Effect of humic acid and chelated iron on yield and quality of two strawberry cultivars (Fragaria X ananassa Duch.)

[1]Ahmed Adel Omar Mohamed* [2]Bahram Khurshid Mohammed [3]Shlier Mohammed Taha

[1,2]College of Agriculture - University of Kirkuk

[3]College of Agriculture - University of Salahaddin

Barznji69@gmail.com

Abstract

The experiment was conducted in the Agricultural Research and Experiments Station belonging to Horticulture and Landscape department, College of Agriculture , University of Kirkuk, located at the university presidency in the Alsiyada area in Kirkuk province, during the season (2019-2020). In order to study the effect of spraying with humic acid (0, 2 and 4) ml.L $^{-1}$ and chelated iron (0, 1.5 and 3) g.L $^{-1}$ on some quantitative and qualitative traits of the fruits of two strawberry cultivars Ruby Gem and Albion. The experiment was conducted according to a completely randomized design (CRD) of three replicates 18 (2 × 3 × 3), where each experimental unit included 6 plants. The results obtained can be summarized as follows:

1. The fruits of the Albion cultivar were significantly higher in the number of fruits, fruit weight, fruit size, average yield per plant, Total Soluble Solids percentage , TSS / TA percentage and fruit content of anthocyanin pigment, while Ruby Gem was significantly excelled in vitamin C
2. The spraying was characterized by a concentration of 2 ml.L $^{-1}$ of humic acid by giving it the highest content of fruits of vitamin C and the content of fruits of the anthocyanin pigment, While the spraying with a concentration of 3 ml.L $^{-1}$ was excelled in the number and weight of the fruit, the percentage of total soluble solids and the fruit content of the anthocyanin pigment , and the control treatment was excelled in the total acidity percentage.
3. It was found that spraying with 1.5 g.L^{-1} of chelated iron was significantly higher in Total Soluble Solids percentage and TSS / TA and the fruit content of anthocyanin pigment. The spraying had a concentration of 3 g.L^{-1} in the percentage of total soluble solids, the percentage of TSS / TA, and the fruit content of vitamin C, and the control treatment gave the highest acidity.

Key words: humic acid, chelated iron, strawberry.

***Research paper from MSc thesis for the First author**

تأثير حامض الهيوميك والحديد المخلبي في حاصل ونوعية صنفين من الفراولة (***Fragaria* X *ananassa* Duch.)**

أحمد عادل عمر محمد* بهرام خورشيد محمد** شلير محمود طه ***

Barznji69@gmail.com

هـ 07706694509

* كلية الزراعة – جامعة كركوك ** كلية الزراعة – جامعة كركوك *** كلية الزراعة – جامعة صلاح الدين

المستخلص

أجريت هذه الدراسة في محطة البحوث والتجارب الزراعية العائدة الى كلية الزراعة/جامعة كركوك، الواقعة في منطقة الصيادة في محافظة كركوك، خلال الموسم (2019-2020). بهدف دراسة تأثير الرش بحامض الهيوميك (0 و 2 و 4) مل.لتر$^{-1}$ والحديد المخلبي (0 و 1.5 و 3) غم.لتر$^{-1}$ في بعض الصفات الكمية والنوعية لثمار صنفين من الفراولة Ruby Gem و Albion، ونفذت التجربة وفق تصميم القطاعات العشوائية الكاملة بثلاث قطاعات 18(2×3×3) حيث اشتملت كل وحدة تجريبية 6 نباتات . ويمكن تلخيص النتائج التي تم الحصول عليها فيما يلي:

1. أن ثمار الصنف Albion تفوق معنوياً في عدد الثمار ووزن الثمرة وحجم الثمرة ومتوسط الحاصل للنبات الواحد ونسبة المواد الصلبة الذائبة الكلية ونسبة TSS/TA ومحتوى الثمار من صبغة الانثوسيانين بينما تفوق الصنفRuby Gem معنوياً في . C
2. تميز الرش بتركيز 2 مل.لتر$^{-1}$ من حامض الهيوميك بأعطائه أعلى محتوى للثمار من فيتامين C ومحتوى الثمار من صبغة الانثوسيانين، بينما تفوق الرش بتركيز 3 مل.لتر$^{-1}$ في صفة عدد ووزن الثمرة ونسبة المواد الصلبة الذائبة الكلية ومحتوى الثمار من صبغة الانثوسيانين، وتفوق معاملة المقارنة في نسبة الحموضة الكلية.
3. وجد أن الرش بـ1.5 غم.لتر$^{-1}$ من الحديد المخلبي قد تفوق معنوياً في نسبة المواد الصلبة الذائبة الكلية و TSS/TAومحتوى الثمار من صبغة الانثوسيانين، وتفوق الرش بـتركيز3 غم.لتر $^{-1}$ في نسبة المواد الصلبة الذائبة الكلية ونسبة TSS/TA ومحتوى الثمار من فيتامين C ، وأعطى معاملة المقارنة اعلى نسبة حموضة.

الكلمات المفتاحية : حامض الهيومك ، الحديد المخلبي ، الفراولة

البحث مستل من رسالة ماجستير للباحث الاول

Introduction

The strawberry plant belongs to Rosaceae family, to the genus Fragaria, and to the species (*Fragaria X ananassa Duch*.)(11),The name of this plant is derived from the Latin word Fragrance and Fragarant, and it is called Strawberry in English and in French Fraise, and Italian Fragola, and from the last name, its name was derived in the Arab world (Egypt) strawberry (2), It is native to Europe and North America, as well as cultivated in Italy, Bologna, Holland, France and Bulgaria, and is the fourth most consumed fruit of apples, oranges and bananas (16), Strawberry is considered one of the fruits of the fruit because it adds annual rings in the crown area, as well as it belongs to the Rosaceae family (2), The estimated area of strawberry cultivated land in the world is about 257 thousand hectares, and the World Food and Agriculture Organization indicates that the global production of strawberries for the year 2017 amounted to about 9.223.815 million tons (8). The abundance of production in strawberry plants with excellent quality depends on adequate nutrients, climate and Cultivars(13), and among the most important factors for strawberry production is the selection of the cultivar, the foliar nutrition plays an essential and important role in the productivity and quality of strawberries and that spraying operation in the appropriate stages improves strawberries in both qualitative and quantitative traits, humic acid is used in agriculture on a large scale, and the most published and reliable research has proven that the effect of humic works similar to that of hormones, especially Auxin, cytokines and gibberellins, (15). The micronutrients, including iron, have an effective

