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B- EVALUATION THE STORAGE ABILITY OF TWO TOMATO HYBRIDS FRUITS (*Lycopersicon esculentum* Mill) GROWN UNDER GREENHOUSE CONDITION IN RESPONSE TO HUMIC ACID

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ABSTRACT

The study was conducted to undertake the response of two tomato hybrids (Royal and Sandra), to humic acid at level (0, 0.4, 0.8 and 1.6) g.L^{-1} during storage time on the postharvest quality of tomato fruits. Plants were grown at vegetable research field, Department of Horticulture, College of Agriculture, University of Dohuk, Kurdistan during the growing season of 2015-2016, in plastic house. Fruits of the two hybrids were harvested manually in the early morning at the maturity stage of fruit growth.

We did not observed a clear difference between the two hybrids in fruits quality characteristics. While, when plant of tomato hybrids treated with humic acid cuased significantly increase in V.C., total acidity, N%, K%, and P% of fruit. In addition, when storage period of fruits was advanced from 7to 14 days, a significant increase was observed in total soluble solids of fruits, on the contrary recorded a significant decreased with progressing time of fruit storage in acidity, vitamin C, N% and K%. The interaction effect of the three factors under study on the quality of fruits showed a difference behavior depending on the response of studied features.

KEY WORD; Tomato hybrid, Humic acid and storage period
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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is a member of the Solanaceae family. It considered a major vegetable crop in many parts of the world for its economic importance and the possibility of being processed and stored. The common garden tomato is botanically classified as a fruit. Actually, it is a berry, but many people think of it a vegetable. The flavor and texture characteristics of tomatoes depend on the variety, growing method, local environment, and handling techniques used during and after harvest. By the time a tomato reaches about 20 percent of full-ripe color, it has reached its full balance of sweetness and acidity potential **(Parnell *et al.*, 2004)**.

On other word, tomato fruits are climacteric so fruits often harvested at the mature green stage to minimize the damage during postharvest handling. The fruits of tomato may later ripen spontaneously **(Wills, and Ku, 2002)**. Tomatoes are highly perishable, thus have an inherently short shelf life and harvesting before the climacteric rise considered as the best strategy to prolong its shelf life and reduce the spoilage rate, losses often occurred from excessive deterioration during holding and marketing of tomatoes **(Saltveit, (2003).**

Fresh fruit and vegetables are very important sources of vitamins that are essential for healthy human diet. The quality and nutritional status of fresh produce is affected by postharvest handling and storage conditions. This includes changes in vitamin content, loss of volatile aroma components and texture properties. Tomato fruits contain significant amounts of vitamin C and lycopene. Vitamin C is an oxidant, which reduces the risk of arteriosclerosis, cardiovascular diseases and some form of cancer **(Harris, 1996)**.Vitamins like other biochemical compounds are vulnerable to change and depletion, particularly after harvest, so postharvest conditions need to be maintained the vitamin quality. Several factors, which contribute to the loss of these compounds in fresh produce, include extended storage, higher temperatures, low relative humidity, physical

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damage and chilling injury **(Lee, and Kader, 2000).**

Humic and Fulvic acids are the final breakdown constituents of the natural decay of plant and animal materials. These organic acids are found in pre-historic deposits. Humic matter is formed through the chemical and biological humification of plant and animal matter and through the biological activities of microorganisms. Humic acids are complex molecules that exist naturally in soils, peats, oceans and fresh waters. The one source of humic acids is the sedimentation layers referred to as Leonardite. These layers were originally deep in the earth's crust, but over many years have been exhumed to near-surface location. Humic acids are found in high concentration in these layers. Leonardite is organic matter, which has not reached the state of coal and differs from soft brown coal by its high oxidation degree, a result of the process of coal formation, and has no value as fuel (**Mac Carthy *et al*., 1999).** Humic acid is a commercial product, which contains many elements, which improve the soil fertility and increase the availability of nutrient elements and consequently increased plant growth and yield. Humic acid particularly is used to ameliorate or reduce the negative effect of chemical fertilizers and some soil chemicals. Many investigators have reported that, humic acid application led to a significant increase in soil organic matter improving plant growth and crop production **(AL-Desuki, 2004).** Organic fertilizers which include humic materials are one of the natural amendments which applied to increase the rate of organic matter in soil associated with improving the physical, chemical and biological properties of the soil and consequently improve plant growth and developments **(Nardi *et al*., 1999)**.

Atiyeh *et al*. (2002) carried out two experiments to evaluate the effect of humic acid on tomato and cucumber growth. Their results showed that the growth of tomato and cucumber plants increased significantly, in terms of plant heights, leaf areas, shoot and root dry weights.

