani –Iraqi, aiming to investigate the effect of three factors including growing media (M1, M2, and M3), boric acid at a concentration (0 and 20 mg. L^{-1}) and humic acid at a concentration (0, 2.5 and 5 mg. L^{-1}), on fruit quality and storability of strawberry fruits stored for 20 days in a cool room at storage (2±2°C) with relative humidity 85-90%. The results showed that growing media affected total soluble solid and anthocyanin content. Boric acid at 20 mg. L^{-1} gave the highest value of total sugars and berry firmness was 6.861% and 486.877g, respectively. Humic acid decreased fruit decay%, while caused an increase in total soluble solid, anthocyanin, and ascorbic acid.

The interaction effect between growing media (M3) and 20 mg. L^{-1} boric acid recorded the highest value of firmness, TSS%, Total sugar%, and ascorbic acid content, but the interaction effect between growing media (M2) and 20 mg. L^{-1} boric acid gave the lowest fruit weight loss%. Application of growing media (M1) without boric acid showed the highest value of anthocyanin content. On the other hand, the interaction effect between growing media (M3) and 5 mg. L^{-1} of humic acid gave the lowest fruit weight loss% but the highest value of firmness and ascorbic acid content, as well as, growing media (M1) with 5 mg. L^{-1} of humic acid gave the lowest decay% and highest value TSS%. The same growing media with 2.5 mg. L^{-1} of humic acid gave the maximum value of anthocyanin content. The interaction effect between 20 mg. L^{-1} boric acid and 5 mg. L^{-1} of humic acid recorded the lowest value of fruit weight loss% and decay%, otherwise, the same treatment gave the highest value of firmness and ascorbic acid content.

Finally, the interaction effects of the three factors obtained the lowest fruit weight loss% was observed by growing media (M3), 20 mg. L^{-1} boric acid and 5 mg. $L^{-1}$of humic acid, while the same treatment realized the highest value of firmness and ascorbic acid content.

Keywords: **Strawberry, growing media, boric acid, humic acid, storage quality**

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Introduction

Strawberry (*Fragaria×ananassa* Duch.) belongs to the Fragaria genus Rosaceae family(26). It is an important small fruit in most temperate climates and adapts to a wide range of climatic condition(2 and 26).

Strawberries are unique with highly desirable taste and flavor considered an excellent source of natural antioxidants among fruits in their contents of vitamin C and minerals, fiber, polyphenols(31). Strawberry fruits are non-climacteric fruits, and they have short shelf life due to highly perishable with a short postharvest shelf-life.

The role of preharvest treatments and conditions must be understood in order to improve the shelf life, the extent of postharvest physical and physiological injury, and potential fruit loss is affected by preharvest parameters(34). Many preharvest factors affect fruit quality at harvest and postharvest such as soil types, fertilization, and composts(36).. Provide characteristics of growing media such as water holding capacity and nutrients, good aeration to root system, and free of pathogens and substances is toxic to plants(16)**.** Manure and compost are organic sources of nutrients that causing to improve soil quality(38). Humic acid improved not only vegetative growth but also yield and quality(39).

Micronutrients are vital to the growth of plants, which act as catalysts in promoting various organic reactions within the plant(10). Boron is an essential micronutrient required for normal plant growth,development,and fruit yield(32). Boron deficiency reduces pollen germination and the growth of pollen tubes leads to the formation of malformed fruits(13 and 21).

Observation of local strawberry producers during the last decades underlined a positive effect of boron application at the beginning and middle of the productive season(20).

Generally, Greenhouse cultivation could lower the demand for locally produced fresh fruits during the off-season(4). Also, proper storage conditions play an important role to increase storage life and management(23). The widespread use of mineral fertilizer in the cultivation of fruits and vegetables is raising concerns about human health and environmental pollution(6).Compost and growth stimulants can be a good substitute for mineral fertilizers.

Objectives of this study are to:

1- Investigate the impact of growing media, humic acid, and boron application on growth, yield, and storability of strawberry cultivar Albion.

2- Maintain postharvest quality and extend the storage life of strawberry fruits.

Materials and Medthods

The experiment was carried out during 2019-2020 growing season in the plastic house and cold room of Horticulture Department, College of Agriculture, University of Sulaimani with 35 32’N, 45 21’E, and 730 meters above sea level. A plastic house, with 27 m length, 9 m width, 3 m height, was used in the current study which was divided into three blocks; each block was divided into 18 plots (experimental units). A total number of 54 plots, the plot was 75cm X 150cm X 30cm with leaving 60cm distance among plots which contain (12) plants per plot. All growing media sterilized with 1% formaldehyde (37%) (7) and mulched (covered) with black polyvinyl chloride (PVC) was used to protect the plant in weeds and resistance to diseases and also to increased temperature in plastic house.