 ISSN 2072-3875

and essential role in the natural growth of plants, and the microelements are no less important than the microelements, and also many research and studies have indicated the importance of these elements (microelements) in the growth of plants (4), The iron component has a stimulating effect for vegetative growth in plants through the active cycle in the formation and activation of its chlorophyll pigment by entering it into the compounds that make up chlorophyll (1),Iron is also included in the composition of many compounds, such as the cytochrome responsible for the respiration process in plants, chloroplasts and the formation of plant proteins (5). Iron has several forms and the most used form is chelated iron. As these compounds (chelating) preserve the element in a soft form for absorption and transfer by the plant, in addition to that they do not dissolve in Fe-EDDHA soil and Fe-EDTA is one of the most common chelating compounds and the most used in many plants (3), The study aims to: improve the qualitative traits and increase the yield of some studied cultivars of the strawberry plant, as well as test the efficiency of chelated iron in the growth and production of strawberries and study the effect of the interaction between them.

Materials and Methods

The experiment was conducted in the Agricultural Research and Experiments Station belonging to Horticulture and Landscape department, College of Agriculture , University of Kirkuk, located at the university presidency in the Alsiyada area in Kirkuk province, during the season (2019-2020). The covered cultivation system (greenhouse) was used without heating, and by using the method of cultivation on the terraces, organic matter was added at an average of (30 m^3) scattered in the field of an experiment to improve the properties of the soil, and then the land was plowed with two perpendicular tillage with Moldboard plows, The process of soil fragmentation and smoothing was conducted using a rotary plow and its modification. The experiment land was divided into three replicates in the form of terraces, length of 12 m, width 100 cm, the height of 25 cm, the distance between a floor and another is 75 cm as a walkway and the distance between plants is 40 cm. It was equipped with a drip irrigation system, and the terraces were covered with black nylon. Seedlings of two strawberry cultivars (Albion and Ruby Gem) were obtained from Sulaymaniyah province, where they were stored in refrigerated stores. The seedlings were taken homogeneous in strength and size as much as possible and ready for cultivation, and the seedlings were treated by dipping them in a fungicide (Uniform446 SE emulsion solution) until wet to prevent the fungal causes causing the rot of crowns, leaves and roots at a concentration of 25 ml.100 L^{-1} water before cultivated on the terraces, The seedlings were cultivated on (1/10/2019), and the seedlings were irrigated immediately after cultivated, using drip irrigation, and all agricultural operations were conducted as 200 kg / hectare of NPK compound fertilizer was added to the soil in two batches, the first after 15 days after cultivated seedlings (10/15/2019) and the second one month after the first date, The Completely Randomized Design was used within the factorial experiments to implement the experiment (RCBD), and with three factors and three replicates within the design of the split-plot, the replicate included 18 treatments (2x3x3), the number of cultivar 2, concentrations of humic acid 3, chelating iron concentrations 3, and the treatments were distributed randomly within Each replicate has an average of 6 plants per experimental unit, thus the number of plants in one replicate is 108 plants, and the total number of seedlings in the experiment is 324 plants. The experiment included a study of three factors: The first factor: the study of two strawberries cultivate (Albion and Ruby Gem).The second factor: spraying with humic acid. It is sprayed in three concentrations: (0, 2 and 4) $ml.L^{-1}$ and the third factor: spraying with chelated iron, sprayed with three concentrations: (0, 1.5 and 3) $ml.L^{-1}$.

 ISSN 2072-3875

Plants were sprayed with humic acid and chelated iron in the early morning until complete wetness by using 0.01% of liquid soap as a diffuser to reduce surface tension. Humic acid was sprayed on four times and the period between spraying was 15 days. While chelated iron was two spraying, and the period between one spraying and another was a month, starting from (12/10/2019) and ending on (1/25/2020). As for the most important traits studied in the research, they were:

Average number of fruits.

Average weight of the fruit (g).

Average size of the fruit (cm ^{3}).

Yield per plant (g).

Fruit content of vitamin C: Vitamin C in fruit juice was estimated for all experimental treatments according to the method mentioned by Sadasivam and Manickam (2005), using Oxalic acid at a concentration of 2% as a preservative solution and correcting with pigment (2,6-Dichlorophenol Indophenol,

Ascorbic acid, alone is able to reduce this pigment by changing from blue in the basic medium to pink in the acid medium.

Total Soluble Solids percentage (TSS): Total Soluble Solids were measured using a (Hand Refractometer) device. Ten ripe and homogeneous fruits were cut from each experimental unit into slices and placed in an electric mixer for a period of (2-3) minutes, after which the juice was filtered with a cotton cloth. The reading was taken to represent TSS in juice.

- Total acidity percentage (TA): TA was calculated by taking a certain volume of the same filtered juice for the determination of (TSS) and correcting it with the base NaoH of standardized (0.1N) and using (2) drops of phenonphthalein indication only on the basis of citric acid as the predominant acid in Strawberry (Ranganna 1977) According to the following equation:

$$\%TA = \frac{T.N.Eq.Vt}{Vs.Vi.\ \ 1000} \times 100$$

As:

TA = total acidity.

T = Volume of base used when titration

N = standard of the base used when titration 1.5.

Eq = equivalent weight of citric acid.

Vt = final volume of juice after dilution of 50 ml.

Vs = volume used upon titration of 10 ml.

Vi = the volume of juice before dilution 5 ml.

Total Soluble Solids percentage / total acidity percentage: The TSS / TA percentage was calculated by dividing the total Soluble Solids by the total acidity values of the fruit and processing the processing.

Determination of the anthocyanin stain in the fruits: Anthocyanins were extracted from the fresh fruits using alcoholic hydrochloric acid (Alcoholic HCl) consisting of 95% as ethyl alcohol and HCl (1.5 standards) at a ratio of 85: 15 by taking 1 g of the mixed soft fruits and dissolving them in 20 ml of acidified alcohol Leave it for 24 hours at room temperature, then filter it with (watman No.1) filter paper.

