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THE EFFECT OF ADDING HUMIC ACID, SPRAYING SOME FOLIAR TREATMENTS, ON CHEMICAL COMPONENTS OF FRUITS OF CHILI PEPPER PLANTS (*Capsicum annuum* L.) PLANTED IN UNHEATED PLASTIC HOUSES CONDITIONS

LAILA TURKI FADALA, DHIA AHMED TAAIN * AND FATIMA ALI HASSAN
Department of Horticulture, College of Agriculture, University of Thiqar, Iraq [LTF].
Department of Horticulture and Landscape, College of Agriculture, University of Basra, Iraq [DAT,FAH].
[*For Correspondence: E-mail: golden_fruitb@yahoo.com]

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ABSTRACT

The experiment was conducted during the winter agricultural season 2020-2021 in one of the unheated greenhouses with dimensions (9 x 50) m and an area of 450 m² belonging to the fields of the department of horticulture at the college of agriculture and marshes - Dhi Qar University, south of Iraq, with the aim of studying the effect of adding humic acid, spraying some foliar treatments, on chemical components of fruits of two hybrids of hot pepper plants (Barbarian F1and Kizil F1). Experiment included 30 factorial treatments which were the possible combinations of two hybrids(Barbarian F1and Kizil F1), three concentrations of humic acid 0, 1, 2 g. l^{-1} and five foliar spray treatments (aqueous extract of jujuba leaves at a concentration (75) g. l^{-1}, aqueous extract of pomegranate peels at a concentration of 5 ml. l^{-1}, calcium at a concentration of 1.5 ml. l^{-1}, arginine acid 200 mg. l^{-1} in addition to control treatment (spraying with distilled water only). Factorial experiment was carried out according to the split-split plot design in R.C.B.D with three replicates. The results were analyzed by the analysis of variance and mean values were compared using the Revised Least Significant Difference Test at 0.05 probability. Results showed that the fruits of Barbarian F1 hybrid excelled in the concentration of total chlorophyll and total soluble solids ,while fruits of Kizil F1 hybrid , were superior in phenols, capsaicin. Adding humic acid at the concentration of 2 g. l^{-1} led to significant increase in the content fruits of total soluble solids and vitamin C, and the concentration of 1 g. l^{-1} caused an increment in concentration of total chlorophyll , while the concentration of o g. l^{-1} was superior in increasing the concentration of phenols and capsaicin in fruits. Spraying aqueous extract of jujuba leaves at the concentration of (75) g. l^{-1} , arginine acid at the concentration of 200 mg. l^{-1} and calcium at the concentration of 1.5

ml. l^{-1} were the best in increasing the concentration of total chlorophyll and vitamin C, while arginine acid at 200 mg. l^{-1} caused significant increase in total soluble solids.In additions, extract of jujuba leaves caused significant increase in the concentration of capsaicin in fruits.

Keywords: Hot pepper; humic acid; extract of jujuba leaves; extract of pomegranate peels; capsaicin.

INTRODUCTION

The hot pepper *Capsicum annuum* L. belongs to the family Solanaceae. The central regions of South America, southern Mexico and Guatemala are the original home of the pepper, from where its cultivation spread to other regions of the world [1].

The hot pepper fruits are distinguished by their high nutritional value, as each 100 gm of fresh fruits contains 85.7 gm of water, 2.9 gm protein, 3 gm carbohydrates, 0.6 gm fat, 6.8 gm fiber, 3 mg carbohydrates, 0.6 gm fat, and 6.8 gm fiber in addition to its content. It contains nutrients such as calcium, phosphorous, potassium and iron [2].

Pepper also contains capsaicin, which has an enzyme structure and anti-obesity and anti-inflammatory properties, activates the immune system and lowers blood pressure [3]. Capsaicin causes the death of cancer cells in mice, and it also helps start insulin production again in pancreatic cells in cases of type 2 diabetes [4]. Hot pepper also contains antioxidants that reduce the risk of cancer, cataracts and cardiovascular diseases, as well as vitamin C, a powerful antioxidant that strengthens the natural immunity to diseases, and vitamin A, a fat-soluble vitamin and an important antioxidant that helps to Reduce health risks caused by free radicals and aid in the formation of red blood cells.