Factorial Experiment using (RCBD) was applied with 3 levels of each growing and humic acid, as well as 2 levels of boron, and three replicates, were used, so the total number of treatment combinations was 54 as (3×3×2×3). The Analysis of Variance (ANOVA) was conducted and the treatment means were compared using (Duncan's multiple range test $p \leq 0.05$)(1).

Data were analyzed using the statistical program from the Statistics and Graphics Guide(XLSTAT,2016).

Three growing media were prepared as follows:

M1= 25% soil + 25% loam +50% mushroom compost

M2= 25% soil + 50% loam +25% mushroom compost

M3= 50% soil + 25% loam +25% mushroom compost

Boron solutions (0, 20) mg/L are prepared from boric acid (H_3BO_3 17% boron) was used three times and sprayed third (October 20, 2019, March 1and April 1, 2020). Soil application for humic acid (0, 2.5, and 5) mg. L^{-1} was carried out a month after planting and repeated 3 times at 1-month interval on (November 1, December 3, 2019, and January 7, 2020). the fruits were harvested every 4 days (April 1 through June 27) once the berry was fully colored, harvested the fruit with about one-quarter of the stem attached in the early morning or late evening when the berries are still cool.

All treated fruits were stored in cold storage (2 ±2°C) with a relative humidity of 85-90% for 20 days with continuous monitoring.

The following parameters were measured:

1. Fresh Weight Loss% (F.W.L.%)

After the storage period, fruits stored for 20 days, fresh weight loss was determined according to Rao *et. al.*(28) and Garuba *et. al.*(12) and evaluated for weight loss by the equation:

$$\text{Fresh weight loss (\%)} = \frac{A-B}{A} \times 100$$

A: the initial fruit weight. B: fruit weight after a storage period

2. Fruit Decay%:

Fruit decay was determined according to the equation:

$$\text{Decay \%} = \frac{\text{No. of decayed fruits}}{\text{No. of fruits at the beginning of storage}} \times 100$$

3. Berry firmness (g)

Firmness was determined by Texture Analyzer (Brookfiled Engineering Labs INC./ U.S.A) as described in Salentijn et. al.(30) and Horwitz(15).

4. Total soluble solids (TSS %)

Total soluble solids were measured by (Portable Hand Refractometer Erma Japan)(5)..

5. Total sugars%

Total soluble sugars have been determined according to Joslyn(17)as follows:

Total soluble sugar% = (absorbance × dilution factor×0.0525) × 100

6. Ascorbic acid (mg/100g F.W.)

Ascorbic acid have been determined according to Elgailani *et. al*.(9).

7. Anthocyanin (mg100 g^{-1}. F. W.)

Pigment content in the strawberry fruits is determined with the method described by Ranganna(27).

Results and Discussion

1. Fresh Weight loss (FWL %)

It can be observed by the table (1), No significant differences that the fresh weight loss of the main effect of growing media. But the main effect of boric acid significant differences was observed by 20 mg. L^{-1} than 20 mg. L^{-1}, the fruit weight loss increased without boric acid.

As shown in the same table, 5 mg. L^{-1} of humic acid was recorded the lowest value (2.872%) in the fresh weight loss of strawberry fruits stored at 2±2°C and 85-90% RH for 20 days, while the maximum loss value (4.311%) was recorded by 0 mg. L^{-1} of humic acid.

The data in the same table show that there were substantial differences in fresh weight loss percent various growing media with boric acid interaction. The most significant losses were reported (4.366%) through the interaction between growing media (M2) and 0 mg. L^{-1} boric acid, while the lowest loss (2.833%) was observed by growing media (M2) with 20 mg. L^{-1} boric acid.

However, as the interaction effect between growing media and humic acid significant differences were confirmed, the lowest value was observed (2.700%) by growing media (M3) with 5 mg. $L^{-1}$of humic acid, while the highest value was documented (4.833%) by the interaction between growing media (M3) and 0 mg. $L^{-1}$of humic acid. In addition, significant differences were confirmed too for the interaction effect between boric acid and humic acid on fresh weight loss%, the lowest value was observed (2.944%) at 20 mg. L-1 boric acid with 2.5 mg. $L^{-1}$of humic acid. But the highest value was recorded (4.589%) by the interaction between 0 mg. L-1 boric acid and 0 mg. L^{-1} of humic acid.

Finally, the interaction effects of the three factors obtained the lowest value was also observed (2.233%) using growing media (M3), 20 mg. L^{-1} boric acid and 5 mg. $L^{-1}$of humic acid. Concerning the highest value (5.200%) recorded by the interaction between growing media (M2), 0 mg. L^{-1} boric acid and 0 mg. L^{-1} of humic acid.

Weight loss of fruit was mainly associated with respiration and moisture evaporation through the skin that the highest losses of weight were obtained at the end of the storage period(8).It can be seen that all treatments significantly reduce the weight loss of strawberry fruits during storage compared to control.