Then the estimation was done using EMC lab v-1 100 Spectrophotometer at wavelength of 535 nm as reported in Ranganna (2011) according to the following equation:

ISSN 2072-3875

Anthocyanins(fresh weight 100 mg).=

$$\frac{Optical\ density\ at\ wavelength\ 535 \times volume\ of\ solution\ used\ for\ extraction \times total\ volume}{98.2\ x\ Sample\ Weight} \times 100$$

Statistical analysis :

The data were analyzed according to the ANOVA table, using a computer according to the (SAS, 2001) system for analyzing agricultural experiments, and the averages were compared using the multinomial Dunkin test at a probability level of 5%.

Results and discussion

1- Average number of fruits (fruit.plant^{-1}).

the results are shown in Table (1) there were significant differences in the number of fruits between the fruits of the two cultivars, where the cultivar Albion excelled 8.1126 fruits.Plant^{-1} on the cultivar Ruby Gem 6.4807 fruit.plant^{-1}. The results also show that spraying humic acid on seedlings at a concentration of 4 ml.L^{-1} recorded the highest number of fruits reaching (8.0800) fruit.plant^{-1}. Therefore, it surpassed the other levels. As for spraying with chelated iron with both concentrations (1.5 and 3) g.L^{-1} has surpassed the control treatment, and the reason for this may be due to the difference in the two types, and the result is consistent with (5) and (8). As for the bi-interaction between cultivar and humic acid, it was found that the concentration of 4 ml.L^{-1} was excelled to achieving the highest number of fruits, which reached (8.9311 fruits.Plant^{-1}), and that the interaction between cultivar and chelated iron had a significant effect on the number of fruits of the plant and the two sprayings treatments (1.5 and 3) g.L^{-1} excelled in the type Albion on the rest treatments,As for the bi-interaction of humic acid and chelated iron, all the interactions between the two factors were excelled on the control treatment. The reason for this is that humic acid contains nutrients such as zinc and boron, activates growth regulators within plants such as IAA, regulates maturation processes, raises the quality of the fruit, and regulates cellular content of auxins and phenols. These results are in line with (9) and (7).The results of the triple interaction of the same table between the cultivar, humic acid and chelated iron showed that the treatment of 4 ml.L^{-1} of humic acid with (1.5 and 3) g.L^{-1} liter of chelated iron in the cultivar Albion was significantly excelled on the control treatment in the cultivar Ruby Gem. That was the lowest average (4,467 fruit.plant^{-1}). The reason for this is due to the role of iron in the contribution of bio processes in the plant because it is a stimulant for the enzymes of the process of respiration and the transfer of electrons, increasing the leaves area and dry matter, and thus increasing the carbohydrates, which led to an increase in these components (yield components). These results agree with (12) and (10).

 ISSN 2072-3875

Table (1): The effect of spraying with humic acid and chelated iron and the interaction between them .on the average number of fruits (fruit .plant $^{-1}$) for two strawberry cultivars Ruby Gem and Albion

interaction cultivars * Humic acid	Chelated iron concentration (ml.L^{-1})			Humic Acid Concentrations (ml.L^{-1})	cultivars
	3 ml.L^{-1}	1.5 ml.L^{-1}	0 ml.L^{-1}		
5.8511 d	6.187 def	6.900 bcde	4.467 f	0 ml.L^{-1}	Ruby Gem
6.3622 cd	6.510 cdef	6.533 cdef	6.043 def	2 ml.L^{-1}	
7.2289 bc	6.953 bcde	6.333 def	8.400 abcd	4 ml.L^{-1}	
7.6111 b	8.767 abc	9.057 ab	5.010 ef	0 ml.L^{-1}	Albion
7.7956 ab	7.350 bcde	7.217 bcde	8.820 abc	2 ml.L^{-1}	
8.9311 a	9.967 a	9.663 a	7.163 bcde	4 ml.L^{-1}	
The effect of cultivars					
6.4807 b	6.5500 b	6.5889 b	6.3033 b	Ruby Gem	interaction cultivars *Chelated iron
8.1126 a	8.6944 a	8.6456 a	6.9978 b	Albion	
The effect of Humic Acid Concentrations (ml.L^{-1})					
67311 b	7.4767 a	7.9783 a	4.7383 b	0 ml.L^{-1}	Interaction Humic acid * chelated iron
7.0789 b	6.8750 a	7.4317 a	7.4317 a	2 ml.L^{-1}	
8.0800 a	8.4600 a	7.9983 a	7.7817 a	4 ml.L^{-1}	
	7.6222 a	7.6172 a	6.6506 b	Effect of chelated iron (ml.L^{-1})	

2- Average fruit weight (g).

The results in Table (2) indicate a significant increase in the fruit weight in the Albion cultivar, which reached (9.541 g) compared to the Ruby Gem cultivar, Compared to Ruby Gem, which gave the lowest average (8.579 g), As for the spraying with humic acid, it was found that the concentration of 4 ml. Liters-1 recorded the highest average (9.974 g) and was significantly excelled on the control treatment, and that both treatments (1.5 and 3) g.L^{-1} of chelated iron were excelled on the control treatment. and it was found from the bi-interaction of the same table that the spraying with a concentration of 4 ml.L^{-1} of humic acid in the Albion cultivar recorded a significant increase of (10.818 g) and thus surpassed the rest of the treatments. As for the bi-interaction between the cultivar and chelated iron, it was found that the use of two concentrations (1.5

 ISSN 2072-3875

and 3) g.L^{-1} of chelated iron in the cultivar Albion has excelled on the other interactions, and the interaction of humic acid at a concentration of 4 g.L^{-1} and chelated iron at a concentration of 3 g.$L^{-1}$for the weight of the fruit, which reached (10.393 g), excelled on the rest of the treatments. The results of the triple interaction between study factors for Table (2) showed that the use of 4 ml.$L^{-1}$of humic acid with 3 g.L^{-1} of chelated iron in the Albion cultivar, which reached (11.187 g).It may be significantly excelled on the control treatment, and the reason for this is due to the containment of humic acid on nutrients such as zinc and boron which are important in the positive effect on this trait. The reason for this is the role of iron in the contribution of vital processes in the plant.