Organic fertilizers prepared from decomposed plant waste (compost) are of great importance in growth and yield, and from those is humic acid that stimulates root and shoot growth, increase available plant nutrients and their uptake from the soil, and enhance plant resistance to biotic and abiotic stress factors [5]. It also helps in increasing the amino acids and the plant's content of proteins and nutrients [6].

The use of plant extracts as an alternative to growth regulators is a natural substance that does not leave any trace on humans and the environment. Among these extracts is the extract of jujuba leaves, which contain flavonoids, which are natural antioxidants, which are compounds found in many plant parts, as well as containing saponins. They also contain antiviral properties against viruses, bacteria and fungi, as well as their effect as promoters or inhibitors, according to the concentrations used [7]. As for pomegranate peels, the polyphenols make up the bulk of its components, which include flavonoids (flavonols, flavanols proanthocyanidins, and anthocyanins). and degradable tannins, ellagitannins and gallotannins .

Arginine acid is one of the amino acids that play roles in many vital processes during the stages of plant growth and development, whether in its free form or as a component of proteins. It is also included in the synthesis of nucleotides and many coenzymes [8].

Given the importance of the hot pepper crop, nutritionally and medically, and the lack of studies in the southern governorates, and the desire to develop its cultivation, increase its productivity, and improve the quality of the product in greenhouses, this study was conducted.

MATERIALS AND METHODS

The experiment was conducted in the winter agricultural season 2020-2021 in one of the unheated greenhouses with dimensions (9 x 50) m and an area of 450 m² belonging to the fields of the department of horticulture at the college of agriculture and marshes - Dhi Qar University.

The soil of the plastic house was plowed perpendicularly, then it was smoothed , leveled and divided into six lines with 36 m length , 40 cm width, and the distance between one line and another was 50 cm. The seedlings of chili pepper , Barbarian F1 and Kizil F1 cultivars , were planted in the plastic house on 15/10/2020 and all the processes using in the production of this crop grown in plastic greenhouses were conducted. A

humic acid fertilizer was prepared at two concentrations (1 and 2 g l^{-1}) in addition to the control treatment, aqueous extract of jojoba leaves at 75 g l^{-1} , aqueous extract of pomegranate peel at 5 g L^{-1} , calcium solution at 1.5 ml. l^{-1} and arginine acid at 200 m g l^{-1} .

A split-split plot design was carried out, according to a randomized complete plot design(R.C.B.D.) with three replications [9]. The effect of two hybrids within the main plot and is symbolized by (V), so it is V1 for the first hybrid Barbarian F1 and V2 for the second hybrid Kizil F1, the second factor represents the humic acid within the sub-plot and is symbolized by (H) and with three levels of H0 for control (without fertilization) , H1 concentration of 1 g l^{-1} and H2 concentration of 2 g l^{-1} and the third factor within the sub-sub-plot represents the effect of spraying with the following treatments aqueous extract of jujuba leaves at a concentration (75) g. l^{-1} symbolized by S1 and spraying with aqueous extract of pomegranate peels at a concentration of 5 ml. l-1 and symbolized by S2 and spraying with calcium at a concentration of 1.5 ml. l- 1 symbolized by S3 and spraying with arginine acid 200 mg. L-1 and symbolized by S4 In addition to comparison (spraying with distilled water only) and symbolized by S0, thus the number of experimental units.

Number of experimental units = 2 x 3 x 5 x 3 = 90

Total chlorophyll in fruits (mg.100 g^{-1}) determined according to the method of Zaehringer and his colleagues described in [10]. Total soluble solids (T.S.S.) of fruit were determined by using hand refractometer and the results were corrected to 20 ° C [11]. Vitamin C (mg / 100 g) determined according to A.O.A.C. [12]. Phenolic substances were determined by using Folin-Denis method mentioned in Dalali and Al-Hakim [13]. The capsaicin content of the fruits was determined by a spectrophotometer and according to the method described by Sadasivam and Mannikam [14].

RESULTS

The Chlorophyll Concentration in the Fruits (mg.100 g^{-1})

It is clear from the results of Table (1) that the hybrids had a significant effect on the total chlorophyll concentration in the fruits, as the fruits of the Barbarian F1 hybrid were superior to those of the Kizil F1 hybrid in this characteristic , with an increase of about 814.2%.