Table 1. Effect of growing media, humic acid, boric acid and their interaction on fresh weight loss% in strawberry fruits cv. Albion stored at 2±2°C and 85-90%RH for 20 days

		0	2.5	5		
	0	3.800 efg	4.100 bcde	3.633 efg	3.844 bc	3.506 a
	20	4.000 cdef	2.967 ghI	2.533 hi	3.167 de	
	0	5.200 a	4.833 abc	3.067 f ghi	4.366 a	3.600 a
	20	3.200 efgh	2.700 hi	2.600 hi	2.833 e	
	0	4.767 abcd	3.900 defg	3.167 efgh	3.944 ab	3.689 a
	20	4.900 ab	3.167 efgh	2.233 i	3.433 cd	
	M1	3.900 bc	3.533 cd	3.083 de	Main effect Of Boric acid	
	M2	4.200 b	3.767 bc	2.833 e		
	M3	4.833 a	3.533 cd	2.700 e		
	0	4.589 a	4.278 ab	3.289 c	4.052 a	
	20	4.033 b	2.944 c	2.456 d	3.144 b	
		4.311 a	3.611 b	2.872 c		

Means within a column, row,and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test($P \leq 0.05$).

M1= 25% normal soil + 25% loam soil +50% mushroom compost, M2= 25% normal soil + 50% loam soil +25% mushroom compost, M3= 50% normal soil + 25% loam soil +25% mushroom compost.

2. Fruit Decay%

Table (2) shows that fruit decay percentage decreased by increasing humic acid concentrations, the lowest values were observed from 5 and 2.5 mg. L^{-1} of humic acid concentration

The interaction between growing media (M2) and 5 mg. L^{-1} of humic acid recorded the lowest value (1.60%). The same trend was also true for the treatments of the interaction between 20 and 0 mg. L^{-1} boric acid with 0 mg. L^{-1} of humic acid. The particle-size distribution of a growing medium is important because it determines bulk density, gas and water exchange, water holding capacity, and therefore plant growth(40).

The importance of boron application for good yield and better utilization of water can be attributed to the role of micronutrients and humic acid fertilization in improving crop resistance to water stress and other stresses(3).

Similar findings with the decay of plum fruits at low temperature were reported by Mahajan *et. al*.(22).

Organic and biofertilizers improved vegetative growth, nutritional status and reduced the residuals of nitrate and nitrite in banana and grapefruits(29).

Table 2. Effect of growing media, humic acid, boric acid and their interaction on decay% in strawberry fruits cv. Albion stored at 2±2°C and 85-90%RH for 20 days

		0	2.5	5		
	0	2.149 abcde	1.932 bcde	1.395 e	1.825 a	1.959 a
	20	2.373 abcde	2.239 abcde	1.667 de	2.096 a	
	0	2.820 abc	1.692 de	1.577 de	2.029 a	2.069 a
	20	2.903 ab	1.797 cde	1.625 de	2.109 a	
	0	3.034 a	1.839 bcde	2.099 abcde	2.324 a	2.16 a
	20	2.613 abcd	1.869 bcde	1.507 de	1.996 a	
	M1	2.261 a b	2.085 b	1.531 b	Main effect Of Boric acid	
	M2	2.862 a	1.744 b	1.601 b		
	M3	2.823 a	1.803 b	1.854 b		
	0	2.667 a	1.821 b	1.690 b	2.06 a	
	20	2.630 a	1.968 b	1.600 b	2.065 a	
		2.648 a	1.894 b	1.645 b		

Means within a column, row,and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test($P \leq 0.05$).

M1= 25% normal soil + 25% loam soil +50% mushroom compost, M2= 25% normal soil + 50% loam soil +25% mushroom compost, M3= 50% normal soil + 25% loam soil +25% mushroom compost.

3. Firmness of Fruits (g)

It can be noticed that data presented in table (3) significant differences were confirmed for the main effect of boric acid, the highest value (486.877g) was achieved by concentration 20 mg. L^{-1} of boric acid, while the lowest value (426.165g) was achieved by 0 mg. L^{-1} boric acid concentration. Interaction effect between growing media and boric acid significantly affected fruit that the highest value was verified (495.954g) through the interaction between growing media (M3) and 20 mg. L^{-1} boric acid. Also, a significant difference was observed by the interaction effect of growing media with humic acid that the highest value was recorded (501.315g) using growing media (M3) with 5 mg. L^{-1} of humic acid. In the same table that significant differences were observed by the effect of boric acid and humic acid on the hardness of fruits. The highest value was recorded (507.041g) by the interaction between 20 mg. L-1 boric acid and 5 mg. L^{-1} of humic acid while the lowest value was observed (406.676g) using 0 mg. L^{-1} boric acid with 0 mg. L^{-1} of humic acid.

Strawberry plants treated with growing media, boric acid, and humic acid were significant interactions growing media (M3) with 20mg. L^{-1} boric acid and 5mg. L^{-1} of humic acid gave the highest value (532.582g).