Table (2): The effect of spraying with humic acid and chelating iron and the interaction between them on fruit weight (g) for two strawberry cultivars Ruby Gem and Albion.

interaction cultivars * Humic acid	Chelated iron concentration (ml.L^{-1})			Humic Acid Concentrations (ml.L^{-1})	cultivars
	3 ml.L^{-1}	1.5 ml.L^{-1}	0 ml.L^{-1}		
8.332 c	8.123 cdef	8.930 cde	6.943 f	0 ml.L^{-1}	Ruby Gem
7.274 c	8.660 def	8.443 def	7.720 ef	2 ml.L^{-1}	
8.130 c	9.600 abc	8.023 def	7.767 ef	4 ml.L^{-1}	
9.813 b	9.433 abc	9.517 ab	7.490 ef	0 ml.L^{-1}	Albion
9.991 ab	10.460 ab	9.257 abc	9.257 abc	2 ml.L^{-1}	
10.818 a	11.187 a	10.060 ab	9.207 bcd	4 ml.L^{-1}	
The effect of cultivars					
8.579 b	8.794 b	8.466 b	7.477 c	Ruby Gem	interaction cultivars *Chelated iron
9.541 a	10.027 a	10.611 a	8.984 b	Albion	
The effect of Humic Acid Concentrations (ml.L^{-1})					
8.573 b	38.778 bc	9.223 ab	5.717 d	0 ml.L^{-1}	Interaction Humic acid * chelated iron
8.633 ab	9.560 abc	8.350 c	8.988 c	2 ml.L^{-1}	
9.974 a	10.393 a	9.042 bc	8.487 c	4 ml.L^{-1}	
	9.911 a	9.538 a	8.731 b	Effect of chelated iron (ml.L-1(	

ISSN 2072-3875

Average fruit size (cm^3).

It is evident from the results in Table (3) shown that the fruits of the cultivar Albion were significantly excelled in size to the fruits of the cultivar Ruby Gem and reached (39.974) cm^3, and for the use of humic acid, the two concentrations (2 and 4) ml. (36.819 and 37.441) cm 3 on the control treatment, as well as for the use of chelated iron, the spraying with two concentrations (1.5 and 3) g. L^{-1} was excelled in the control treatment. The reason for this may be due to the difference between the two cultivars, which may lead to an increase in the final yield. These results are consistent with (7) and (9). The bi-interaction of the same table revealed the existence of significant differences in the average fruit size, where the use of 2 $ml.L^{-1}$ of humic acid in the Albion cultivar gave the highest average (42.204 cm3) compared to the control treatment in the Ruby Gem cultivar, which reached the lowest percentage (29,403) ,As for the bi-interaction between cultivar and chelated iron for the average size of the fruit, it was found that spraying chelated iron at two different concentrations (1.5 and 3) $g.L^{-1}$ on the cultivar Albion was significantly excelled on the cultivar Ruby Gem when it interaction with all concentrations of chelated iron and that the bi-interaction between humic acid and chelating iron had a significant effect on the average size of the fruit, where the spraying with a concentration of 4 $ml.L^{-1}$ of humic acid was excelled on the interaction with 3 $g.L^{-1}$ of chelated iron, which reached (44.620 cm^3) significantly on the other treatments.The reason for this is due to the activation of some growth regulators (auxins) inside the plant, which led to the regulation of ripening processes and raising the quality of the fruit. These results are in line with (4) and (6). The triple interaction of study factors for Table (3) showed that there were significant differences in the average fruit size, where the highest average was (51.803 cm^3) when spraying 4 $ml.L^{-1}$ of humic acid and 3 $g.L^{-1}$ liter of chelated iron in the Albion cultivar compared to other treatments.

4- Yield of one plant (g).

The results in Table (4) confirm that the yield of one plant was significantly affected in the Albion cultivar, where it achieved the highest yield of 102.643 g compared to the Ruby Gem cultivar, which reached 82.643 g, and there was no significant effect for this trait when spraying humic acid on the strawberry plant. For using chelated iron, it was found that both concentrations were excelled to the control treatment. The excelled of the cultivar may be due to its excelled in the yield components (number of fruits and fruit weight) which positively affected the trait and the result is consistent with (15) and (16) As for the bi-interaction between the cultivar and the humic acid, it was found that all the spraying of humic acid in the Albion cultivar did not differ significantly with some of them, and it was significantly excelled to the Ruby Gem cultivar.As for the bi-interaction between the cultivar and the chaleted iron, it was found that spraying with a concentration of 1.5 $g.L^{-1}$ of chelated iron on the cultivar Albion was significantly excelled to the rest of the treatments, where it gave the highest average (116.378 g). As for the interaction between humic acid and chelating iron, the non-interaction between the control treatment of humic acid and 1.5 $g.L^{-1}$ of chelated iron was significantly excelled to the other treatments in the average yield of the plant, where the highest average was 122.00 g. This excelled concentration may be due to its excelled in the important yield components, which positively affected the trait, and the result is consistent with (7) and (11). As for the triple interaction between study factors, it had a significant effect on the yield average of the plant, where the highest average was 141.00 g when the control treatment for humic acid and sprayed with 1.5 g. 1 liter of chelated iron in the Albion cultivar compared to the lowest average of 47.33 g when the control treatment for each of Humic acid and chelated iron in Ruby Gem.

 ISSN 2072-3875

Table (3): The effect of spraying with humic acid and chelating iron and the interaction between them on the average fruit size (cm3) for two strawberry cultivars Ruby Gem and Albion.

interaction cultivars * Humic acid	Chelated iron concentration (ml.L^{-1})			Humic Acid Concentrations (ml.L^{-1})	cultivars
	3 ml.L^{-1}	1.5 ml.L^{-1}	0 ml.L^{-1}		
29.403 d	32.227 cdef	33.243 bcde	22.740 f	0 ml.L^{-1}	Ruby Gem
31.433 d	38.933 bc	27.383 ef	27.983 def	2 ml.L^{-1}	
34.093 cd	37.437 bcd	31.203 cdef	33.640 bcde	4 ml.L^{-1}	
36.930 bc	38.557 bc	48.680 a	23.553 f	0 ml.L^{-1}	Albion
42.204 a	34.507 bcde	49.380a	42.727 ab	2 ml.L^{-1}	
40.789 ab	51.803 a	36.617 bcde	33.947 bcde	4 ml.L^{-1}	
The effect of cultivars					
31.643 b	36.199 b	30.610 cd	28.121 d	Ruby Gem	interaction cultivars *Chelated iron
39.974 a	41.622 a	44.892 a	33.409 bc	Albion	
The effect of Humic Acid Concentrations (ml.L^{-1})					
33.167 b	35.392 bc	40.962 ab	23.147 d	0 ml.L^{-1}	Interaction Humic acid * chelated iron
36.819 a	36.720 bc	38.382 abc	35.355 bc	2 ml.L^{-1}	
37.441 a	44.620 a	33.910 c	33.793 c	4 ml.L^{-1}	
	38.911 a	37.751 a	30.765 b	Effect of chelated iron (ml.L-1(	