The fruits of plants treated with humic acid at a concentration of 1 g. l^{-1} showed significant superiority for this trait compared to untreated plants with humic acid and those treated with humic acid at a concentration of 2 g. l^{-1} with an increase of (25.22 and 15.30)%, respectively .The plants treated with humic acid at a concentration of 2 g. l^{-1} were superior to the control plants with an increase of 8.60% .

The foliar spray had a significant effect on the total chlorophyll concentration in the fruits, as the fruits of plants sprayed with extract of jujuba leaves, calcium and arginine acid, compared to the fruits of control plants and plants sprayed with pomegranate peel extract, with an increase of (23.37 and 33.65%), (18.63 and 28.52)% and (20.56 and 30.60)%, respectively. There was no significant difference among extract of jujuba leaves , calcium and arginine acid, while the fruits of the control plants were superior to those of plants treated with pomegranate peel extract with an increase of 8.33% in the chlorophyll concentration .

As for the binary interactions between the study factors, all of them had a significant effect on this trait, where the interaction between the hybrid and humic acid had a significant effect, and the highest concentration of chlorophyll in the fruits was 9.82 mg.100 g^{-1} fresh weight in Barbarian F1 plants treated with 1 g. l^{-1} humic acid compared to the lowest concentration of 6.40 mg.100 g^{-1} fresh weight was obtained from the Kizil F1 hybrid plants untreated with humic acid .The binary interaction between the hybrids and foliar spray treatments had a significant effect on this trait .The plants of the Barbarian F1 sprayed with arginine outperformed and recorded the highest concentration of 9.83 mg.100 g^{-1} fresh weight, while the lowest concentration of chlorophyll was in fruits of plants of cultivar (Berberi) sprayed with pomegranate peel extract, which was 5.23 mg.100 g^{-1} fresh weight, and the dual interaction between humic acid and foliar spray had a significant effect, as plants treated with humic acid excelled at a concentration of 1 g. l^{-1} and

sprayed with arginine acid, and recorded the highest concentration of 10.53 mg.100 g^{-1} fresh weight compared to the lowest concentration of 5.27 mg.100 g^{-1} fresh weight was recorded in the fruits of Kizil F1 plants not treated with humic acid and non- sprayed on foliar treatments.

The triple interaction between the study factors had a significant effect on the chlorophyll concentration in the fruits, where the Barbarian F1 plants treated with humic acid at a concentration of 1 g. l^{-1} and sprayed with arginine acid were superior to 15.50 mg.100 g^{-1} fresh weight compared to the lowest concentration recorded in the fruits of plants of the same hybrid treated with humic acid at a concentration of 1 g. l^{-1} and sprayed with pomegranate peel extract which was 5.05 mg.100 g^{-1} soft weight.

Total Soluble Solids (%)

The results of the Table (2) indicate that the hybrids had a significant effect on the percentage of total soluble solids (T.S.S) in the fruits, where the fruits of Barbarian F1 hybrid plants outperformed those of Kizil F1 hybrid plants with an increase of about 10.12%.

The fruits of plants treated with humic acid at a concentration of 2 g. l^{-1} showed a significant superiority in this trait compared to the fruits of untreated plants and plants treated with humic acid at a concentration of 1 g. l^{-1} , with an increase of (38.12 and 11.85)%, respectively. Plants treated with humic acid at a concentration of 1 g. l^{-1} compared to fruits of untreated plants with humic acid, with an increase of 23.48%.

The effect of foliar spray treatments significantly affected on the percentage of total soluble solids (TSS) in the fruits, where the fruits of plants sprayed with arginine were superior to those of control plants and plants sprayed with the rest of the foliar spray treatments.

As for the binary interactions between the factors of the study, all of them were significant, as the interaction between the hybrids and humic acid showed a significant effect in this trait. The plants of Barbarian F1 hybrid treated with humic acid at a concentration of 2 g. l^{-1} outperformed in increasing the percentage of total soluble solids, the highest percentage was recorded, amounting to 5.55%, while the percentage was lower in the fruits of untreated plants of the Kizil F1 hybrid , which amounted to 3.56%.