Wang *et al.* (1995) reported that addition of humic acids to soil with P fertilizer significantly increased the amount of water-soluble phosphate, strongly retarded the formation of occluded phosphate and increased P uptake and yield by 25 %.

Türkmen *et al*. (2004) conducted a study on tomato using four concentrations of humic acid (0, 500, 1000 and 2000) mg/kg of soil. They found that the foliage content of (Zn, Mn, Fe, Ca, Mg, K, P, and N) was significantly increased. They also found that the humic acid sprays enhance plant growth and nutrient absorption.

Rickman, (2007) shows that refrigeration cause slows down the respiration of fruits and vegetables and allows for longer shelf lives. **Mohsen, (2014)** the results showed that humic acid (30ppm) and calcium chloride (15 mM) spray either alone or in combination (30 ppm HA+15 mM Ca) improved the quality of tomato fruits by increasing humic acid Which recorded the maximum TSS, vitamin C, nitrate reductase activity, fruit firmness, fruit lycopene content and the lowest blossom end rot incidence.

One of the major problems is what happens to the nutritional quality parameters of the fresh produce during the period of storage. These help to know how long the fresh crops can be stored without losing in its quality. Therefore, the objective the present study was to assess how foliar spraying of humic acid in different concentration and varies storage period either alone or in combination on fruit quality characteristics.

MATERIAL AND METHODS

This study was conducted at vegetable research field, Department of Horticulture, College of Agriculture, University of Dohuk, Kurdistan during the growing season of 2015-2016, in plastic house. Tomato seeds of both hybrids (Royal and Sandra) were planted in 23 December 2015 in the glasshouse. All cultural practices were conducted for the field during the study season. The humic acid was sprayed on the vegetative growth, four times. The first one was at fruit set, and it was repeated every15days between spray at three first fruit clusters colored. Also, Tween-80 as surfactant agent was annex to all solutions at 0.01%.

The study was conducted to determine the effect of humic acid at (0, 0.4, 0.8 and 1.6) $g.L^{-1}$, on the storage ability of the two hybrids Royal and Sandra fruits. Fruits of the two hybrids were harvested manually in the early morning at the late maturity stage of fruit growth. The infected fruits were excluded and homogeneous fruits

were selected in weight, size and color, after that the fruits were divided according to the studied factors and packed in polythene bags perforated and then stored in refrigerated house under appropriate conditions to store the fruits of the tomato.

The treatments were randomly arranged in a factorial experiment in a Randomized Complete Block design (RCBD). The experimental include 3 factors (2 tomato hybrid * 3 storage period * 4 Humic acid) with three replicates, each replicate content 8 fruit for each time of storage.

The results were analyzed using the **SAS, 2007** program. Means value was compared using Duncan's multiple range tests at 0.05 or 5% level **(AL-Rawi and Khalaf Alah, 2000).**

The measurement was taken at the end of each storage period.

1. Total soluble solids (TSS %); were determined with a hand Refractmeter.
2. Titratable acidity it was determined by titration of fruit juice according to **Srivastava and Kumar, (1993)**.
3. Vitamin C (mg $100ml^{-1}$ juice) determined by titration depending to (Ranganna, 1977).
4. Nitrogen (%): it was determined by the method **(Rowell, 1996)**.
5. Phosphorus (%): it was determined using Spectrophotometer Pharmacia LKB. **(Ranganna, 1977).**
6. Potassium(%):determined according to **Bhargave and Raghupathi, (1999).**

RESULT AND DISCUSSION

The obtained results of table (1) revealed that there was no significant difference between the two hybrids Royal and Sandra in fruit TSS. Moreover, significant differences were not detected in TSS between the humic acid concentration and check fruits. However, when the storage period advanced the TSS of fruits lowered significantly. It could be considered from the combination among the three factors under study that the treatment Royal, 14 or 21days storage with 0.8 or 0.4 humic acid and sandra, 7days storage treated with 0.8 humic acid gave higher TSS of fruit, but the lower TSS recorded with fruits treated with Royal, 7 days and 0.4 humic acid.