Khalaj *et. al.*(19)reported that spraying boric acid at 5 mg. L^{-1} significantly increased the firmness of pear fruit.

Table 3. Effect of growing media, humic acid, boric acid and their interaction on firmness (g) of strawberry fruits cv. Albion stored at 2±2°C and 85-90%RH for 20 days

		0	2.5	5		
	0	**417.500 abc**	**409.333 bc**	**417.708 abc**	**414.847 b**	**450.538 a**
	20	**498.892 ab**	**473.625 abc**	**486.167 ab**	**486.228 a**	
	0	**361.110 c**	**422.250 abc**	**440.958 abc**	**408.106 b**	**443.278 a**
	20	**469.333 abc**	**463.642 abc**	**502.375 ab**	**478.450 a**	
	0	**441.417 abc**	**455.158 abc**	**470.050 abc**	**455.542 ab**	**475.748 a**
	20	**471.492 abc**	**483.790 ab**	**532.582 a**	**495.954 a**	
	M1	**458.196 ab**	**441.479 a b**	**451.938 ab**	**Main effect Of Boric acid**	
	M2	**415.222 b**	**442.946 ab**	**471.667 ab**		
	M3	**456.454 ab**	**469.474 ab**	**501.315 a**		
	0	**406.676 c**	**428.914 bc**	**442.906 ab**	**426.165 b**	
	20	**479.906 ab**	**473.686 ab**	**507.041 a**	**486.877 a**	
		443.291 a	**451.300 a**	**474.973 a**		

Means within a column, row,and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test($P \leq 0.05$).

M1= 25% normal soil + 25% loam soil +50% mushroom compost, M2= 25% normal soil + 50% loam soil +25% mushroom compost, M3= 50% normal soil + 25% loam soil +25% mushroom compost.

4. Effect on Total Soluble Solids (TSS%)

Table (4) shows that significant differences were observed among growing media on TSS%. The highest value (10.333%) were recorded from growing media (M3). The strawberry plants that treated with 5 mg. L-1 of humic acid was significantly superior in TSS. Furthermore, results show that the highest value was confirmed (10.711%) from the interaction between growing media (M3) and 20 mg. L-1 boric acid. The interactions between growing media and humic acid resulted in the highest value of TSS (10.683%).Interaction between boric acid 0 mg. L-1 and humic acid 5 mg. L-1 gave the highest value of TSS (10.411%).

As for the interaction effect among three factors (growing media, boric acid, and humic acid) on total soluble solid in strawberry fruits cv. Albion, the highest value (10.900%) was obtained using the growing media (M2), 0 mg. L-1 boric acid and 5 mg. L-1 of humic acid.

Farahi et. al.(11)Suggested that foliar application of humic acid led to improvement of quantitative and qualitative characteristics of strawberry (TSS and fruit firmness). Similar results were reported by Kadir et. al.(18) indicated that high tunnels can improve strawberry fruit quality, including higher soluble solid content.

Table 4. Effect of growing media, humic acid, boric acid and their interaction on total soluble solids (%)in strawberry fruits cv. Albion stored at 2±2°C and 85-90%RH for 20 days

		0	2.5	5		
	0	**9.567 ef**	**9.800 cdef**	**10.733 abc**	**10.033 b**	**10.089 ab**
	20	**9.600 ef**	**10.200 abcdef**	**10.633 abcd**	**10.144 b**	
	0	**10.133 abcdef**	**9.367 f**	**10.900 a**	**10.133 b**	**9.922 b**
	20	**9.900 bcdef**	**9.667 def**	**9.567 ef**	**9.711 b**	
	0	**10.033 abcdef**	**10.233 abcdef**	**9.600 ef**	**9.956 b**	**10.333 a**
	20	**10.500 abcde**	**10.767 abc**	**10.867 ab**	**10.711 a**	
	M1	**9.583 bc**	**10.000 abc**	**10.683 a**		
	M2	**10.017 abc**	**9.517 c**	**10.233 ab**	**Main effect Of Boric acid**	
	M3	**10.267 a**	**10.500 a**	**10.233 ab**		
	0	**9.911 a b**	**9.800 b**	**10.411 a**	**10.041 a**	
	20	**10.000 a b**	**10.211 a b**	**10.356 a**	**10.189 a**	
		9.956 b	**10.006 b**	**10.383 a**		

Means within a column, row,and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test(P ≤ 0.05).

M1= 25% normal soil + 25% loam soil +50% mushroom compost, M2= 25% normal soil + 50% loam soil +25% mushroom compost, M3= 50% normal soil + 25% loam soil +25% mushroom compost.