Table 1. The effect of adding humic acid , spraying foliar treatments on chlorophyll concentration (mg.100 g^{-1}) of the fruits of two hybrids of chili pepper

Hybrids	Humic acid	foliar spray treatments					V * H
V	H	S0	S1	S2	S3	S4	
V1	H0	5.33	11.42	5.20	7.29	6.20	7.09
	H1	6.21	9.41	5.05	12.92	15.50	9.82
	H2	9.01	5.75	5.46	7.46	7.80	7.10
V2	H0	5.21	7.27	6.00	7.03	6.50	6.40
	H1	6.41	6.82	9.23	7.27	5.57	7.06
	H2	8.40	9.36	6.53	6.13	7.34	7.55
			$L.S.D_{0.05}$ = 0.91				$L.S.D_{0.05}$ = 0.64
Means of foliar spraying treatments		6.76	8.34	6.24	8.02	8.15	
			$L.S.D_{0.05}$ = 0.35				
							Means of hybrids
V×S	V_1	6.85	8.86	5.23	9.23	9.83	8.00
	V_2	6.67	7.81	7.25	6.81	6.47	7.00
$L.S.D_{0.05}$			0.65				0.83
							Means of humic acids
H×S	H_0	5.27	9.34	5.60	7.16	6.35	6.74
	H_1	6.31	8.12	7.14	10.09	10.53	8.44
	H_2	8.70	7.55	5.99	6.79	7.57	7.32
			$L.S.D_{0.05}$= 0.59				$L.S.D_{0.05}$= 0.24

The interaction between the hybrids and the foliar spray treatments had a significant effect on this trait, as the plants of the Barbarian F1 hybrid sprayed with arginine outperformed and recorded the highest percentage of total soluble solids amounted to 5.04%, while it was the lowest percentage of total soluble solids Total in fruits of the Kizil F1 hybrid sprayed with pomegranate peel extract, which amounted to 3.55%.

Plants treated with 2 g. l^{-1} humic acid outperformed and sprayed with arginine acid outperformed and recorded the highest percentage of total soluble solids amounted to 6.10%, while the lowest percentage of total soluble solids was in the fruits of control plants, which was 3.36%.

The triple interaction between the study factors had a significant effect on the percentage of total soluble solids. The plants of the Barbarian F1 hybrid treated with humic acid at a concentration of 2 g. l^{-1} and sprayed with arginine acid were superior and recorded the highest percentage of total soluble solids amounted to 6.83%, while the lowest percentage of total soluble solids were in fruits of Kizil F1 hybrid not treated with humic acid and sprayed with pomegranate peel extract that amounted to 3.06%.

Ascorbic Acid (Vitamin C) (mg.100gm^{-1} fresh weight)

Table (3) refers that there was no significant effect of the two hybrids on the content of the fruits of vitamin C (ascorbic acid).

The fruits of plants treated with humic acid at a concentration of 2 g. l^{-1} were superior to the fruits of untreated plants and plants treated with 1 g. l^{-1} humic acid, with an increase of (17.90 and 10.06)%, respectively. The fruits of plants treated with1 g. l^{-1} humic acid were superior to the fruits of untreated plants with humic acid with an increase of 7.12%.

The foliar spray had a significant effect on the content of the fruits of vitamin C, where the plants sprayed with jujuba extract, calcium and arginine were superior in the content of their fruits of vitamin C compared to the control plants and plants sprayed with pomegranate extract, with no significant difference among them (jujuba extract, calcium and arginine) fror their effect on fruit concentration of vitamin C .