ISSN 2072-3875

Table (4): The effect of spraying with humic acid and chelating iron and the interaction between them on the yield of one plant (g) for two strawberry cultivars Ruby Gem and Albion.

interaction cultivars * Humic acid	Chelated iron concentration (ml.L^{-1})			Humic Acid Concentrations (ml.L^{-1})	cultivars
	3 ml.L^{-1}	1.5 ml.L^{-1}	0 ml.L^{-1}		
79.057 b	86.83 bcd	103.00 abc	47.33 d	0 ml.L^{-1}	Ruby Gem
77.218 b	77.17 bcd	75.19 cd	79.30 bcd	2 ml.L^{-1}	
91.656 ab	106.67 abc	87.00 bcd	81.30 bcd	4 ml.L^{-1}	
104.707 a	118.93 ab	141.00 a	54.19 d	0 ml.L^{-1}	Albion
101689 a	96.83 bc	103.97abc	104.27 abc	2 ml.L^{-1}	
101.533 a	10490 abc	104.17 abc	95.53 bc	4 ml.L^{-1}	
The effect of cultivars					
82.643 b	90.222 bc	88.397 bc	69.311 c	Ruby Gem	interaction cultivars *Chelated iron
102.643 a	106.889 ab	116378 a	84.662 c	Albion	
The effect of Humic Acid Concentrations (ml.L^{-1})					
91.882 a	102.88 ab	122.00 a	50.76 c	0 ml.L^{-1}	Interaction Humic acid * chelated iron
89.453 a	87.00 b	89.58 b	91.78 b	2 ml.L^{-1}	
96.594 a	105.78 ab	95.58 ab	88.42 b	4 ml.L^{-1}	
	98.556 a	102.387 a	76.987 b	Effect of chelated iron (ml.L-1(	

5- Vitamin C concentration (mg. 100 g $^{-1}$ Fresh weight).

The results of the statistical analysis in Table (5) showed that the fruits of the Ruby Gem cultivar were significantly excelled in the juice content of ascorbic acid (vitamin C), which amounted to (18.7912 mg. 100 g $^{-1}$ Fresh weight) on the cultivar Albion. The reason for this may be due to the difference between the two cultivars. In increasing photosynthesis products that affected this trait. These results are consistent with (4) and (8). As for the use of humic acid, it was found that the spraying with 4 ml.L^{-1}, which reached the highest average of 19.6478 mg. 100 g $^{-1}$ Fresh weight, was significantly excelled to other treatments, and the reason for this was due to the containment. Humic acid on the important nutrients that may affect this trait. These results are in line with (10) and (13).As for spraying with chelated iron, it was found that spraying at a concentration of 3 g.L^{-1} was significantly excelled in all treatments, as it achieved the highest average (19.7758 mg. 100 g $^{-1}$ Fresh weight).As for the bi-interaction between the cultivar and the

 ISSN 2072-3875

humic acid in the trait of the juice content of vitamin C, it was found that spraying with 2 ml.L^{-1} of humic acid on the cultivar Ruby Gem, which reached (20.9867 mg. 100 g $^{-1}$ Fresh weight) was significantly excelled on the other interactions. ,The interaction of the cultivar with chelated iron showed that the control treatment of both cultivars, as well as the spraying with 1.5ml.L^{-1} on the cultivar Ruby Gem, was significantly excelled on the other treatments and that the interaction between humic acid and chelated iron showed that the interaction of the spraying was 4 ml.L^{-1} of humic acid with 3 g. L^{-1} of chelated iron significantly excelled on the rest of the treatments, reaching (21.5852 mg. 100 gm-1 soft weight). As for the triple interference between the studied factors, it was found that the highest average (21.8370 mg. 100 g $^{-1}$ Fresh weight) was when using the spraying with 4 ml. L^{-1} of humic acid with 3 g. L^{-1} of chelated iron in the cultivar Albion, It may be significantly excelled to other treatments.

Table (5): The effect of spraying with humic acid and chelating iron and the interaction between them on the fruit content of vitamin C (mg. 100 g fresh weight) for two strawberry cultivars Ruby Gem and Albion.

interaction cultivars * Humic acid	Chelated iron concentration (ml.L^{-1})			Humic Acid Concentrations (ml.L^{-1})	cultivars
	3 ml.L^{-1}	1.5 ml.L^{-1}	0 ml.L^{-1}		
16.5848 c	16.4877 f	21.2667 ab	12.0000 g	0 ml.L^{-1}	Ruby Gem
20.9867 a	21.3033 ab	20.7567 abc	20.9000 abc	2 ml.L^{-1}	
18.8022 b	21.3333 ab	17.3700 ef	17.7033 ef	4 ml.L^{-1}	
16.6959 c	19.8667 bcd	18.5867 de	11.6333 g	0 ml.L^{-1}	Albion
18.3089 b	17.8267 ef	19.6633 cd	17.4367 ef	2 ml.L^{-1}	
18.9579 b	21.8370 a	16.4533 f	18.5833 de	4 ml.L^{-1}	
The effect of cultivars					
18.7912 a	19.7081 a	19.7978 a	16.8678 c	Ruby Gem	interaction cultivars *Chelated iron
17.9874 b	19.8434 a	18.2344 b	15.8844 d	Albion	
The effect of Humic Acid Concentrations (ml.L^{-1})					
16.6402 c	18.1772 c	19.9267 b	11.8167 e	0 ml.L^{-1}	Interaction Humic acid * chelated iron
19.6478 a	19.5650 b	20.2100 b	19.1683 bc	2 ml.L^{-1}	
18.8801 b	21.5852 a	16.9117 d	18.1433 c	4 ml.L^{-1}	
	197758 a	19.0161 b	16.3761 c	Effect of chelated iron (ml.L-1(	

ISSN 2072-3875

6- Total Soluble Solids percentage (TSS) .