5. Total Sugars%

After storage for 20 days, the highest significant value was recorded (6.861%) by applying 20 mg. L^{-1} boric acid concentration, while (6.260%) was achieved by 0 mg. L^{-1} boric acid which was the lowest value (Table 5). From the same table growing media (M3) and 20 mg. L^{-1} boric acid gave the highest significant value (7.028%) of total sugars,

On the other hand, the significant differences were clear between the interaction of growing media, boric acid, and humic acid on this character. Growing media (M1) with 20 mg. L^{-1} boric acid and 5 mg. L^{-1} of humic acid gave the highest values (7.686 %) of total sugars.

Nunes and Emond(24)reported significant affected in sugar content by storage time and respiration rate. Strawberry fruits are non-climacteric fruits and have short shelf life due to highly perishable with a short postharvest shelf-life; therefore, there is low sugar consumption for respiration during postharvest life.

Table 5. Effect of growing media, humic acid, boric acid and their interaction on total sugar% in strawberry fruits cv. Albion stored at 2±2°C and 85-90%RH for 20 days

		0	2.5	5		
	0	6.319 a b	5.975 b	6.885 a b	6.393 ab	6.617 a
	20	6.263 ab	6.573 ab	7.686 a	6.841 ab	
	0	6.479 ab	6.771 ab	6.067 ab	6.439 ab	6.577 a
	20	6.567 ab	6.685 a b	6.895 ab	6.716 ab	
	0	5.939 b	5.814 b	6.093 ab	5.949 b	6.488 a
	20	7.224 ab	6.873 ab	6.986 ab	7.028 a	
	M1	6.291 a	6.274 a	7.286 a	Main effect Of Boric acid	
	M2	6.523 a	6.728 a	6.481 a		
	M3	6.581 a	6.343 a	6.540 a		
	0	6.246 a	6.186 a	6.349 a	6.260 b	
	20	6.685 a	6.710 a	7.189 a	6.861 a	
		6.465 a	6.448 a	6.769 a		

Means within a column, row,and their interactions followed with the same letters are not significantly different from each other according to Duncan’s multiple range test($P \leq 0.05$).

M1= 25% normal soil + 25% loam soil +50% mushroom compost, M2= 25% normal soil + 50% loam soil +25% mushroom compost, M3= 50% normal soil + 25% loam soil +25% mushroom compost.

6. Ascorbic Acid (mg/100g F.W.)

Table (6)indicated that strawberry plants treated with humic acid significant differences were shown for the main effect of humic acid were significantly differences which the highest value of ascorbic acid was recorded (40.719) mg.100g^{-1} at 5 mg. L^{-1} of humic acid concentration. From the same table, significant differences were recorded between growing media (M3), and 20 mg. L^{-1} boric acid gave the highest value (39.673) mg/100g of ascorbic acid.

Alongside, significant differences were observed through the interaction effect between growing media and humic acid on ascorbic acid in strawberry fruit that the highest value was verified (43.431) mg/100g from the interaction between growing media (M3) and 5 mg. L^{-1} of humic acid. It can be noticed from the data presented in the same table that significant differences were observed by the effect of boric acid and humic acid on ascorbic acid. The highest value was recorded (41.830) mg/100g by the interaction between 20 mg. L^{-1} boric acid and 5 mg. L^{-1} of humic acid.

The interactions of growing media, boric acid, and humic acid for this character gave the highest value (45.882) mg/100g of ascorbic acid using growing media (M3), 20mg. L^{-1} boric acid with 5mg. L^{-1} of humic acid, whereas the lowest (33.922) mg/100g was recorded using growing media (M2), 0 mg. L^{-1} boric acid and 0 mg. L^{-1} of humic acid. The present study was aimed to evaluate the effects of humic acid applications on yield, ascorbic acid in fruits of processing tomato(25 and 33)studies indicated that Pre-harvest application Ca + B has significantly influenced fruit firmness, quality parameters (TSS, acidity, ascorbic acid content) in 'Chandler' strawberry.

Table 6 Effect of growing media, humic acid, boric acid and their interaction on ascorbic acid (mg/100g) of strawberry fruits cv. Albion stored at 2±2°C and 85-90%RH for 20 days

	0	2.5	5		
0	**35.098 de**	**38.431 bcde**	**39.216 bcd**	**37.582 ab**	**38.039 a**
20	**35.882 cde**	**37.843 bcde**	**41.765 ab**	**38.497 a b**	
0	**33.922 e**	**37.451 bcde**	**38.627 bcde**	**36.667 b**	**37.320 a**
20	**34.902 de**	**41.176 b**	**37.843 bcde**	**37.974 ab**	
0	**36.863 bcde**	**36.667 bcde**	**40.980 de**	**38.170 ab**	**38.922 a**
20	**35.882 cde**	**37.255 bcde**	**45.882 a**	**39.673 a**	
M1	**35.490 de**	**38.137 bcd**	**40.490 ab**	**Main effect Of Boric acid**	
M2	**34.412 e**	**39.314 bc**	**38.235 bcd**		
M3	**36.373 cde**	**36.961 cde**	**43.431 a**		
0	**35.294 c**	**37.516 bc**	**39.608 a b**	**37.473 a**	
20	**35.556 c**	**38.758 b**	**41.830 a**	**38.715 a**	
	35.425 c	**38.137 b**	**40.719 a**		

Means within a column, row,and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test(P ≤ 0.05).