Table 2. The effect of adding humic acid , spraying foliar treatments on total soluble solids (%) of the fruits of two hybrids of chili pepper

Hybrids V	Humic acid H	foliar spray treatments S0	S1	S2	S3	S4	V * H
V1	H0	3.23	3.46	3.80	4.43	3.46	3.68
	H1	4.56	4.36	4.40	4.33	4.83	4.50
	H2	5.23	5.23	6.26	4.20	6.83	5.55
V2	H0	3.50	3.36	3.06	3.83	4.03	3.56
	H1	4.20	4.40	3.86	4.33	5.43	4.44
	H2	5.06	4.16	3.73	3.93	5.36	4.45
			$L.S.D_{0.05}$ = 0.63				$L.S.D_{0.05}$ = 0.37
Means of foliar spraying treatments		4.30	4.16	4.18	4.17	4.99	
			$L.S.D_{0.05}$ = 0.36				
							Means of hybrids
V×S	V_1	4.34	4.35	4.82	4.32	5.04	4.57
	V_2	4.25	3.97	3.55	4.03	4.94	4.15
$L.S.D_{0.05}$				0.47			0.22
							Means of humic acids
H×S	H_0	3.36	3.41	3.43	4.13	3.75	3.62
	H_1	4.38	4.38	4.13	4.33	5.13	4.47
	H_2	5.15	4.70	5.00	4.06	6.10	5.00
			$L.S.D_{0.05}$= 0.86				$L.S.D_{0.05}$= 0.31

The interaction between the hybrids and humic acid showed a significant effect in this trait. The plants of Barbarian F1 hybrid treated with humic acid at a concentration of 2 g. l^{-1} in the content of their fruits of vitamin C and recorded the highest concentration of 269.6 mg.100 g^{-1} of fresh fruits, while the lowest concentration of vitamin C in fruits of plants of the same hybrid untreated with humic acid, which amounted to 198.7 mg.100 g^{-1} of fresh fruits. The interaction between the hybrids and foliar spray treatments had a significant effect in this characteristic , as the fruits of the plants of the Barbarian F1 hybrid sprayed with arginine were the best, and the highest concentration of vitamin C was 267.2 mg.100 g^{-1} of fresh fruits, while the lowest concentration of vitamin C was in the non-sprayed fruits of Kizil F1 hybrid , which was 208.9 mg.100 g^{-1} of fresh fruits.

The interaction between humic acid and spray showed a significant effect on this trait, where plants treated with humic acid at a concentration of 2 g. l^{-1} and sprayed with arginine acid outperformed and recorded the highest concentration of vitamin C in their fruits, which was 288.3 mg.100 g^{-1} of fresh fruits, while the lowest concentration was in the fruits of untreated plants with humic acid and non-sprayed, which recorded 185.8 mg.100 g^{-1} fresh fruits .

The triple interaction between the study factors had a significant effect on the vitamin C content of the fruits. The plants of Barbarian F1 hybrid treated with humic acid at a concentration of 2 g. l^{-1} and sprayed with arginine acid recorded the highest concentration of vitamin C in the fruits reached (335.0) mg.100 g^{-1} of fresh fruits, while the lowest concentration of vitamin C was in the fruits of plants of Barbarian F1 hybrid untreated with humic acid and non-sprayed, with foliar spray treatments, which recorded 178.3 mg.100 g^{-1} of fresh fruits.

Phenols Content of the Fruits (%)

It is noticed from the Table (4) that the hybrids had a significant effect on phenols , as the plants of Kizil F1 hybrid outperformed the Barbarian F1 hybrid, with an increase of 44.97% .

The same table shows that the plants of the control treatment were significantly superior to both concentrations of humic acid in this trait with an increase of (47.36 and 22.22)%, respectively, and both concentrations of humic acid did not differ significantly in their effect on phenols content of the fruits.

Table 3. The effect of adding humic acid , spraying foliar treatments on vitamin C (ascorbic acid) concentration (mg.100 g^{-1}) of the fruits of two hybrids of chili pepper

Hybrids V	Humic acid H	foliar spray treatments					V * H
		S0	S1	S2	S3	S4	
V1	H0	178.3	211.7	173.3	181.7	248.3	198.7
	H1	246.7	193.3	220.0	276.7	218.3	231.0
	H2	213.0	313.3	236.7	250.0	335.0	269.6
V2	H0	193.3	226.7	246.7	266.7	206.7	228.0
	H1	190.0	300.0	193.3	246.7	200.0	226.0
	H2	243.3	260.0	221.7	200.0	241.7	233.3
			$L.S.D_{0.05}$ = 53.78				$L.S.D_{0.05}$ = 10.43
Means of foliar spraying treatments		210.8	250.8	215.3	236.9	241.7	
			$L.S.D_{0.05}$ = 14.14				
							Means of hybrids
V×S	V_1	212.7	239.4	210.0	236.1	267.2	233.1
	V_2	208.9	262.2	220.6	237.8	216.1	229.1
$L.S.D_{0.05}$			18.89				NS
							Means of humic acids
H×S	H_0	185.8	219.2	210.0	224.2	227.5	213.3
	H_1	218.3	246.7	206.7	261.7	209.2	228.5
	H_2	228.2	286.7	229.2	225.0	288.3	251.5
			$L.S.D_{0.05}$=22.57				$L.S.D_{0.05}$=6.52