Table (1): influence of Humic acid and storage and their interaction on fruit TSS% of two tomato hybrids.

tomato Hybrids	Storage period (days)	Humic acid ($g.L^{-1}$)				hybrids * Storage period	Mean of hybrids
		0	0.4	0.8	1.8		
Royal	7	3.633 ab	3.200 bc	2.600 c	4.100 ab	3.383 b	3.828 a
	14	3.400 a-c	4.067 ab	4.200 a	3.867 ab	3.883 a	
	21	4.300 a	4.200 a	4.067 ab	4.300 a	4.217 a	
Sandra	7	3.733 ab	3.833 ab	3.767 ab	4.200 a	3.883 a	3.969 a
	14	3.767 ab	4.133 ab	4.067 ab	3.800 ab	3.942 a	
	21	4.267 a	4.133 ab	4.133 ab	3.800 ab	4.083 a	
Humic		3.850 a	3.928 a	3.806 a	4.011 a	**Means of Storage**	
Hybrids *	Royal	3.778 a	3.822 a	3.622 a	4.089 a		

humic	Sandra	3.922 a	4.033 a	3.989 a	3.933 a	
Storage period	7	3.683 a-c	3.517 bc	3.183 c	4.150 ab	3.633 b
*	14	3.583 bc	4.100 ab	4.133 ab	3.833 ab	3.913 a
humic	21	4.283 a	4.167 ab	4.100 ab	4.050 ab	4.150 a

Means within a column, row and their interaction followed with the same letters are not significantly differ from each other's according Duncan multiple range test at 5%level.

Hybrid Royal showed significantly the highest vitamin C as compared to hybrid sandra table (2). However, they displayed significant vitamin C reductions when the storage period increased to 21 days storage. The average of fruit vitamin C not affected significantly by foliar spray of different concentration of humic acid. Hybrid Royal treated with 0.8 humic acid and stored for 14 days recorded the higher level of vitamin C, but the lower level of vitamin C showed in combination of hybrid Sandra, 21 or 14days storage and untreated fruits.

Table (2): influence of Humic acid and storage and their interaction on fruit vitamin C of two tomato hybrids.

tomato Hybrids	**Storage period (days)**	**Humic acid (g.L^{-1})**				**hybrids * Storage period**	**Mean of hybrids**
		0	0.4	0.8	1.8		
Royal	7	5.300 a-c	4.367 c-g	4.233 e-g	5.367 ab	4.817 a	4.722 a
	14	4.500 b-g	4.133 e-g	5.800 a	4.367 c-g	4.700 a	
	21	4.400 c-g	4.733 b-g	5.067 b-e	4.400 c-g	4.650 a	
Sandra	7	4.533 b-g	4.633 b-h	4.800 b-f	5.267 b-d	4.808 a	4.325 b
	14	3.767 h	4.267 e-g	4.133 e-g	4.333 d-g	4.125 b	
	21	3.667 h	4.200 e-g	4.067 f-g	4.233 e-g	4.042 b	
Humic		4.361 a	4.389 a	4.683 a	4.661 a	**Means of Storage**	
Hybrids *	Royal	4.733 ab	4.411 bc	5.033 a	4.711 ab		
humic	Sandra	3.989 c	4.367 bc	4.333 bc	4.611 ab		
Storage period	7	4.917 ab	4.500 bc	4.517 bc	5.317 a	4.813 a	
*	14	4.133 c	4.200 c	4.967 ab	4.350 bc	4.413 b	
humic	21	4.033 c	4.467 bc	4.567 bc	4.317 bc	4.346 b	

Means within a column, row and their interaction followed with the same letters are not significantly differ from each other's according Duncan multiple range test at 5%level.

Data in table (3) manifested that Royal hybrid did not differ significantly in the acidity of fruits with Sandra. When storage period increased from 7, 14 to 21 days caused significantly decrease in total acid as compared to 7 days, on other hand there were no significant deference between 7 and 14-days storage or 14 and 21 days. The higher total acid showed in fruits untreated fruits with humic acid and the lowest total acid was in fruits treated with 1.8 humic acid. Also, the data showed that the maximum total acid showed from the interaction among Sandra hybrid, 21days storage and 0.4 humic acid. While the minimum total acid of fruit appeared in the Royal hybrid, 7days storage and 0 humic acid.

Table (3): influence of Humic acid and storage and their interaction on fruit Total acid % of two tomato hybrids.