M1= 25% normal soil + 25% loam soil +50% mushroom compost, M2= 25% normal soil + 50% loam soil +25% mushroom compost, M3= 50% normal soil + 25% loam soil +25% mushroom compost.

7. Anthocyanin (mg/100g F.W.)

Table (7) shows that the fruit anthocyanin content increased by different growing media types, the strawberry plant cultivated in growing media (M1 and M3) was significantly superior to the growing media (M2) in anthocyanin contents. Also, the strawberry plant that treated with 2.5 mg. L^{-1} of humic acid was significantly superior to both 0 and 5 mg. L^{-1} of humic acid treatment in anthocyanin contents. From the same table, significant differences were recorded between growing media and boric acid, growing media (M1), and 0 mg. L^{-1} boric acid gave the highest value (49.0603 mg/100g) of anthocyanin while the lowest value was observed (34.155 mg/100g) using growing media (M2) and 0 mg. L^{-1} boric acid.

In the same table, the highest value was verified (55.136 $mg.100g^{-1}$) using the growing media (M1) and 2.5 mg. L^{-1} of humic acid. Also true for the interaction effect of boric acid and humic acid on anthocyanin content gave the highest value was recorded (47.364 mg/100g) using the 0 mg. L-1 boric acid with 2.5 mg. L^{-1} of humic acid while.

The significant differences were clear between the interaction of growing media, boric acid, and humic acid on this character. Growing media (M1), 0 mg. L-1 boric acid and 2.5 mg. L^{-1} of humic acid gave the highest values (61.646 $mg.100g^{-1}$) of anthocyanin content. Storage of strawberry fruits at 8°C for 11 weeks caused a significant loss of the anthocyanin content,which emphasizes the high sensitivity of these substances to oxidation,light,and heat (Hartmann *et al.*, 2008). Boron decreases anthocyanin pigments in the fruit by increasing the absorption of oxygen that acts as a factor in the anthocyanin degradation and causes instability of this pigment (Wang *et al.*, 2004). The application of 500 mg L^{-1} boric acid reduced the anthocyanin content of sweet cherry (*Prunus avium* L.)(35).

Table 7. Effect of growing media, humic acid, boric acid and their interaction on anthocyanin content (mg/100g) of strawberry fruits cv. Albion stored at 2±2°C and 85-90%RH for 20 days

		0	2.5	5		
	0	32.841 de	61.646 a	52.702 ab	49.0603 a	42.744 a
	20	29.423 e	48.625 abc	31.229 de	36.426 bc	
	0	36.296 cde	36.998 cde	29.170 e	34.155 c	35.550 b
	20	34.466 a	39.797 bcde	36.573 cde	36.946 bc	
	0	38.734 bcde	43.448 bcde	45.691 bcd	42.624 ab	42.385 a
	20	36.573 cde	44.381 bcd	45.485 bcd	42.146 ab	
	M1	31.132 e	55.136 a	41.965 bcd	Main effect Of	
	M2	35.381 cde	38.398 bcde	32.873 de		

	M3	**37.654 bcde**	**43.915 bc**	**45.588 b**	**Boric acid**
	0	**35.957 cd**	**47.364 a**	**42.521 abc**	**41.947 a**
	20	**33.487 d**	**44.268 ab**	**37.763 bcd**	**38.506 a**
		34.722 c	**45.816 a**	**40.142 b**	

Means within a column, row,and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test($P \leq 0.05$).

M1= 25% normal soil + 25% loam soil +50% mushroom compost, M2= 25% normal soil + 50% loam soil +25% mushroom compost, M3= 50% normal soil + 25% loam soil +25% mushroom compos

References:

1-Al-Rawi, K. M. and A. Khalaf-Allah.1980. Design and Analysis of Agricultural Experiments, University of Mosul. Ministry of Higher Education and Scientific Research. Mosul. Iraq.

2-Alsaidi,I.2000.Grape Production, Part One. Ministry of Higher Education and Scientific Research-University of Mosul. Iraq.

3-Ati, A. and N. Ali.2011.The Effect of Boron Fertilization on Faba bean (Vicia faba L) yield, fertilizer and water productivity. Researches of the First International Conference (Babylon and Universities). Iraq. pp3875.