The plants of all spraying treatments showed a significant superiority compared to plants treated with arginine acid, and the plants sprayed with those treatments did not differ significantly in affecting phenols in fruits.

It appears from the same table that the binary interaction between the hybrid and humic acid had a significant effect, as the untreated plants of the Kizil F1 hybrid , with humic acid, gave the highest amount of phenols in the fruits, which amounted to 0.421%, while the fruits of control plants of Barbarian F1 hybrid and those of treated with concentration 1 $g.l^{-1}$ recorded the lowest amount of phenols which was was 60.19%.

The interaction between the hybrids and the foliar spray treatments showed a significant effect on this trait. Where the plants of the Kizil F1 hybrid sprayed with calcium outperformed significantly and recorded the largest amount of phenols amounting to 0.366 % compared to the lowest amount recorded in the fruits of the Barbarian F1 hybrid plants sprayed with calcium amounted to 0.183% .

The interaction between humic acid and foliar spray treatments shows a significant effect in this trait. The plants untreated with humic acid and sprayed with pomegranate peel extract outperformed and gave the largest amount of phenols, which amounted to 0.373%, compared to the lowest phenols amount recorded in the fruits of untreated plants with humic acid and sprayed with arginine acid, which amounted to 0.159%.

The triple interaction between the experimental factors for this trait had a significant effect, where the plants of the Kizil F1 hybrid , untreated with humic acid and sprayed with pomegranate peel extract, outperformed, and gave the highest amount of phenols which was 0.553% compared to the lowest amount recorded in untreated Kizil F1 hybrid plants with humic acid and sprayed with arginine acid amounted to 0. 120%.

The Capsaicin Content of the Fruits ($mg.kg^{-1}$)

The results of Table (5) showed that the hybrids had a significant effect on the content of capsaicin in the fruits, as the Kizil F1 hybrid plants outperformed the Barbarian F1 hybrid plants, with an increase of 33.35%.

Table 4. The effect of adding humic acid , spraying foliar treatments on phenols (%) of the fruits of two hybrids of chili pepper

Hybrids	Humic acid	foliar spray treatments					V * H
V	H	S0	S1	S2	S3	S4	
V1	H0	0.191	0.198	0.194	0.198	0.197	0.196
	H1	0.195	0.197	0.197	0.196	0.196	0.196
	H2	0.465	0.177	0.188	0.155	0.197	0.236
V2	H0	0.443	0.450	0.553	0.541	0.120	0.421
	H1	0.225	0.224	0.199	0.226	0.231	0.221
	H2	0.231	0.335	0.221	0.333	0.215	0.267
$L.S.D_{0.05}$ = 0.137							$L.S.D_{0.05}$ = 0.068
Means of foliar spraying treatments		0.291	0.263	0.259	0.275	0.193	
$L.S.D_{0.05}$ = 0.056							
							Means of hybrids
V×S	V_1	0.283	0.191	0.193	0.183	0.197	0.209
	V_2	0.300	0.336	0.324	0.366	0.189	0.303
$L.S.D_{0.05}$	0.080						0.073
							Means of humic acids
H×S	H_0	0.317	0.324	0.373	0.370	0.159	0.308
	H_1	0.210	0.210	0.198	0.211	0.214	0.209
	H_2	0.348	0.256	0.204	0.244	0.206	0.252
$L.S.D_{0.05}$=0.097							$L.S.D_{0.05}$=0.050

The control plants outperformed the plants treated with concentrations (1 and 2) g.l-1 significantly in the effect on the capsaicin content of fruits, and recorded 88 mg.kg-1, while the concentration 1 g.l^{-1} was superior to concentration 2 1 g.l^{-1}.