tomato Hybrids	**Storage period (days)**	**Humic acid (g.L^{-1})**				**hybrids * Storage period**	**Mean of hybrids**
		0	0.4	0.8	1.6		
Royal	7	5.233 ab	3.833 c	3.600 c	3.567 c	4.058 b	4.456 a
	14	4.667 bc	4.600 bc	4.367 bc	3.867 c	4.375 ab	
	21	5.400 ab	5.133 ab	4.733 bc	4.467 bc	4.933 a	
Sandra	7	5.433 ab	4.400 bc	4.333 bc	4.733 bc	4.725 a	4.719 a
	14	4.633 bc	4.533 bc	5.167 ab	4.433 bc	4.692 a	
	21	4.233 bc	6.067 a	4.433 bc	4.233 bc	4.742 a	
Humic		4.933 a	4.761 ab	4.439 bc	4.217 c	**Means of Storage**	
Hybrids *	Royal	5.100 a	4.522 a-c	4.233 bc	3.967 c		
humic	Sandra	4.767 ab	5.000 a	4.644 ab	4.467 a-c		
Storage period	7	5.333 ab	4.117 cd	3.967 d	4.150 cd	5.421 a	
*	14	4.650 b-d	4.567 b-d	4.767 b-d	4.150 cd	4.533 ab	
humic	21	4.817 bc	5.600 a	4.583 b-d	4.350 cd	4. 383 b	

Means within a column, row and their interaction followed with the same letters are not significantly differ from each other's according Duncan multiple range test at 5%level.

Table (4) cleared that there was no significant deference in N% between fruit of both hybrid Royal and Sandra. Storage period have a significant effect on N% of fruit, so when storage period advanced from 7 to21 days the N% reduced. N% positively increased as a response to different level of humic acid in cooperation to untreated fruits, it was worth mentioning that there was no significant various between humic acid level. Depending to the

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interaction among hybrids, storage period and humic acid, we can report that the highest N% recorded among Royal hybrid, 21days storage and 0.4 humic acid. In addition, the lowest N% appeared from the same hybrid and storage period but untreated fruits.

Table (4): influence of Humic acid and storage and their interaction on fruit N % of two tomato hybrids.

tomato Hybrids	Storage period (days)	Humic acid ($g.L^{-1}$)				hybrids * Storage period	Mean of hybrids
		0	0.4	0.8	1.6		
Royal	7	0.567 b-d	0.567 b-d	0.667 b	0.700 b	0.625 ab	0.594 a
	14	0.433 ed	0.567 b-d	0.600 b-d	0.600 b-d	0.550 b	
	21	0.400 e	0.967 a	0.467 c-e	0.600 b-d	0.608 ab	
Sandra	7	0.600 b-d	0.633 bc	0.667 b	0.700 b	0.650 a	0.606 a
	14	0.467 c-e	0.567 b-d	0.700 b	0.667 b	0.600 ab	
	21	0.467 c-e	0.567 b-d	0.600 b-d	0.633 bc	0.567 b	
Humic		0.489 b	0.644 a	0.617 a	0.650 a	**Means of Storage**	
Hybrids * humic	Royal	0.467 d	0.700 a	0.578 bc	0.633 ab		
	Sandra	0.511 cd	0.589 bc	0.656 ab	0.667 ab		
Storage period * humic	7	0.583 cd	0.600 b-d	0.667 a-c	0.700 ab	0.638 a	
	14	0.450 e	0.567 cd	0.650 bc	0.633 b-d	0.575 b	
	21	0.433 e	0.767 a	0.533 ed	0.617 b-d	0.588 b	

Means within a column, row and their interaction followed with the same letters are not significantly differ from each other's according Duncan multiple range test at 5%level.

From the table (5) the data cleared that the Sandra hybrid surpasses to the Royal hybrid in K% of fruit. It was found significant reduced in K% with the advancement of storage period. It estimated that K% content of fruit was increased significantly with foliar application with varied concentration of humic acid. The interaction among the all factors under study recorded variation Significant in K% as response of fruits to these factors. So, the highest K% observed in Sandra hybrid, 7days storage and 0.8 or 1.8 humic acid. While the lowest K% founded in Royal hybrid, 21days storage and untreated fruits.

Table (5): influence of Humic acid and storage and their interaction on fruit K% of two tomato hybrids.

tomato Hybrids	Storage period (days)	Humic acid ($g.L^{-1}$)				hybrids	Mean of hybrids
		0	0.4	0.8	1.6	*	
						Storage period	
Royal	7	10.000 e-g	10.333 d-g	11.333 b-g	14.000 ab	11.417 b	10.889 b
	14	9.667 fg	10.000 e-g	11.000 c-g	12.333 a-f	10.750 b	
	21	9.000 g	10.000 e-g	11.000 c-g	12.000 a-f	10.500 b	
Sandra	7	13.000 a-d	13.333 a-c	14.667 a	14.667 a	13.917 a	13.278 a
	14	12.667 a-e	13.333 a-c	13.000 a-d	13.667 a-c	13.167 a	
	21	11.333 b-g	12.333 a-f	13.333 a-c	14.000 ab	12.750 a	
Humic		10.944 c	11.556 bc	12.389 b	13.444 a	**Means of Storage**	
Hybrids *	Royal	9.556 e	10.111 de	11.111 cd	12.778 ab		
humic	Sandra	12.333 bc	13.000 ab	13.667 ab	14.111 a		
Storage period	7	11.500 bc	11.833 bc	13.000 ab	14.333 a	12.667 a	
*	14	11.167 bc	11.667 bc	12.000 bc	13.000 ab	11.958 ab	
humic	21	10.167 c	11.167 bc	12.167 b	13.000 ab	11.625 b	

Means within a column, row and their interaction followed with the same letters are not significantly differ from each other's according Duncan multiple range test at 5%level.