It was found from the results of the statistical analysis in Table (6) that the Albion cultivar differed significantly in the percentage of Total Soluble Solids (TSS), it reached (8.6704%) and surpassed Ruby Gem cultivar in the percentage of Total Soluble Solids (TSS). To the genetic nature between them and that the use of 4 ml.L^{-1} of humic acid gave the highest average (8.6778%), where it significantly excelled the control treatment, and with regard to the use of chelated iron, it was found that spraying with both concentrations (1.5 and 3 g.L^{-1}) was significantly excelled to control treatment. The bi-interaction between the cultivar and humic acid in the percentage of Total Soluble Solids (TSS) showed that spraying with 4 ml.L^{-1} of humic acid on the cultivar Albion reached (9.0778%), where it was significantly excelled on the other treatments. The interaction of the cultivar with chelated iron showed that spraying the cultivar Albion with 3 g.L^{-1} of chelated iron was excelled on the other treatments, where it reached the highest average (9.0500%), and for the bi-interaction between humic acid and chelated iron in the percentage of Total Soluble Solids(TSS), It was found that all the interaction excelled on the control treatment for both factors. The results of the triple interaction in the same table showed that the interaction of 4 ml.L^{-1} of humic acid and 3 g.L^{-1} of chelated iron in the Albion cultivar reached the highest percentage (9.500%), which significantly excelled on the control treatment for humic acid. The chelated iron in the cultivar Ruby Gem.

.

7- The percentage of total acidity (TA).

It was found from the results in Table (7) that the cultivar had no significant effect on the percentage of total acidity (TA).As for the use of humic acid, it was found that a control treatment recorded the highest acidity percentage (0.96950%) compared to other treatments. The results are consistent with (6) and (14).As for the use of chelated iron, it was found that the control treatment gave the highest acidity percentage (0.99575%) compared to other treatments. The excelled of this treatment is due to its excelled in other treatments, which positively affected the trait. The results of the statistical analysis of the same table showed that the interaction of the cultivar with humic acid had no significant effect on the total acidity percentage, as for the interaction of the cultivar with chelated iron, it was found that the control treatment in the Albion cultivar had the highest acidity (1.01722%) compared to With other interactions, as for the interaction of spraying with humic acid with chelated iron, it was found that the control treatment for humic acid and chelated iron was excelled on the other treatments as it gave the highest pH (1.15408%).The results of the triple interaction of study factors showed that the interaction of the control treatment for humic acid and chelated iron in the Albion cultivar had the highest acidity percentage(1.19067%), which significantly excelled on the other treatments.

 ISSN 2072-3875

Table (6): The effect of spraying with humic acid and chelating iron and the interaction between them on the percentage of total Soluble Solids (TSS) for two strawberry cultivars Ruby Gem and Albion.

interaction cultivars * Humic acid	Chelated iron concentration (ml.L^{-1})			Humic Acid Concentrations (ml.L^{-1})	cultivars
	3 ml.L^{-1}	1.5 ml.L^{-1}	0 ml.L^{-1}		
8.3667 b	87500 abc	9.2500 ab	7.1000 e	0 ml.L^{-1}	Ruby Gem
8.4444 b	8.8333 abc	8.5000 bc	8.0000 cd	2 ml.L^{-1}	
8.2778 b	8.0000 cd	8.5000 bc	8.3333 bc	4 ml.L^{-1}	
8.33000 b	9.1500 ab	8.5000 bc	7.2500 de	0 ml.L^{-1}	Albion
8.6333 ab	8.5000 bc	8.6500 abc	8.7500 abc	2 ml.L^{-1}	
9.0778 a	9.5000 a	8.5000 bc	9.2333 ab	4 ml.L^{-1}	
The effect of cultivars					
8.3630 b	8.5278 b	8.7500 ab	7.8111 c	Ruby Gem	interaction cultivars *Chelated iron
8.6704 a	9.0500 a	8.5500 b	8.4111 b	Albion	
The effect of Humic Acid Concentrations (ml.L^{-1})					
8.3333 b	8.9500 a	8.8750 a	7.1750 b	0 ml.L^{-1}	Interaction Humic acid * chelated iron
8.5389 ab	8.6667 a	8.5750 a	8.3750 a	2 ml.L^{-1}	
8.6778 a	8.7500 a	8.5000 a	8.7833 a	4 ml.L^{-1}	
	8.7889 a	8.6500 a	8.1111 b	Effect of chelated iron (ml.L-1(	

ISSN 2072-3875

Table (7): The effect of spraying with humic acid and chelating iron and the interaction between them on the percentage of total acidity (TA)for two strawberry cultivars Ruby Gem and Albion.

interaction cultivars * Humic acid	Chelated iron concentration ($ml.L^{-1}$)			Humic Acid Concentrations ($ml.L^{-1}$)	cultivars
	3 $ml.L^{-1}$	1.5 $ml.L^{-1}$	0 $ml.L^{-1}$		
0.97100 a	0.97700 bc	0.81850 cd	1.11750 ab	0 $ml.L^{-1}$	Ruby Gem
0.91644 a	0.97500 bc	0.88867 cd	0.88567 cd	2 $ml.L^{-1}$	
0.89056 a	0.82600 cd	0.92600cd	0.91967 cd	4 $ml.L^{-1}$	
0.96800 a	0.92333 cd	0.79000 d	1.19067 a	0 $ml.L^{-1}$	Albion
0.877611 a	0.82350 cd	0.88100 cd	0.92833 cd	2 $ml.L^{-1}$	
0.90211 a	0.90767 cd	0.86600 cd	0.93267 cd	4 $ml.L^{-1}$	
The effect of cultivars					
0.92600 a	0.92600 bc	0.87772 c	0.97428 ab	Ruby Gem	interaction cultivars *Chelated iron
0.91591 a	0.88483 c	0.84567 c	1.01722 a	Albion	
The effect of Humic Acid Concentrations ($ml.L^{-1}$)					
0.96950 a	0.95017 b	0.80425 c	1.15408 a	0 $ml.L^{-1}$	Interaction Humic acid * chelated iron
0.89703 b	0.89925 bc	0.88483 bc	0.90700 bc	2 $ml.L^{-1}$	
0.89633 b	0.86683 bc	0.89600 bc	0.92617 b	4 $ml.L^{-1}$	
	0.90542 b	0.86169 b	0.99575 a	Effect of chelated iron (ml.L-1(	

8- Total Soluble Solids / total acidity percentage (TSS / TA).