The plants sprayed with jujuba leaves extract significantly outperformed the rest of the spraying treatments and recorded 82.72 mg.kg^{-1}, while the lowest concentration of capsaicin was in the fruits of plants sprayed with arginine, which scored 77.89 mg.kg^{-1} with a non-significant difference from the control treatment.

The interaction between the hybrids and humic acid had a significant effect on this trait, as the untreated plants of the Kizil F1 hybrid with humic acid gave the highest concentration of capsaicin which amounted to 094.8 mg.kg^{-1}, compared to plants of Barbarian F1 hybrid treated with humic acid at a concentration of 2 g.l^{-1}, which gave the lowest amount of 56.53 mg.kg^{-1}.

The interaction between hybrids and foliar spray treatments had significant differences in this trait, where the plants of the Kizil F1 hybrid sprayed with jujuba leaves extract gave the largest amount of capsaicin, which amounted to 95.78 mg.kg^{-1} compared to the non-sprayed plants of Barbarian F1 hybrid with foliar spray treatments, which gave the lowest amount of capsaicin which amounted to 61.54 mg.kg^{-1}, while the interaction between humic acid and foliar spray treatments showed a significant effect on this trait, where the untreated plants untreated with humic acid and non-sprayed with foliar treatments outperformed and gave the highest amount of capsaicin alkaloid amounting to 102.98 mg.kg^{-1} compared to the lowest amount of capsaicin recorded in plants treated with humic acid at a concentration of 1 g.l^{-1} and non-sprayed with foliar treatments , which was 65.57 mg.kg^{-1}.

The triple interaction had a significant effect on this trait, as the plants of the Kizil F1 hybrid , which were not treated with humic acid and foliar spray treatments gave the highest amount of capsaicin which was 110.30 mg. kg^{-1}, while the lowest amount of capsaicin which was 42 mg. kg^{-1} recorded in plants of Barbarian F1 hybrid treated with humic acid at a concentration of 2 g.l^{-1} and non-sprayed with foliar treatments .

Table 5. The effect of adding humic acid , spraying foliar treatments on the content of capsaicin (mg. kg^{-1}) of the fruits of two hybrids of chili pepper

Hybrids V	Humic acid H	foliar spray treatments					V * H
		S0	S1	S2	S3	S4	
V1	H0	95.63	76.67	83.67	78.00	72.00	81.19
	H1	47.00	72.33	75.33	68.00	79.67	68.47
	H2	42.00	60.00	57.00	62.00	61.67	56.53
V2	H0	110.33	96.00	98.33	86.67	82.67	94.80
	H1	84.33	94.33	86.33	97.00	86.00	89.60
	H2	90.33	97.00	89.00	95.33	85.33	91.40
			$L.S.D_{0.05}$ = 2.23				$L.S.D_{0.05}$ = 0.77
Means of foliar spraying treatments		78.27	82.72	81.61	81.17	77.89	
			$L.S.D_{0.05}$ = 0.97				
							Means of hybrids
V×S	V_1	61.54	69.67	72.00	69.33	71.11	68.73
	V_2	95.00	95.78	91.22	93.00	84.67	91.93
$L.S.D_{0.05}$			1.23				0.15
							Means of humic acids
H×S	H_0	102.98	86.33	91.00	82.33	77.33	88.00
	H_1	65.67	83.33	80.83	82.50	82.83	79.03
	H_2	66.17	78.50	73.00	78.67	73.50	73.97
			$L.S.D_{0.05}$=1.61				$L.S.D_{0.05}$=0.67

DISCUSSION

It is evident from the previous tables that most of study factors had a significant effect on the characteristics of the qualitative fruits of chili pepper.

The results showed that the hybrids affected the qualitative indicators of the yield (the concentration of chlorophyll, TSS, , phenols, and capsaicin), where the plants of the Barbarian F1 hybrid excelled in the concentration of chlorophyll, TSS) compared to plants of the Kizil F1 hybrid , which was superior in phenols, capsaicin. The differences between the two hybrids in the above-mentioned indicators may be due to the genetic differences between them which occurs due to the variation in the genetic factors controlling the specific characteristics of the fruits [15].