The fruits of the Royal did not significantly exceed the fruits of the Sandra hybrid in the P%. P% of fruits was improved by increase storage period (7 to 21days) significantly. Fruit treated with humic acid showed a higher increase in P% more than untreated fruit (table 6). The maximum P% content of fruit founded in combination of Sandra hybrid, 21days storage and 0.8 humic acid which significantly defer from most other interactions.

Table (6): influence of Humic acid and storage and their interaction on fruit P% of two tomato hybrids.

tomato Hybrids	Storage period (days)	Humic Acid (g.L^{-1})				Means of Hybrids * Storage period	Means of Hybrids
		0	0.4	0.8	1.6		
Royal	7	0.045 c-f	0.040 d-f	0.036 f	0.045 c-f	0.042 b	0.048 a
	14	0.041 d-f	0.039 ef	0.054 b-e	0.045 c-f	0.045 b	
	21	0.046 c-f	0.065 ab	0.058 ac	0.055 bc	0.056 a	
Sandra	7	0.046 c-f	0.037 f	0.036 f	0.045 c-f	0.041 b	0.046 a
	14	0.038 f	0.036 f	0.046 c-f	0.049 c-f	0.042 b	
	21	0.047 c-f	0.051 c-f	0.070 a	0.050 c-f	0.054 a	
Humic		0.044 b	0.045 ab	0.050 a	0.048 ab	**Means of Storage**	
Hybrids*	Royal	0.044 ab	0.048 ab	0.049 ab	0.048 ab		
humic	Sandra	0.043 ab	0.041 b	0.050 a	0.048 ab		
Storage period	7	0.046 ce	0.039 de	0.036 e	0.045 ce	0.041 b	
*	14	0.040 de	0.038 de	0.050 bc	0.047 cd	0.044 b	
humic	21	0.046 ce	0.058 ab	0.064 a	0.052 bc	0.055 a	

Means within a column, row and their interaction followed with the same letters are not significantly differ from each other's according Duncan multiple range test at 5%level.

According to the results of the mentioned feature under study which clarified in the tables (1, 2, 3, 4, 5, and 6) showed differences between the two hybrids Royal and Sandra in the all fruit characters in term (TSS, V.C, total acid, N, P, and K). This variation between the two hybrids might be due to the differences in genotype between it and the deference environmental. These results agree with those of **Abdul-Rahman (2011) and Aboutalebi *et al*., (2012).** It is observed from the mentioned results that an increase showed in (N, P, and K)% when the plants treated with different rate of humic acid. The organic fertilizers are considered the conceder as a source of macro and micro elements that are essential for plant growth and proved the soil with humus that enhance the physical and chemical propeartis of soil and their available to absorption water, also its reduce the loss of nutrient elements and increase the activity of microorganisms, and improve fruits qualities **(Molivko, 2001 and Grandy *et al*., 2002),** on other hand humic acid caused the increase in TSS, V.C and total acid of fruits because humic acid increase the vegetative growth of plants which lead to improvement the photosynthesis products and the efficiency of photosynthesis **(Jensen, 2004).**

Also, our results indicated that the qualitative properties decline and progress the ripening process of tomatoes during storage in term increase in TSS, decrease in VC, total acid, N

and K., it is known that qualitative attributes generally change with advance time of ripening , as part of the normal metabolism of the product (**Tijskens and Polderdijk 1996).** Softening is due to the breakdown of cell wall structure's carbohydrates and the increase in soluble pectin substances that results in weakening of the cell walls and reduction of the cohesive forces binding cells together **(O'Donoghue *et al*., 1997).** As aresult of there is a sharp increase in respiration at the onset of ripening, usually in concert with increased production of ethylene **(Giovannoni, 2001).** The TSS increase and decline in the acidity, VC, N, and K level in this study has been associated with fruits quality loss during tomato postharvest storage, and together with soluble solids content **(Zapata *et al*., 2008).**

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