The results of the statistical analysis in Table (8) confirm that the Albion cultivar was significantly excelled in the percentage of total Soluble Solids / total acidity TSS / TA, which amounted to (4.79314%) compared to the cultivar Ruby Gem, and the reason for this may be due to the difference in the two cultivars. Photosynthesis products, particularly TSS / TA. These results are consistent with (5) and (12).The use of humic acid had no significant effect on the TSS / TA percentage, and the use of two concentrations (1.5 and 3) $g.L^{-1}$ of chelated iron was excelled on the control treatment. As for the bi-interaction between the cultivar and the humic acid, it was found that the use of spraying with a concentration of 4 $ml.L^{-1}$ of humic acid on the cultivar Albion significantly excelled on the other treatments, where it reached the highest average (4.9899%). The interaction of the cultivar with chelated iron was found to have a significant effect on the TSS / TA ratio, where it reached the highest percentage (4.9674%) when spraying the

 ISSN 2072-3875

cultivar Albion with 3 g. L^{-1} of chelated iron compared to other treatments, and for the interaction of spraying with humic acid and chelated iron All interaction were excelled on the control treatment. The triple interaction in Table (8) that the study factors showed a significant effect on the percentage of TSS / TA, as the interaction of spraying with 4 $ml.L^{-1}$ of humic acid with 3 $g.L^{-1}$ of chelated iron in the cultivar Albion recorded the highest percentage (5.2038 %) Compared to the lowest percentage when compared to Ruby Gem cultivar , which was (4.1088%).

Table (8): The effect of spraying with humic acid and chelating iron and the interaction between them on the percentage of Soluble Solids / total acidity percentage (TSS / TA) for two strawberry cultivars Ruby Gem and Albion.

interaction cultivars * Humic acid	Chelated iron concentration ($ml.L^{-1}$)			Humic Acid Concentrations ($ml.L^{-1}$)	cultivars
	3 $ml.L^{-1}$	1.5 $ml.L^{-1}$	0 $ml.L^{-1}$		
4.6688 b	4.8635 abcd	5.0343 ab	4.1088 f	0 $ml.L^{-1}$	Ruby Gem
4.6804 b	4.9042 abc	4.6943 bcd	4.4428 cdef	2 $ml.L^{-1}$	
4.5842 b	4.4130 def	4.7130 bcd	4.6265 bcde	4 $ml.L^{-1}$	
4.6340 b	5.0367 ab	4.6450 bcde	4.2203 ef	0 $ml.L^{-1}$	Albion
4.7555 b	4.6618 bcde	4.7655 abcd	4.8392 abcd	2 $ml.L^{-1}$	
4.9899 a	5.2038 a	4.6830 bcd	5.0830 ab	4 $ml.L^{-1}$	
The effect of cultivars					
4.64448 b	4.7269 b	4.8139 ab	4.3927 c	Ruby Gem	interaction cultivars *Chelated iron
4.79314 a	4.9674 a	4.6978 b	4.7142 b	Albion	
The effect of Humic Acid Concentrations ($ml.L^{-1}$)					
4.65142 a	4.9501 a	4.8396 a	4.1645 b	0 $ml.L^{-1}$	Interaction Humic acid * chelated iron
4.71796 a	4.7830 a	4.7299 a	4.6410 a	2 $ml.L^{-1}$	
4.78706 a	4.8084 a	4.6980 a	4.8548 a	4 $ml.L^{-1}$	
	4.84715 a	4.75585 a	4.55343 b	Effect of chelated iron (ml.L-1(	

ISSN 2072-3875

9-The fruit content of anthocyanin pigment(mg. 100 g $^{-1}$ fresh weight).

The results of the statistical analysis in Table (9) confirm that the fruits of the Albion cultivar were significantly excelled in the fruit content of anthocyanins, which reached (23.2289 mg. 100 g $^{-1}$ fresh weight) on the cultivar Ruby Gem, As for the use of humic acid, it was found that the spraying with two concentrations (2 and 4) ml.L^{-1} was excelled on the control treatment, and for the use of chelated iron, it was found that spraying with 1.5 g. L^{-1} gave the highest average (24.0017 mg. 100 g $^{-1}$ fresh weight) which excelled on other treatments . The reason for this is that humic acid contains nutrients such as zinc and boron, activates growth regulators within plants such as IAA, regulates maturation processes, raises the quality of the fruit, and regulates cellular content of auxins and phenols. These results are in line with (9) and (15). As for the bi-interaction with the humic acid of the same table, it was found that spraying with two concentrations (2 and 4) mlL^{-1} of Humic acid on the cultivar Albion was significantly excelled on the control treatment in the cultivar Ruby Gem.The bi-interaction between the cultivar and the chelating iron showed that the spraying with a concentration of 1.5 g. L^{-1} of chelated iron for the two cultivars and 3 g. L^{-1} of the cultivar Albion was significantly excelled on the other treatments, and for the bilateral interaction between humic acid and chelated iron, it was found that the interaction of 4 mlL^{-1} of humic acid and 0 g.L $^{-1}$ of chelated iron and the non-spraying interaction of humic acid with 1.5 g.L $^{-1}$ of chelated iron excelled on the other interactions.The reason for this is due to the role of iron in the contribution of vital processes in the plant because it is a stimulant for the enzymes of the process of respiration and the transfer of electrons. Increasing the leaf area and dry matter and thus led to an increase in carbohydrates, which led to an increase in these components. These results are in line with (8) and (10).The triple interaction between the cultivar, humic acid and chelated iron contributed to a significant increase when the control treatment of humic acid and spraying with the second concentration of 1.5 g.L $^{-1}$ of chelated iron in the cultivar Ruby Gem achieved an increase of (25.700 mg. 100 g $^{-1}$ fresh weight).Which was distinguished from the rest of the treatments.