Data showed a significant effect of treated plants with humic acid in most of the qualitative characteristics of fruits, where the fruits of plants treated with humic acid excelled in the qualitative characteristics compared to the fruits of untreated plants, and that this superiority is due to the role of humic acid in increasing the absorption of nutrients by the plant, leading to an improvement in the nutritional status of the plant, which was positively reflected in the growth stage, causing an increase in the total concentration of nitrogen in the leaves that considers an essential element in biological processes and the synthesis of amino acids [16,17]. As for the effect of humic acid on increasing total soluble solids and vitamin C ,the reason for this maybe due to the role of humic acid in increasing the nutrients ready for absorption and the increment of the products of carbon metabolism ,in addition to a better accumulation of complex compounds such as carbohydrates, amino acids and organic acids, these compounds are transferred to the fruits, which leads to an increase in the quality characteristics of the fruits mentioned above. The increment of nitrogen concentration in the plant increases the amino acids and therefore, increase the protein, of which amino acids are the basic units [18,19].

The role of humic acid in increasing the efficiency of the vegetative and root system, which worked to improve growth and thus, the accumulation of nutrients that are transmitted to the roots leading to activation and increase the growth of roots or improving the absorption of important elements in the synthesis of cytokinin and important in cell division, in addition to its role in synthesis the hormones gibberellin and auxin, and these hormones contributed to increase the elasticity of cells [20].

The tables confirm that foliar spray treatments had a significant effect on the most indicators of the specific yield, as these indicators increase with the application of spray treatments, where the superiority of jujuba extract in the chlorophyll , vitamin C and capsaicin concentrations in fruits. This may be due to the fact that this extract contains effective compounds, especially terpene compounds whose action is similar to hormones that help in the accumulation of pigments such as chlorophyll, vitamins and organic acids such as vitamin C .Spraying of calcium had a significant effect on improving the quality of fruits ,that may be due to that , the calcium is one of the most important elements for plant growth, as it enters the formation of the middle plate that connects cells with each other, thus holding adjacent cells together, regulating membrane permeability, encouraging cell division, stretching and elongation [21].

Calcium also has a role in activating the photosynthesis process by affecting the interactions of light and the manufacture and accumulation of carbohydrates and their transfer to the different parts of the plant accelerating the growth of fruits and improving their quality by accumulating pigments in them such as chlorophyll and carotene and the accumulation of sugars and the increase of dry matter [21,22].

The superiority of arginine acid was due to its role in increasing the concentrations of tannins, phenolic compounds, carbohydrate content, protein content and formation of amino acids [23] and the increase in nitrogen and calcium in fruits, which are the essential source of pro-active proteins directly or indirectly in the formation of carbohydrates and proteins and improve the production of carbohydrates and proteins and an increase in the activity of physiological and biological activities inside the plant, leading to an

improvement in plant growth and quality of yield [24].

CONCLUSION

It is concluded from the current study that adding humic acid, spraying foliar treatments (jujuba leaves extract ,arginine acid and calcium) had a significant effect on increasing the most of studied indicators of hot pepper fruits . The results showed that the hybrids affected the qualitative indicators of the yield (the concentration of chlorophyll, TSS, , phenols, and capsaicin), where the plants of the Barbarian F1 hybrid excelled in the concentration of chlorophyll, TSS) compared to plants of the Kizil F1 hybrid , which was superior in phenols, capsaicin. Results appeared a significant effect of treated plants with humic acid at concentrations of (2 and 1) g. l^{-1} in most of the qualitative characteristics of fruits and the spraying treatments had also significant effect on the most indicators of the specific yield, as these indicators increase with the application of spray treatments. According to the results of the study, it is recommended to add humic acid with the two mentioned concentrations(2 and 1) g. l^{-1} , as well as spraying plants with the aqueous extract of jujuba leaves at the concentration of (75) g. l^{-1} , arginine acid at the concentration of 200 mg. l^{-1} and calcium at the concentration of 1.5 ml. l^{-1} to improve qualitative characteristics of fruits of chili pepper planted in unheated plastic houses conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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