4-Banaeian, N.; M. Omid and Ahmadi, H.2011.Energy and economic analysis of greenhouse strawberry production in Tehran province of Iran, Energy Conversion and Management,52(2):1020-1025.DOI:10.1016/j.enconman.2010.08.030

5-Cao, S.; Z. Hu; B. Pang; H. Wang; H., Xie and Wu, F.2010. Effect of ultrasound treatment on fruit decay and quality maintenance in strawberry after harvest', Food Control,21(4):529-532.DOI:10.1016/j.foodcont.2009.08.002

6-Chandini, K. R.; R. Kumar and Prakash, O.2019. Research Trends in Environmental Sciences(The Impact of Chemical Fertilizers on our Environment and Ecosystem). Akinik. India. pp. 69-86.

7-Chupp, R. E.; R. C. Hendricks; S. B. Lattime and Steinetz, B. M.2006. Sealing in turbomachinery. Journal of Propulsion and Power,22(2):313-349. https://doi.org/10.2514/1.177.

8-Davarynejad, G.; M. Zarel; E. Ardakani and Nasrabadi, M. E.2013.Influence of putrescine application on storability. postharvest quality and antioxidant activity of two Iranian apricot (Prunus armeniaca L.) cultivars. Notulae Scientia Biologicae,5(2): 212-219.DOI:10.15835/nsb.5.2.9041

9-Elgailani, I. E. H.; M. Elkareem; E. Noh; O. Adam and Alghamdi, A.2017. Comparison of two methods for the determination of vitamin C (ascorbic acid) in some fruits. American Journal of Chemistry, 2(1):1-7.DOI: 10.20448/812.2.1.1.7

10-Eshghi, S. and M. Garazhian.2015. Improving growth, yield and fruit quality of strawberry by foliar and soil drench applications of humic acid', Iran Agricultural Research, 34(1):14-20. DOI:10.22099/IAR.2015.3031

11-Farahi, M. H.; A. Aboutalebi; S. Eshghi; M. Dastyaran and Yosefi, F.2013. Foliar application of humic acid on quantitative and qualitative characteristics of 'aromas' strawberry in soilless culture', Agricultural Communications,1(1): 13-16. https://www.cabdirect.org/cabdirect/abstract/20143146341

12-Garuba, T.; O. Mustapha and Oyeyiola, G.2018.Shelf life and proximate composition of tomato (*Solanum lycopersicum* L.) fruits as influenced by storage methods, Ceylon Journal of Science,47(4):387-393.http://doi.org/10.4038/cjs.v47i4.7557

13-Guttridge, C. and J. Turnbull.1975. 'Improving anther dehiscence and pollen germination in strawberry with boric acid and salts of divalent cations. Horticultural Research(UK),14(2/3):73-79. https://agris.fao.org/agris-search/search.do?recordID=CZ19760050500

14-Hartmann, A.; C. D. Patz; W. Andlauer; H. Dietrich and Ludwig, M.2008. Influence of processing on quality parameters of strawberries. Journal of Agricultural and Food Chemistry, 56(20):9484-9489. https://doi.org/10.1021/jf801555q

15-Horwitz, W. 2002. Instructions for inserting: Official Methods of Analysis of A.O.A.C. Association of Official Analytical Chemists. Washington, DC . USA.

16-Johnson, K.; R. Kleerebezem and Van Loosdrecht, M. C.2010.Influence of ammonium on the accumulation of polyhydroxybutyrate(PHB)in aerobic open mixed cultures. J. of Biotechnol.,147(2):73-79.doi: 10.1016/j.jbiotec.2010.02.003.

17-Joslyn, M.1970.Analítico: Methods in Food Analysis. Physical, Chemical, and Instrumental Methods of Analysis. 2nd. Academic Press Inc. New York; USA.https://www.cabdirect.org/cabdirect/abstract/19710400601?freeview=true

18-Kadir, S., Carey, E. and Ennahli, S. 2006. 'Influence of high tunnel and field conditions on strawberry growth and development', HortScience, 41(2), pp. 329-335.

19-Khalaj, K.; N. Ahmadi and Souri, M.2015. Effect of calcium and boron foliar application on fruit quality in Asian pear cultivar'KS10'', Isfahan University of Technology-Journal of Crop Production and Processing, 4(14):89-97. http://jcpp.iut.ac.ir/article-1-2271-en.html

20-Kiryakova, Y.; M. C. Padula; R. Rossano and Martelli, G.2016.Effect of boron and zinc application on HXK1 and MAKR6 gene expression in strawberry, Emirates Journal of Food and Agriculture,28(5):317-325. DOI https://doi.org/10.9755/ejfa.2016-02-178

21-Lieten, F. 2000.Boron deficiency of strawberries grown in substrate culture. Acta Hort.,567(567):451-454.DOI:10.17660/ActaHortic.2002.567.94

22-Mahajan, B.; J. Randhawa; H. Kaur and Dhatt, A.2008. Effect of post-harvest application of calcium nitrate and gibberellic acid on the storage life of plum. Indian Journal of Horticulture, 65(1):94-96. http://epubs.icar.org.in/ejournal/index.php/IJH/issue/archive

23-Nazir, A.; I. Mukhopadhyay; D. Saxena and Chowdhuri, D. K.2001. Chlorpyrifosinduced hsp70 expression and effect on reproductive performance in transgenic Drosophila melanogaster (hsp70-lacZ) Bg 9', Archives of Environmental Contamination and Toxicology,41(4):443-449. doi:10.1007/s002440010270

24-Nunes, M. and J. P. Emond.1999. Chlorinated water treatments affects postharvest quality of green bell peppers. Journal of Food Quality, 22(3):353-361 https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.17454557.1999.tb00563.x.