Conclusions and recommendations:

Conclusions:

1. Albion cultivar was significantly excelled in most vegetative trait on Ruby Gem cultivar.

2. The excelled of spraying with both concentrations 2 and 4 ml.L^{-1} of humic acid resulted in improved quantity and quality compared to the control treatment.

3. The spraying of both concentrations of 1.5 and 3 g.L^{-1} of chelated iron had a significant effect on the quantitative and qualitative traits of strawberry seedlings, as compared to the control treatment.

4- That the interaction between the cultivar and humic, as well as between the cultivar and the iron, as well as between humic and chelated iron, as well as the triple interference between the cultivar , humic acid and chelated iron, had a significant effect on increasing the quantity and quality of the yield.

Recommendations:

1. Using other concentrations of humic acid and chelating iron, and knowing its effect on different strawberry cultivar.

2. We recommend that you do not use a concentration less than 1.5 g.L^{-1} of chelated iron.

3. We recommend that you pay attention to the cultivation of strawberries in Kirkuk in

 ISSN 2072-3875

greenhouses or lath house , especially the Albion cultivar , because its production and growth are good.

4. Conducting research on other special permanent-bearing cultivars to provide the market with strawberry fruits for a longer period.

Table (9): The effect of spraying with humic acid and chelating iron and the interaction between them on the fruit content of anthocyanin pigment (mg. 100 g $^{-1}$ fresh weight) for two strawberry cultivars Ruby Gem and Albion.

interaction cultivars * Humic acid	Chelated iron concentration (ml.L^{-1})			Humic Acid Concentrations (ml.L^{-1})	cultivars
	3 ml.L^{-1}	1.5 ml.L^{-1}	0 ml.L^{-1}		
20.1833 c	18.500 de	25.700 a	16.350 f	0 ml.L^{-1}	Ruby Gem
22.5667 bc	21.900 cd	22.350 bcd	24.700 abc	2 ml.L^{-1}	
22.5667 ab	19.950 de	22.750 abcd	25.000 ab	4 ml.L^{-1}	
21.5367 bc	22.900 abcd	25.410 ab	16.300 f	0 ml.L^{-1}	Albion
23.9667 a	23.850 abc	25.250 ab	22.800 abcd	2 ml.L^{-1}	
24.1833 a	24.800 abc	22.550 bcd	25.200 ab	4 ml.L^{-1}	
The effect of cultivars					
21.9111 b	20.1167 c	23.6000 a	22.0167 b	Ruby Gem	interaction cultivars *Chelated iron
23.2289 a	23.8500 a	24.4033 a	21.4333 bc	Albion	
The effect of Humic Acid Concentrations (ml.L^{-1})					
20.8600 b	20.7000 c	25.5550 a	16.3250 d	0 ml.L^{-1}	Interaction Humic acid * chelated iron
23.4750 a	22.8750 b	23.8000 ab	23.7500 ab	2 ml.L^{-1}	
23.3750 a	22.3750 bc	22.3750 bc	25.1000 a	4 ml.L^{-1}	
	21.9833 b	24.0017 a	21.7250 b	Effect of chelated iron (ml.L-1(	

ISSN 2072-3875

References

1-Jundia, Hassan (2003). Physiology of fruit trees. Arab House for Publishing and Distribution. The Egyptian Arabic Republic.

2- Al-Saidi, Ibrahim (2000). Production of small fruits. House of Books and Publishing. University of Mosul, Iraq.

3- Al-Shalt, Omar Mahmoud (2006). Symptoms of deficiency and toxicity of nutrients in vegetables and fruits. Informational leaflet. Damascus Chamber of Agriculture. Syria.

4- Siddiq, Essam Abdel Sattar, Muzaffar Ahmad Daoud and Muhammad Ali Jamal (1995). Distribution of ready-made microelements in some limestone soils in northern Iraq, the fifth symposium of micro-nutrients: 23-30 MP.

5- Al-Mawsili, Muzaffar Ahmad (2011). Soil fertility and horticultural plant nutrition. Ibn Al-Atheer House for Printing and Publishing. University of Al Mosul. Iraq.

6-Cagler, H. and S. Paydas (2005). Changes of quality characteristics and aroma compound of hybrids and strawberry cultivars during harvest period. Acta .Hort. 567(1): 203-206.

7-El-Kosary, S:, I. E. El-Shenawy and S. I. Radwan (2011). Effect of microelements, amino and humic acid on growth, flowering and fruiting of some mango cultivars. J. Hort. Sci.& Ornamental plants 3(2):152-161 .

8-FAO. (2017). Food and Agriculture Organi Zation The Vnited nation. Web site FAO.org http://www.FAO.org.

9-Fathy ,M.A.,Gaber and S.A. El-Shall . (2010) . Effect of humic acid treatment on ″Canino ″ apricot growth ,yield and fruit quality .*New York Science Journal* ;3(12):109-115

10-Fawzi, M. I. F.; Shahin.; F.M. Daood and E.A. Kandil(2010).Effect of organic and biofertilizers E.A and Magneium sulphate on growth yield chemical composition and fruit auality of Le-Conte pear trees, Nature and Sci., 8(12):273-280.

11-Garden strawberry. (2007). From wikipedia, the free encyclopedia

12-Kazemi, M. (2014). Influence of foliar application of iron, calcium and zinc sulfate on vegetative growth and reproductive characteristics of strawberry cv. 'PAJARO´ Trakia Journal of Sciences, No 1, pp 21-26, 2014.

13-Kikas, A. and Libek, A. (2005)."Influence of Temperature Sums on Hort. Sci.70 (2), pp. 85–88.

14-ÖNAL , K . (2001) . Investigations on the performance of some Strawberry cultivars (*Fragaria x ananassa* Duch) . Grown in open fields and under high tunnel conditions . Turk . Jour. Agri . 24 : 31 – 36 .

15-Serenella, S. N., D. Pizzeghelloa, A. Muscolob, and A. Vianello. , A.; D. B. Singh ; R. K. Sharma . and U. Iqbal . (2002) . Comparative evaluation of strawberry (*Fragaria x ananassa* Duch.,) cultivars under Allahabad condition . The Asian Journal of Horticulture, 4 (1) :178-180

16-Virginie , P.(2010).Variability of health and taste promoting compounds in strawberry (*Fragaria x ananassa* Du

 ISSN 2072-3875