25-Padem, H. and A. Ocal.1998.Effects of humic acid applications on yield and some characteristics of processing tomato'. VI International Symposium on Processing Tomato & Workshop on Irrigation & Fertigation of Processing Tomato 487:159-164.

26-Potter, D.; T. Eriksson; R. C. Evans; S. Oh; J. Smedmark; D. R. Morgan; M. Kerr; K. R. Robertson; M. Arsenault and Dickinson, T. A.2007. Phylogeny and classification of Rosaceae. Plant Systematics and Evolution,266(1):5-43. DOI:10.1007/s00606-007-0539-9

27-Ranganna, S.2011.Handbook of Analysis and Quality Control for Fruit and Vegetable products. Tata McGraw-Hill Education. USA.

28-Rao, T. R.; N. B. Gol and Shah, K. K.2011. Effect of postharvest treatments and storage temperatures on the quality and shelf life of sweet pepper (*Capsicum annum* L.). Scientia Horticulturae,132:18-26.

29-Saleh, M.; S. El-Ashry and Gomaa, A.2006. Performance of Thompson Seedless Grapevine as influenced by organic fertilizer', Humic acid and biofertilizers under sandy soil conditions. Res. J. Agri. & Biol. Sci., 2(6):467-471.

30-Salentijn, E. M.; A. Aharoni; J. G. Schaart; M. J. Boone and Krens, F. A.2003. Differential gene expression analysis of strawberry cultivars that differ in fruit-firmness. Physiologia Plantarum,118(4):571-578 https://doi.org/10.1034/j.13993054.2003.00138.x.

31-Sharma, V. and R. R. Sharma.2004.The Strawberry. ICAR,New Delhi,India.

32-Shehata, S.; H. S. Abdel-Azem; A. Abou El-Yazied and El-Gizawy, A.2011. Effect of foliar spraying with amino acids and seaweed extract on growth chemical constitutes, yield and its quality of celeriac plant. European Journal of Scientific Research,58(2),:257-265. http://www.eurojournals.com/ejsr.htm

33-Singh, R.; R. Sharma and Tyagi, S.2007. Pre-harvest foliar application of calcium and boron influences physiological disorders, fruit yield and quality of strawberry (Fragaria× ananassa Duch.). Scientia Horticulturae,112(2):215-220.DOI: 10.1016/j.scienta.2006.12.019.

34-Taghavi, T.; R. Siddiqui and Rutto, L. K. 2019.The effect of preharvest factors on fruit and nutritional quality in strawberry(In. Strawberry-Pre-and Post-Harvest" Management Techniques for Higher Fruit Quality, T. Asao, and M. Asaduzzaman, eds.(IntechOpen), pp. 1-22.).

35-Thurzo, S.; Z. Szabo; J. Nyeki; P. Nagy; A. Silva and Goncalves, B.2010. 'Effect of B and Ca sprays on photosynthetic pigments, total phenols and flavonoid content of sweet cherry (*Prunus avium* L.). Acta Horti.(ISHS), 868:457-462.

36-Wang, S. Y. and S. S. Lin.2002.Composts as soil supplement enhanced plant growth and fruit quality of strawberry. Journal of Plant Nutrition, 25(10):2243-2259.DOI:10.1081/PLN-120014073.

37-Wang, Y.; M. Lau; J. Tang and Mao, R. .2004.Kinetics of chemical marker M-1 formation in whey protein gels for developing sterilization processes based on dielectric heating. Journal of Food Engineering,64(1):111-118. doi:10.1016/j.jfoodeng.2003.09.019.

38-Wright, S.; A. Upadhyaya and Buyer, J.1998.Comparison of N-linked oligosaccharides of glomalin from arbuscular mycorrhizal fungi and soils by capillary electrophoresis. Soil Biology and Biochemistry, 30(13):1853-1857.

39- Zandonadi, D. B.; L. P. Canellas and Façanha, A. R.2007.Indolacetic and humic acids induce lateral root development through a concerted plasmalemma and tonoplast H+ pumps activation. Planta,225(6): 1583-1595.DOI:10.1007/s00425006-0454-2.

40-Zhang, L. and X. Sun.2014.Effects of rhamnolipid and initial compost particle size on the two-stage composting of green waste. Bioresource Technology,163:112-122.DOI:10.1016/j.biortech.2014.04.041.